ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Baku – Tbilisi – Ceyhan Oil Pipeline Azerbaijan

Technical and Baseline Appendices

Prepared for BP

By AETC Ltd / ERM

May 2002

GENERAL NOTES

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PART 1: PROJECT CODES AND STANDARDS

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1. PROJECT DESIGN CODES AND STANDARDS

1.1 PRIMARY CODES

The primary codes for the design and construction of the BTC pipeline are:

- ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and other Liquids (1998 Edition)
- ASME B31.3 Process Piping (1999 Edition)

Generally the API / ASME codes will be utilized for all pump station equipment.

1.2 SUPPLEMENTARY CODES

The principal supplementary codes and standards upon which the engineering phase has been based are listed below in terms of:

a) the principal codes/standards being used for design
b) the principal national standard from where additional codes/standards may be obtained

Table 1-1: Supplementary codes and standards

Witness
OREDA-97 (Offshore Reliability Data)
OREDA – Phase IV, 2001 (Offshore Reliability Data)
Mechanical
American Society of Mechanical Engineers (ASME)
• ASME VIII Latest Edition
American Petroleum Institute (API)
• API 610 8th Edition 1995
Supplemented by the following where appropriate:
• National Fire Protection Association (NFPA)
• NFPA 20
• National Association of Corrosion Engineers (NACE)
• American Society of Testing of Materials (ASTM)
• International Standards Organisation (ISO)
• ISO 3046 Diesel Engines
• British Standards Institute (BSI)
• National Electrical Manufacturers Association (NEMA)
• Chartered Institution of Building Services Engineers (CIBSE)
Loss Prevention
Institute of Petroleum (IP)
National Fire Protection Association (NFPA)
British Standards Institute (BSI)
Underwriters Laboratory (UL)
Factory Mutual (FM)
Industrial Risk Insurers (IRI)

Table 1-1: Supplementary codes and standards

American Petroleum Institute (API)
MET (Material Engineering Technology)
The design codes used by during the engineering design programme to date are as follows:
• API 5L: Specification for Line Pipe – 42nd Edition Jan 2000
• ISO 12094: Welded Steel Tubes for Pressure Purposes – Ultrasonic Testing for the Detection of Laminar Imperfections in Strips/Plates used in the Manufacture of Welded Tubes.
• SNT-TC-1A: American Society of Non-Destructive testing, Standard for Qualification and Certification of Non-Destructive Testing Personnel
Principal National Body
American Petroleum Institute (API)
Supplemented by the following where appropriate:
• American National Standards Institute (ANSI)
• American Society of Mechanical Engineers (ASME)
• American Society of Non-Destructive Testing (ASNT)
• American Society of Testing and Materials (ASTM)
• International Standards Organisation (ISO)
• Manufacturers Standardisation Society (MSS)
• National Association of Corrosion Engineers (NACE)
• Steel Structures Painting Council (SSPC)
Process / Hydraulics
American National Standards Institute (ANSI)
Piping
• Institute of Petroleum, Model Code of Safe Practice, Part 19, Fire Precautions at Petroleum Refineries and Bulk Storage Installations
• IM 2.5.2 June 3 1996 Hazard Classification of Process Operations for Spacing Requirements
Supplemented by the following where appropriate:
• American National Standards Institute (ANSI)
• American Petroleum Institute (API)
• American Society of Testing and Materials (ASTM)
Control Systems
American Petroleum Institute (API) Hardware Installation
International Electrotechnical Commission (IEC) Electrical Installation & certification
National Fire Protection Association (NFPA)
• IEC 61508
Supplemented by the following where appropriate:
• American Society of Testing and Materials (ASTM)
• American Society of Mechanical Engineers (ASME)
• Fluid Controls Institute (FCI)
• British Standards Institute (BSI)
• European Economic Community (EEC)
• Instrument Society of America (ISA)
• International Standards Organisation (ISO)

Table 1-1: Supplementary codes and standards

• European Committee for Electrotechnical Specification (CENELEC)
Telecommunications
International Telecomms Union (ITU)
• ITU-T ReC G707: Synchronous Digital Hierarchy
• ITU-T G705: Characteristics Required to Terminate Digital Links on a Digital Exchange
• ITU-T G703: Physical / Electrical Characteristics of Hierarchical Digital Interfaces
• ITU-T G652: Characteristics of Surface Mode Simple Mode Official Fibre Cable
Supplemented by the following where appropriate:
• International Electrotechnical Commission (IEC)
• International Standards Organisation (ISO)
• European Telecommunications Standards Institute (ETSI)
• Normalised Standards of the European Union (Euronorms) (EN)
• British Standards Institute (BSI)
• United Kingdom MPT Specifications
• American National Standards Institute (ANSI)
• Institute of Electrical and Electronic Engineers (IEEE)
• Electronic Industries Association (EIA)
• Telecommunication Industries Association (TIA)

REGULATORY REVIEW OF ENVIRONMENTAL AND SOCIAL ISSUES

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1 REGULATORY REVIEW ON ENVIRONMENTAL AND SOCIAL ISSUES

1.1 INTRODUCTION

The BTC pipeline will be designed, built and operated in conformance with a number of legislative requirements, policies and guidelines including:

- BP corporate environmental policy and management system
- Host government agreements (HGA)

The laws and procedures that apply to the BTC pipeline will ultimately be determined by the Host Government Agreement (HGA) between the proponent, BP and the government of Azerbaijan. This sets out the national legislation and international regulations applicable to the project, and the responsibilities of governmental departments and other organisations in relation to the project.

The relevance of each of these to the BTC project is discussed below.

1.2 CORPORATE ENVIRONMENTAL POLICY AND MANAGEMENT SYSTEM

BP has operations in more than 90 countries and employs some 100,000 people. It is BP’s policy to carry out all its operations in a safe and environmentally responsible manner. The corporate health, safety and environmental (HSE) policy (Figure 1) reflects the commitment to high standards throughout all phases of a project.

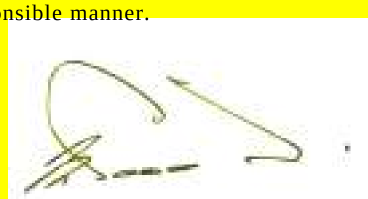
Figure 1 BP's Corporate Health Safety and Environmental Policy

Health Safety & Environmental Policy

We fully endorse the BP Group Policy and are committed to our worldwide corporate goals: no accidents, no harm to people and no damage to the environment.
Getting HSE right is a fundamental part of our business in the Caspian Sea Region and BP through our operations in exploration, development, extraction and transporting of oil & gas fully supports its goals and requirements.
In meeting with this policy we will:

1. Expect all personnel to demonstrate commitment to, and leadership in, health, safety and environmental (HSE) protection, performance and compliance.
2. Manage HSE performance in compliance with the expectations in the BP "Getting HSE Right" management system.
3. Audit the environmental management system against ISO 14001.
4. Inform our employees, contractors, partners, stakeholders, government agencies and the public of relevant HSE aspects of our operations. Openly listen, consult and respond to their concerns.
5. Endeavour to continuously improve HSE performance.
6. Meet or exceed applicable HSE legislation, regulations and company requirements.
7. Ensure our employees and contractors are familiar with our HSE systems, and are competent and trained to carry out their work safely and with due regard for the environment.
8. Provide employees with a safe place to work.
9. Maintain a commitment to incident and pollution prevention, maintain emergency response plans and resources, and manage emergency situations resulting from our activities.
10. Set annual HSE objectives and targets and openly report our performance. Audit compliance with our policies and take corrective action where appropriate.

No task is so important that we cannot take time to plan and implement it in a safe and environmentally responsible manner.



David Woodward
Business Unit Leader BP Azerbaijan
September, 2001

1.3 CORPORATE SOCIAL POLICIES AND REQUIREMENTS

1.3.1 BP business policies

BP has 3 Business Policies related to social aspects of the project:

- Ethical Conduct
- Employees
- Relationships

- Health and Safety and Environmental Performance
- Control & Finance

Contractors will be required to comply with these BP policies. Potential contractors will be asked to set out in their response to the Invitation To Tender for construction how they propose to achieve this compliance.

The relevant Health and Safety and Environmental Performance policies are covered in the URS BP Shah Denis Mid Stream Pre Host Government Agreement Regulatory Review.

The full set of BP Business policies can be found in the BP booklet, What We Stand For.

1.3.2 Ethical conduct policy

We will pursue our business with integrity, respecting the different cultures and the dignity and rights of individuals in all the countries where we operate.

BP supports the belief that human rights are universal. They are enshrined in the UN Universal Declaration of Human Rights (UDHR), which we support. The Charter sets out the obligations to promote universal respect for and observance of human rights and fundamental freedoms for all, without distinction as to race, gender, language, or religion. The promotion and protection of all human rights is a legitimate concern of business.

In our actions and our dealings with others, we will:

- Respect the rule of law
- Promise only what we expect to deliver, make only commitments we intend to keep, not knowingly mislead others and not participate in or condone corrupt or unacceptable business practices
- Fulfil our obligations and commitments, treat people according to merit and contribution, refrain from coercion and never deliberately do harm to anyone
- Act in good faith, use company assets only for further company business and not seek personal gain through abuse of position in the company
- We will expect the same commitments from third parties acting directly on BP’s behalf.

Policy Expectations

- We will respect the law in the countries and communities in which we operate
- We will never offer, solicit, or accept a bribe in any form
- BP’s preference is not make facilitation payments
- We will hold no secret or unrecorded funds of money or assets
- We will only give or accept gifts and entertainment that are for business purposes and are not material or frequent
- We will avoid situations where loyalty to the company may come into conflict with personal interests or loyalties
- BP supports the principles set forth in the UN Universal Declaration of Human Rights and will respect the 1977 International Labour Organisation ‘Tripartite Declaration of Principles Concerning Multinational Enterprises and Social Policy’ and the 1976 OECD ‘Guidelines for Multinational Enterprises’
- BP will not employ forced labour or child labour
- Before we make major investments in a new area, we will evaluate the likely impact of our presence and activities
- BP will make political contributions only when they are lawful, of modest size and properly recorded

- Fees for services rendered by third parties, including agents and consultants, must be for legitimate business purposes that are demonstrably commensurate with the service provided
- We will not choose business partners who contravene these commitments.

1.3.3 Employees Policy

Our approach to managing people and developing their skills is consistent with the principles of our brand.

We respect the rights and dignity of all employees. Everyone who works for BP contributes to our success and to creating a distinctive company. Working together, drawing from our diverse talents and perspectives, we will stimulate new and creative opportunities for our business. Collectively we will generate a more exciting and rewarding environment for work in which every individual feels responsible for the performance and reputation of our company.

We commit to creating a work environment of mutual trust and respect, in which diversity and inclusion are valued, and where everyone who works for BP:

- Knows what is expected of them in their job
- Has open and constructive conversations about their performance
- Is helped to develop their capabilities
- Is recognised and competitively rewarded for their performance
- Is listened to and involved in improving the team’s performance
- Is fairly treated
- Feels supported in the management of their personal priorities

1.3.4 Relationships Policy

We believe that long-term relationships founded on trust and mutual advantage are vital to BP’s business success.

Our commitment is to create mutual advantage in all our relationships so that others will always prefer to do business with BP.

We will do this by:

- Understanding the needs and aspirations of individuals, customers, contractors, suppliers, partners, communities, governments, and non-government organisations
- Conducting our activities in ways that bring benefits to all those with whom we have relationships
- Fulfilling our obligations as a responsible member of the societies in which we operate
- Demonstrating respect for human dignity and the rights of individuals

We will work to build long-term relationships founded upon:

- High performance standards
- Delivering on our promises
- Openness and flexibility
- Learning from others
- Mutual interdependence
- Sharing success

Policy Expectations

In specific relationships:

With Individuals

- We will respect their rights, culture and dignity
- We will act fairly and justly

With Customers

- We will provide our customers with high-quality goods and services that meet their needs
- We will deliver what we promise

Partners, Contractors and Suppliers

- We will seek partners whose policies are consistent with our own
- We will combine complementary skills, appropriate technology and experience to create greater effectiveness
- We will make our contractors and suppliers aware of our own commitments and expectations, and of their responsibilities in implementing them

With Communities

BP is committed to achieving the following through our relationships with communities:

- Our aim is that countries and communities in which we operate should benefit directly from our presence - through the wealth and job created, the skills developed within the local population and the investment of our time and money in people rather than in things so that we create sustainable human progress
- We will work toward improvements that are measurable and contribute to the real, independent growth of communities where we operate
- Wherever we operate, we will strive to minimise any disruption to the environment arising from our activities
- We will conduct our activities with a standard of care in which our employees can take pride
- We will take into consideration the specific developmental needs of communities in which we operate through a process of open dialogue and consultation

With governments

- We will respect national sovereignty
- We will work constructively with governments in the development of policy
- We recognise changing public expectations of the extent to which companies should put pressure on the governments on human rights issues and will seek, working in partnership with others, to resolve any tensions or conflicts arising between international expectations and national or local practices in a sensitive manner

With non-governmental organisations

- We will seek to create mutual understanding and build constructive relationships with non-governmental organisations who have a genuine interest in our business and concerns about its impact upon individuals, society and the environment

With the media

- We will seek to form a constructive and productive relationship with all branches of the media: television, radio, newspapers and the Internet

With trade bodies

- We will seek to influence trade bodies for the mutual benefit of the industry and society

With Employee Representative Bodies

- We will seek to work in good faith with trade unions and other bodies that our employees collectively choose to represent them within the appropriate local legal framework

1.4 HOST GOVERNMENT AGREEMENT

The HGA was ratified and adopted on 25 May 2000 and was signed by the Government of Azerbaijan and the sponsor companies in October 2001.

The HGA is a legally binding document, which operates under the force of the law. The HGA specifies the work programme that the operator must undertake, including environmental aspects and specific environmental standards that the Contractor must accomplish.

The HGA provides that the BTC partners will comply with present and future Azerbaijani laws and regulations of general applicability with respect to the public health, safety and protection and restoration of the environment, to the extent that such laws and regulations are not different from or more stringent than the standards and practices generally prevailing in the international petroleum pipeline industry.

It is also stated that existing pollution is not the liability of the BTC partners.

In conducting all pipeline activities, the BTC participants shall use Best Endeavours to minimise potential disturbance to the environment, including the surface, subsurface, sea, air, lakes, flora, fauna and other natural resources and property.

1.4.1 EIA under the HGA

Relevant sections of the HGA outline environmental protection and safety measures to be employed during the pipeline operations of the BTC partners.

According to the provisions, the BTC partners must develop an ‘Environmental Strategy Product’. The Environmental Strategy Product will include and implement the standards and practices prevailing in the international oil pipeline industry and Applicable Technical Standards, as appropriate.

The environmental Strategy Product will comply with the principles of EC directive 85/337/EEC (as amended by EC Directive 97/11/EC) and will include all of the following general environmental principles

- There will be no discharging of Petroleum
- Waste petroleum, sludge, pigging wastes, polluted ballast waters and other wastes will either be recycled, treated, burned or buried employing the best environmental option
- All waste streams will be disposed of in an acceptable manner and concentration as determined during the course of the EIA
- Emission monitoring programs will be developed to ensure environmental compliance

The 'Environmental Strategy Product' will comprise the following:

- A scoping study
- An environmental risk assessment that will serve to highlight potential environmental risks and costs impacts to the engineering design requirements of the project
- A contaminated land Baseline Study to provide a qualitative assessment of the existing pollution and contamination in the areas within the Territory relevant to pipeline activities as of the effective date. The Baseline Survey will include:

    1. A desk study review of the relevant and available information
    2. An audit of existing operations and practices and the collection of relevant environmental data from the areas surrounding the location of the Facilities, including information on:
        - Surface and subsurface geology
        - Geomorphology
        - Rock permeability and the presence of aquifers
        - Assessment of existing quality of surface waters
        - The effect of any existing contamination on flora, fauna, landscapes and ecosystems; and
        - A qualitative assessment of any pollution, environmental damage and contamination in respect of the Facilities

- An environmental impact assessment (EIA) that will assess the potential environmental impacts of pipeline activities (whether from pipeline activities within or without the Territory). The EIA will include:

    1. A project description
    2. An environmental and socio-economic description of the relevant areas of possible impact
    3. An evaluation of the impact to the environment of the proposed construction and operation of the Facilities, including an estimate of those emissions and discharges into the environment (eg associated air emissions, aqueous discharges and solid waste produced) that are reasonably foreseeable
    4. A plan for the identification and implementation of practicable mitigation measures for each identified impact
    5. An assessment of the environmental risks associated with pipeline activities; and
    6. The formulation of a monitoring programme to verify that mitigation measures are effective, and in the event that additional impacts are identified to ensure that additional mitigation measures are effected

- An Oil Spill Response Plan that will prepare a plan for emergency response capability as to leaks or emissions of natural gas within or that could threaten life or property or adversely affect the Territory. The Oil Spill Response Plan will include:

    1. Environmental mapping of habitats vulnerable to potential natural gas leaks or

emissions in the entire BTC pipeline system

2. Plans for the provision of relevant Petroleum spill clean up equipment and materials
3. Plans of the deployment of relevant equipment and emergency response notification details of the organisation required to handle natural gas leaks, emissions, explosions and fires
4. Plans of the treatment and disposal of resulting contaminated materials
5. The Emergency Response plan sets out the equipment, personnel and management systems needed to respond to an incident along the pipeline. This is developed in outline as part of the ESIA and completed prior to commissioning
6. An abandonment plan must be completed less than 30 days after termination of the HGA, describing proposed actions associated with abandonment

1.4.2 Land and associated issues

Article 4 of the Host Government Agreement sets forth the Rights to Land for Project Participants that are further outlined in the Appendix 2 of the Agreement. Appendix 2 entitles Project Participants exclusive and unrestricted Rights to use and posses land within project activities. Thus, it supersedes the current applicable land legislature and requires amendments or adoption of new laws as set out in Article 6 of the Agreement:

> "the State Authorities have, or have the legal authority to obtain in a timely manner, sole and exclusive jurisdiction respecting Rights to Land (including the Permanent Land) and the full power, authority and right under Azerbaijan Law to grant the rights and privileges provided in Article 4, which rights are transferable by an MEP Participant in accordance with this Agreement"

The Appendix 2 provides the following land rights to the Project Participants:

> "Right to transport all construction material, plant and equipment within the Territory and cross border by land or air without hindrance, including the right to construct and maintain temporary and permanent roads and to use such airfields as are designated, from time to time, by the BTC Participants
>
> Right to designate and use other areas of land, both in the vicinity of the proposed Facilities and remote from the Facilities, for the conduct of all Project Activities, including for pipe storage dumps, site compounds, construction camps, fuel storage dumps, parking areas, roads and other activity sites
>
> Right to install generation and transmission equipment and to connect to any existing electricity supply and, where necessary, the right to lay cables from such supply to the Construction Corridor
>
> Right to receive confirmation that each affected landowner and/or occupier has been made aware of and has consented to and/or has been compensated under Azerbaijan Law for the rights acquired by the MEP Participants through the State Authorities
>
> The right to the exclusive use, possession and control, and the right to construct upon and/or under, and peaceful enjoyment of, these Rights to Land without hindrance or interruption"

Appendix 2 of the Host Government Agreement specifies the procedures and principles to be applied for the acquisition of non-state (private) land. It is a government responsibility to acquire and transfer such land to the project participants. State authorities are obliged to acquire such land

at a possible reasonable cost in line with the standards and procedures set forth in Land Code of Azerbaijan Republic (June 25, 1999), the Law of Azerbaijan Republic on Land Market (May 7, 1999) and any Decrees of the President and/or the Cabinet of Ministers of Azerbaijan Republic implementing the Land Code and Law. The Project Participants pay the State Authorities (through an appropriate escrow account mechanism) the amount of all actual, verifiable costs to be incurred by them in acquiring such Non-state Land within thirty (30) days before such costs are required to be paid.
It is also the Government obligation to protect, defend and indemnify each of the Project Participants and other affected Project Participants from and against any loss or damage in respect of the Rights to Land and any and all third-party claims or demands.

1.4.3 Public Consultation and Disclosure

Section 3.9 of Appendix 3 sets forth the requirements for public review and comment in accordance with the procedures outlined therein. HGA requires that affected public and non-governmental organisations be notified about the nature of the operation of the Facilities during the development of the EIA through dissemination of information to these organisations through meetings and exhibitions.

Following the completion of the EIA, the public is to be provided with information on the environmental aspects of the Project to enable it to comment with respect thereto. To facilitate this process, the EIA and an executive summary (in the Azeri language) are to be made available in a public place for review and comments. In addition, an information copy of the executive summary shall be submitted simultaneously to the Government.

A maximum of sixty (60) days are allowed for public comments, which are then to be provided to the Government by the BTC Participants within thirty (30) days after the expiration of the sixty (60)-day period. Demonstration that the BTC Participants have reasonably addressed public concerns (through modification of the EIA, if necessary) is to be included in a final executive summary that to be submitted to the Government.

1.4.4 Labour and Employment

Article 4, Article 7, and Article 18 of the Host Government Agreement cover regulatory aspects for labour and employment within the project. The provisions of these articles authorize Project Participants and Project Contractors to select and determine the number of employees to be hired in connection with the project. All citizens of Azerbaijan hired in respect of the Project will be hired pursuant to written employment contracts that specify the hours of work required of the employees and the compensation and benefits to be paid or furnished to them and other material terms of employment. Consistent with their respective employment contracts, such employees may be located wherever deemed appropriate in connection with their employment. Subject to requirement that no Project Participant shall be required to follow any employment practices or standards that exceed those international labour standards or practices which are customary in international Petroleum transportation projects or are contrary to the goal of promoting an efficient and motivated workforce, all employment programs and practices applicable to citizens of Azerbaijan working on the Project in-country, including hours of work, leave, remuneration, fringe benefits and occupational health and safety standards, shall not be less beneficial than is provided by the Azerbaijan labour legislation generally applicable to its citizenry.

1.4.5 Ethics

Ethical standards and principles are outlined in Appendix 3 of the HGA and referred as Best Endeavours. Best Endeavours are to be used to minimize potential disturbances to the environment, surrounding communities and the property of inhabitants thereof during the conduct of any project activities. The order of priority for actions shall be protection of life, environment and property.

Atmospheric Emissions Inventories – Method and Assumptions

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1 ATMOSPHERIC EMISSIONS INVENTORIES – METHOD AND ASSUMPTIONS

This appendix details how the estimated figures for atmospheric emissions in Section 10.3.3 were calculated.

1.1 CONSTRUCTION EMISSIONS – PIPELINE SPREAD

This section considers the emissions associated with the pipeline spread. Construction of the AGIs is not included as no information is available at this stage.

1.1.1 Non-road vehicles and equipment

The exhaust gases of vehicles and equipment used in construction are the major source of air pollutants during this phase of the project. Emissions were estimated as follows:

The total number of each vehicle/equipment type to be used was determined from the mobilisation/demobilisation report of the engineering design contractor. Vehicles and equipment were categorised according to available emission factors in the US EPA's Nonroad Engine and Vehicle Emission Study (NEVES) as shown in Table 1, below.

Table 1 Inventory of non-road vehicles and equipment

Basic description of project equipment	Corresponding NEVES category	Total number
Dozers	Dozer (rubber tyred)	21
Sidebooms	Other construction equipment	29
Backhoes, loaders and tractors	Tractor/loader/backhoe	80
Athey wagon	Off-highway truck	4
10 ton forklift	Forklift	3
Graders	Grader	12
Dump Truck	Dumper	38
Compactor	Roller	4
Ditcher	Trencher	2
Crane	Crane	19
Pumps	Pump	18
Generators, light plant	Generator set <50 hp	32
Road boring machine	Bore/drill rig	1
Air compressor	Air compressor	29

NEVES lists average horsepower ratings for each of its equipment types. For the generator sets, however, the power rating was given in the mobilisation/demobilisation report - 2 x 10 kWe generators, 30 x 12.5 kWe light plant. An average power rating per unit was calculated from this information. Generators associated with operation of the construction camps are covered in Section 1.2. Table 2 below lists the horsepower ratings and pollutant emission factors from NEVES. The factor for CO_2, however, is derived from AP-42 Table 3.3-1 (diesel industrial engines) as NEVES does not give factors for CO_2.

Table 2 Power ratings and emission factors for non-road vehicles and equipment

Equipment Type	**hp rating**	**Pollutant emission factor, g/hp-hr**					
		HC	**CO**	**NOx**	**PM**	**SO_2**	**CO_2**
Dozer (rubber tyred)	356	0.86	2.80	9.60	0.66	0.93	522
Other construction equipment	161	1.44	9.20	11.01	1.44	0.93	522
Tractor/loader/backhoe	77	1.43	6.80	10.10	1.05	0.85	522
Off Highway truck	658	0.86	2.80	9.60	0.80	0.89	522
Forklift	83	1.60	6.06	14.00	1.60	0.85	522
Grader	172	1.57	3.80	9.60	1.00	0.87	522
Dumper	23	0.86	2.80	9.60	1.44	0.89	522
Roller	99	0.82	3.10	9.30	0.78	1.00	522
Trencher	60	1.57	9.14	10.02	1.44	0.93	522
Crane	194	1.29	4.20	10.30	1.44	0.93	522
Pump	23	1.22	5.00	6.00	1.00	0.93	522
Generator set <50 hp	17	1.22	5.00	6.00	1.00	0.93	522
Bore/drill rig	209	1.44	9.20	11.01	1.44	0.93	522
Air compressor	23	1.22	5.00	6.00	1.00	0.93	522

Every unit was assumed to operate for 12 hours per day, every day for the duration of the 15 month construction period (ie 5,472 hours in total, note that this is a conservative estimate). Hence the calculation to derive the mass emission for each equipment type and each pollutant over the entire construction period is:

Mass emission = number of units x hp rating of each unit x pollutant emission factor x 5,472

Table 3 below presents the results of this calculation for each equipment category and pollutant.

Table 3 Total emissions for non-road vehicles and equipment

Equipment Type	**Emission (tonne) over construction period**					
	HC	**CO**	**Nox**	**PM**	**SO_2**	**CO_2**
Dozer (rubber tyred)	35	115	393	27	38	21,366
Other construction equipment	37	235	281	37	24	13,344
Tractor/loader/backhoe	48	229	341	35	29	17,605
Off-highway truck	12	40	138	12	13	7,522
Forklift	2	8	19	2	1	712
Grader	18	43	108	11	10	5,899
Dumper	4	13	46	7	4	2,498
Roller	2	7	20	2	2	1132
Trencher	1	6	7	1	1	343
Crane	26	85	208	29	19	10,534
Pump	3	11	14	2	2	1,183
Generator set <50 hp	4	14	17	3	3	1,513
Bore/drill rig	2	11	13	2	1	597
Air compressor	4	18	22	4	3	1,906
Total	**198**	**836**	**1,627**	**173**	**149**	**86,154**

1.1.2 Road-going vehicles

Vehicles that were judged to be road-going were categorised according to the UK Emission Factors Database (UKEFD) as shown in Table 4, below.

Table 4 Inventory of road-going vehicles

Basic description of project description	Corresponding UKEFD category	Total number
Trucks, lowboys, flatbeds, concrete mixer trucks	Artic HGV	157
Pickups, 4x4s, carryalls, ambulances, crew cabs	Diesel LGV	155
Buses	Bus	53

Emission factors from the UKEFD were used to estimate emissions. The vehicles were assumed to be of 2003 specification and the usage type was assumed to be 'rural single carriageway'. Each vehicle was assumed to travel 500 km/day for the entire 456 day construction period (ie 228,000 km in total, note that this is a conservative estimate).

Table 5 presents the emission factors and the estimated emissions for each vehicle type over the construction period, calculated by:

Mass emission = Number of vehicles x emission factor x 228,000 km

Table 5 Emission factors and total mass emissions for road-going vehicles

Vehicle type	Emission factors, g/km						
	NMVOC	CO	NOx	PM_{10}	SO_2	CO_2	CH_4
Artic HGV	1.00	1.54	7.48	0.23	0.26	1,155.00	0.06
Diesel LGV	0.13	0.46	0.35	0.10	0.05	228.80	0.00
Bus	1.11	2.22	5.98	0.28	0.19	855.10	0.06
Vehicle type	**Emission over construction period, tonne**						
	NMVOC	**CO**	**NOx**	PM_{10}	SO_2	CO_2	CH_4
Artic HGV	36	55	268	8	9	41,367	2
Diesel LGV	5	16	12	4	2	8,090	0
Bus	13	27	72	3	2	10,339	1
Total	**54**	**98**	**353**	**15**	**13**	**59,796**	**3**

1.1.3 Large generators

There were two categories of generator whose power rating was outside the NEVES category (generator sets <50 hp). Emission factors from the USEPA's Compilation of Air Pollutant Emission Factors, AP-42, Volume 1, Table 3.3-1 (diesel industrial engines) were used for these. They are 317 kWe and 60 kWe generators respectively. Generators associated with operation of the construction camps and pipe storage yards are covered in Section 1.2.

Table 6 below presents the emission factors and total mass emissions from these generators over the construction period. Each unit is assumed to operate for 12 hours per day throughout the entire 456 day construction period (i.e. 5,472 hours in total). The calculation is:

Mass emission = Number of units x power rating of each unit x emission factor x 5,472 hours

Table 6 Emission Factors and Total Mass Emissions for Large Generators

		Emission factors					
		HC	CO	NOx	PM_{10}	SO_2	CO_2
	lb/hp-hr	0.003	0.007	0.031	0.002	0.002	1.150
	kg/kW-hr	0.002	0.004	0.019	0.001	0.001	0.699
Generator type	**Number**	**Emission over construction period, tonne**					
		HC	**CO**	**NOx**	PM_{10}	SO_2	CO_2
317 kWe	3	8	21	98	7	6	3641
60 kWe	3	2	4	19	1	1	689
	Total	**9**	**25**	**117**	**8**	**8**	**4330**

Emissions for all other powered equipment listed in the mobilisation/demobilisation report were not estimated as it was assumed they would be powered by the generator sets.

1.2 CONSTRUCTION EMISSIONS – CONSTRUCTION CAMPS AND PIPE STORAGE YARDS

There are two main sources of emissions associated with the construction camps and pipe storage yards: waste incineration and power generation.

1.2.1 Waste incineration

Emissions from waste incineration at the construction camps were estimated on the basis of the total mass of waste to be incinerated, estimated as 2,281 tonnes. This total tonnage of waste to be incinerated was applied to emission factors from AP-42 Vol 1 Chapter 2.1 ‘Refuse Combustion’. It is assumed that the incinerator will be of the mass burn type, with uncontrolled emissions – ie no emissions abatement technology incorporated, although it should be noted that the incinerator will be fitted with emissions control technology and will comply with the project emission standards as discussed in Section 10.3. However, insufficient detail is available at this stage to calculate emissions from this information and hence worst case assumptions are employed.

Table 7 below details the emission factors and the predicted mass emissions over the entire construction period. Note that no emission factor is published for hydrocarbons, VOC or methane.

Table 7 Emission factors and total mass emissions from construction phase waste incineration

Pollutant	Emission factor (kg/tonne of waste combusted)	Total mass emission (tonne)
PM	12.6	29
SO_2	1.73	4
NOx	1.83	4
CO	0.232	1
CO_2	985	2,247

1.2.2 Power generation

The requirement for power at the construction camps and pipe storage yard is estimated based on the mobilisation/demobilisation report of the engineering design contractor. Included in this are 2 x 480 kWe and 6 x 775 kWe Camp Generators. These, operating together, produce 5.61 MWe of power. It is anticipated that the 775 kW generators will be used at the accommodation camps – either 3 sets at each of 2 camps or 2 at each of 3 camps. The 480 kW generators are to be used at the double-jointed pipe storage yard (double jointing will take place at only one location in Azerbaijan at a time).

Emission factors from AP-42 Volume 1 Chapter 3.3 ‘Gasoline and Diesel Industrial Engines’ were used to estimate emissions. The generators are assumed to run on diesel fuel and operate continuously for the entire 15 month construction period (ie 10,944 hours). The calculation to determine the total mass emission of each pollutant is as follows:

Mass emission = emission factor x total power output of generators x hours of operation of each generator
= EF x 5,610 x 10,944

Table 8 below details the emission factors and the resulting mass emissions.

Table 8 Emission factors and total mass emissions from power generation at the construction camps and pipe storage yards

Pollutant	Emission factor (kg/kW-hr)	Total emission (tonnes)
NOx	0.019	1,158
CO	0.004	249
SO_2	0.001	77
PM_{10}	0.001	82
CO_2	0.699	42,952
HC	0.002	94

1.3 SUMMARY OF CONSTRUCTION EMISSIONS

Table 9 below summarises the emissions from the construction phase. Hydrocarbon emissions from non-road vehicles and equipment are split into methane/non-methane according to the ratio of total methane: total NMVOC emissions from road-going vehicles. Hydrocarbon emissions from power generators >50 hp are split according to the ratio of methane:non-methane emission factors from the UKOOA Guidelines for the Compilation of an Atmospheric Emissions Inventory (UKOOA 1999, hereafter referred to as the ‘UKOOA emission factors’) as below:

Emissions from diesel combustion in engines (tonnes/tonne of fuel burnt):
Methane: 0.00018
Non-methane VOCs: 0.002

Table 9 Summary of estimated atmospheric emissions arising from construction phase

Source	Total emission over 15 month construction phase (tonne)						
	NMVOC	CO	NOx	PM_{10}	SO_2	CO_2	CH_4
Pipeline construction activities	249	960	2,096	197	170	150,279	15
Waste incineration	No data	1	4	29	4	2,247	No data

Table 9 Summary of estimated atmospheric emissions arising from construction phase

Source	Total emission over 15 month construction phase (tonne)						
	NMVOC	CO	NOx	PM_{10}	SO_2	CO_2	CH_4
Power generation (camps and pipe storage yards)	86	249	1,158	82	77	42,952	8
TOTAL	336	1,210	3,258	308	251	195,478	**23**

1.4 OPERATIONAL EMISSIONS – PUMP DRIVER TURBINES

Four Solar Mars 100 dual fuel turbines will drive the pumps at pump station A2 (PS A2). They will be fired on liquid (diesel) fuel until SCP gas becomes available. Under normal operating conditions three will be in operation at a time; the fourth being a standby unit.

Emissions were calculated using vendor data, principally.

1.4.1 Liquid Fuel

The following data were provided by Solar test runs, 12 Dec 2001 (source, vendor and engineering design contractors).

- Exhaust gas volumetric flow rate = 283,657 m^3/hr = 78.79 m^3/s
- Exhaust gas temperature = 511°C = 784 K
- Stack gas moisture content = 8.28% v/v
- Stack gas oxygen content = 14.37% v/v
- Stack gas CO_2 content = 3.57% (wet basis)

Pollutant concentrations at reference conditions were taken from Addendum 12 of the Engineering Design Contractors 'Main Oil Pumps Equipment Selection Study'. Reference conditions are 0°C, 101.3 kPa, 15% O_2, dry.

- NOx 165 mg/Nm^3
- CO 64 mg/Nm^3
- PM 18 mg/Nm^3
- SO_2 550 mg/Nm^3. This is based on a sulphur content of the fuel of 1%. The fuel produced by the crude topping plant will have a sulphur content of less than 0.1%; hence the SO_2 concentration was reduced accordingly to 55 mg/Nm^3

The VOC concentration of 25 ppm (it was assumed this is reported on a dry basis) in the stack gas was obtained from personal correspondence between the vendor and the engineering design contractors. VOCs are assumed to have an average molecular weight of 75. Hence the 25 ppm is converted to mg/Nm^3 by 25 x 75/22.414 = 84 mg/Nm^3.

The concentrations at reference conditions were then converted to concentrations at discharge conditions by correcting for temperature, water and oxygen as follows:

$$C_d = C_r \times T_r/T_d \times (100 - W_d)/(100 - W_r) \times (21 - O_d)/(21 - O_r)$$

Where:
C = pollutant concentration (mg/m^3 or mg/Nm^3)
T = temperature (K)

W = moisture content (%)
O = oxygen content (%)
Suffix d = parameter at discharge conditions
Suffix r = parameter at reference conditions.

Performing this calculation for each pollutant yields the following concentrations at discharge conditions:

Table 10 Pollutant concentrations at discharge conditions – turbines on liquid fuel

Concentrations at discharge conditions (mg/m^3)					
NOx	**CO**	**SO_2**	**PM**	**CO_2**	**VOC**
58.3	22.6	39.0	6.4	27,009[(1)]	29.6

(1) The calculation for CO_2 excludes the water correction term as the concentration was reported on a wet basis.

These are then multiplied by the exhaust gas volumetric flow rate (m^3/s) and divided by 1,000 to obtain a mass flow rate (g/s). The three turbines are assumed to operate continuously. Using this assumption the g/s discharge rate was converted to tonnes per year.

Table 11 Pollutant discharge rates – turbines on liquid fuel

	Nox	**CO**	**SO_2**	**PM**	**CO_2**	**VOC**
g/s	4.6	1.8	3.1	0.5	2,128	2.3
te/yr/turbine	145	56	97	16	67,113	73
te/yr total	**435**	**169**	**291**	**47**	**201,339**	**220**

Methane was estimated by means of applying a factor to the VOC emission total according to the ratio of the UKOOA emission factors as follows:

Emissions from diesel combustion in turbines (tonnes/tonne of fuel burnt):
Methane: 0.0000328
Non-methane VOCs: 0.000295

Hence methane emission (tonnes/year total) = 220 x 0.0000328 / 0.000295 = 25.

1.4.2 Gaseous fuel

The method and data sources used were the same as for liquid fuel. The data used was as follows:

- Exhaust gas volumetric flow rate = 299,964 m^3/hr = 83.32 m^3/s
- Exhaust gas temperature = 512°C = 785 K
- Stack gas moisture content = 10.21% v/v
- Stack gas oxygen content = 14.01% v/v
- Stack gas CO_2 content = 2.76% (wet basis).

Pollutant concentrations at reference conditions:

- NOx 125 mg/Nm^3
- CO 64 mg/Nm^3
- PM 5 mg/Nm^3
- SO_2 0 mg/Nm^3

- VOC 8 mg/Nm^3 (calculated as for liquid fuel from 2.5 ppmvd).

Table 12 Pollutant concentrations at discharge conditions – turbines on gas

Concentrations at discharge conditions (mg/m^3)					
NOx	**CO**	**SO_2**	**PM**	**CO_2**	**VOC**
45.6	23.3	0	1.8	22,004$^{(1)}$	3.1

$^{(1)}$The calculation for CO_2 excludes the water correction term as the concentration was reported on a wet basis.

Table 13 Pollutant discharge rates – turbines on gas

	NOx	CO	SO_2	PM	CO_2	VOC
g/s	3.8	1.9	0	0.2	1,833	0.3
te/yr/turbine	120	61	0	5	57,820	8
te/yr total	**359**	**184**	**0**	**14**	**173,459**	**24**

No vendor data was available for methane emissions, therefore they were estimated by means of applying a factor to the VOC emission total according to the ratio of the UKOOA emission factors as follows:

Emissions from gas combustion in turbines (tonnes/tonne of fuel burnt):
Methane: 0.00092
Non-methane VOCs: 0.000036

Hence methane emission (tonnes/year total) = 24 x 0.00092 / 0.000036 = 615.

1.5 OPERATIONAL EMISSIONS – PUMP STATION GENERATOR ENGINES

Power requirements at PS A2 will be met by 3 generators, each powered by a 1.2 MWe dual fuel engine. They will be fired on liquid (diesel) fuel until SCP gas becomes available. Under normal operating conditions two will be in operation at a time; the third being a standby unit.

Emissions were calculated using vendor data, principally, with emission factors used where data on certain pollutants was not available. The basic method of calculation was the same as for the pump driver turbines.

1.5.1 Liquid fuel

The following data were taken from Wartsila Document ID WDAAA192848 (attached to Synchronous Generator Data Sheet 24630-000-MGD-0000-00001 Rev 0):

- Exhaust gas volumetric flow rate = 10.2 m^3/s
- Exhaust gas temperature = 340°C = 613 K
- Stack gas moisture content = 10.2% v/v
- Stack gas oxygen content = 11.5% v/v

Pollutant concentrations at reference conditions (0°C, 101.3 kPa, 15% O_2, dry):

- NOx 2000 mg/Nm^3

- SO2 110 mg/Nm^3
- PM 50 mg/Nm^3
- HC 150 mg/Nm^3 (wet basis)

Table 14 Pollutant concentrations at discharge conditions – PS A2 engines on liquid fuel

Concentrations at discharge conditions (mg/m^3)			
NOx	**SO_2**	**PM**	**HC**
1274.3	70.1	31.9	106.4[1]

[1] The calculation for HC excludes the water correction term as the concentration was reported on a wet basis.

Table 15 Pollutant discharge rates – PS A2 engines on liquid fuel

	NOx	SO_2	PM	HC
g/s	13.0	0.71	0.32	1.09
te/yr/engine	410	23	10	34
te/yr total	**820**	**45**	**20**	**68**

No vendor data was available for carbon monoxide and carbon dioxide emissions, therefore they were estimated based on the power output (1.2 MWe) of the engines and their operating hours (2 engines operating continuously) using emission factors from AP-42 Vol 1 Ch.3.4 Table 3.4-1, as follows:

Table 16 Pollutant discharge rates calculated from AP-42 emission factors – PS A2 engines on liquid fuel

	Emission factor (kg/kW-hr)	Discharge rate (te/yr, 2 engines)
Carbon monoxide	0.00334	70
Carbon dioxide	0.70528	14,828

The vendor data gave a stack concentration of total hydrocarbons. This was split into methane and non-methane VOCs using the ratio of UKOOA emission factors as follows:

Emissions from diesel combustion in engines (tonnes/tonne of fuel burnt):
Methane: 0.00018
Non-methane VOCs: 0.002

Hence methane emission (tonnes/year total) = 68 x 0.00018 / (0.00018+0.002) = 6
Non methane VOC emission (tonnes/year total) = 68 x 0.002 / (0.00018+0.002) = 63

1.5.2 Gaseous fuel

The method and data sources used were the same as for liquid fuel. The data used was as follows:

- Exhaust gas volumetric flow rate = 7.1 m^3/s
- Exhaust gas temperature = 405°C = 678 K
- Stack gas moisture content = 14.0% v/v
- Stack gas oxygen content = 10.1% v/v

Pollutant concentrations at reference conditions (0°C, 101.3 kPa, 15% O_2, dry):

- NOx 230 mg/Nm^3
- SO_2 25 mg/Nm^3
- PM 25 mg/Nm^3
- NMVOC 225 mg/Nm^3 (wet basis)

Table 17 Pollutant concentrations at discharge conditions – PS A2 engines on gas

Concentrations at discharge conditions (mg/m^3)			
NOx	**SO_2**	**PM**	**NMVOC**
145.8	15.8	15.8	165.8[(1)]

[(1)] The calculation for NMVOC excludes the water correction term as the concentration was reported on a wet basis.

Table 18 Pollutant discharge rates – PS A2 engines on gas

	NOx	SO_2	PM	NMVOC
g/s	1.04	0.11	0.11	1.2
te/yr/engine	33	4	4	37
te/yr total	**65**	**7**	**7**	**74**

No vendor data was available for carbon monoxide and carbon dioxide emissions, therefore they were estimated based on the power output (1.2 MWe) of the engines and their operating hours (2 engines operating continuously) using emission factors from AP-42 Vol 1 Ch.3.4 Table 3.4-1, as follows:

Table 19 Pollutant discharge rates calculated from AP-42 emission factors – PS A2 engines on gas

	Emission factor (kg/kW-hr)[(1)]	Discharge rate (te/yr, 2 engines)
Carbon monoxide	0.00456	96
Carbon dioxide	0.46938	9,868

[(1)] These emission factors are based on dual fuel use: 95% gas, 5% liquid

Methane was estimated by means of applying a factor to the NMVOC emission total according to the ratio of the UKOOA emission factors as follows:

Emissions from gas combustion in engines (tonnes/tonne of fuel burnt):
Methane: 0.0198
Non-methane VOCs: 0.0032

Hence methane emission (tonnes/year total) = 74 x 0.0198 / 0.0032 = 460.

1.6 OPERATIONAL EMISSIONS – FIREWATER PUMPS AND INTERMEDIATE PIGGING STATIONS

At the pump station there will be two firewater pumps, each powered by a 200 kWe diesel engine. At the two standalone intermediate pigging stations, two 180 kWe diesel engines will be used for power generation at each station. No vendor data was available for these units and their emissions were calculated based on their power output and operating hours using emission factors from AP-42 Vol 1 Chapter 3.3 Table 3.3-1. The power generation engines are assumed to operate continuously. The firewater pump engines are assumed to operate for 1 hour per week (52 hours per year) for testing purposes.

Table 20 Pollutant emissions for power generation at intermediate pigging stations and firewater pumps at pump station

Pollutant	Emission factor (kg/kW-hr)	Emission rate (te/yr, all units)	
		Power generators	Firewater pumps
NOx	0.0188	119	0.4
CO	0.0041	26	0.1
SO2	0.0012	8	0.0
PM	0.0013	8	0.0
CO2	0.6992	4410	14.5
HC	0.0015	10	0.0

As the emission factor in AP-42 is for total hydrocarbons, this emission was split into methane and non-methane VOCs in the same way as the generator engines at PS A2:

Power generators:
Emissions from diesel combustion in engines (tonnes/tonne of fuel burnt):
Methane: 0.00018
Non-methane VOCs: 0.002

Hence methane emission (tonnes/year total) = 10 x 0.00018 / (0.00018+0.002) = 1
Non methane VOC emission (tonnes/year total) = 10 x 0.002 / (0.00018+0.002) = 9

Firewater Pumps:
Hydrocarbon emission below rounding limit.

1.7 SUMMARY OF OPERATIONAL EMISSIONS

Table 21 below summarises the annual emissions from the operational phase.

Table 21 Summary of estimated atmospheric emissions arising from operation phase

	Annual emission (tonnes)						
	NOx	SO_2	CO	VOC	PM	CO_2	CH_4
Pump driver turbines - liquid	435	145	169	220	47	201339	25
Pump driver turbines - gas	359	0	184	24	14	173459	614.5
PS A2 engines - liquid	820	45	70	63	20	14828	6
PS A2 engines - gas	65	7	96	74	7	9868	460
IPS generator engines	119	8	26	9	8	4410	1
PS A2 firewater pumps	0.4	0.0	0.1	0.0	0.0	14.5	0.0
Total - dual fuel units on gas	544	15	306	107	30	187,752	1,075
Total - dual fuel units on liq	1,374	198	265	292	76	220,591	31
Total worst case(1)	1,374	198	306	304	76	220,591	1,075

(1) It is highly unlikely that the dual fuel units would be operating on different fuels but this represents the worst case of all possible combinations

PUMP STATION ATMOSPHERIC DISPERSION MODELLING STUDY

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1 PUMP STATION ATMOSPHERIC DISPERSION MODELLING STUDY

1.1 MODELLING APPROACH AND METHOD

Atmospheric dispersion modelling has been used to predict the potential air quality impact of emissions at the pump station PS A2. The approach and the input data used are described in this section.

Modelling has been undertaken using ADMS 3.1, a model developed by Cambridge Environmental Research Consultants (CERC). ADMS 3.1 is a model of dispersion in the atmosphere of passive, buoyant or slightly dense, continuous or finite duration releases from single or multiple sources. ADMS has had extensive use for similar studies.

Long-term and short-term pollutant concentrations have been calculated for comparison with WHO air quality guidelines and EU standards as per Table 1 below. All other pollutants that have local air quality impacts are predicted to be released in relatively small quantities and thus resulting ground level concentrations will be very low and therefore have not been modelled.

Table 1 Output parameters and associated standards/guidelines

Pollutant	Averaging Period	Percentile	Relevant Standards/Guidelines	Limit/guideline value ($\mu g/m^3$)
Nitrogen dioxide NO_2	1 year	N/A	WHO guideline EU standard for protection of human health EU standard for protection of vegetation	40 40 30
	1 hour	100th	WHO guideline	200
	1 hour	99.79th	EU standard for the protection of human health	200
Sulphur dioxide SO_2	1 year	N/A	EU standard for the protection of ecosystems WHO guideline	20 50
	24 hours	100th	WHO guideline	125
	24 hours	99.18th	EU standard for the protection of human health	125
	1 hour	99.73rd	EU standard for the protection of human health	350
Carbon monoxide CO	8 hour running	100th	EU standard	10,000
	8 hour	100th	WHO guideline	10,000
	1 hour	100th	WHO guideline	30,000
Particulate matter PM	1 year	N/A	EU standard (Stage 2) for the protection of human health(1)	20
	24 hours	98.08th	EU standard (Stage 2) for the protection of human health(1)	50

(1)These standards apply to PM_{10} (particulate matter less than 10μm in diameter). As this is a subset of (total) PM, the model will yield conservative results when comparing with these limit values. Only data on total PM was available.

1.1.1 Definitions

- Annual average: average concentration experienced throughout a calendar year
- 1 hour average (99.79th percentile): 1 hour average concentration that is not exceeded for 99.79% of the year (ie may be exceeded for 18 hours of the year)
- 1 hour average (100th percentile): the maximum concentration averaged over 1 hour
- 8 hour running average (100th percentile): the maximum concentration averaged over all possible (ie overlapping) 8 hour periods
- Similarly for other percentiles and averaging periods

The scenarios modelled include emissions from three pump driver turbines, operating at full load. This will be the standard mode of operation when the pumps at PS A2 are brought online and represents worst-case emissions.

1.1.2 Model input data

Input data to ADMS 3.1 (described in detail in the subsequent sections) include:

- Pollutant emission rates
- Stack characteristics
- Dimensions and location of buildings that may affect dispersion
- Coordinates / site layout
- Meteorological data

1.1.3 Emission rates

Pollutant emission rates were calculated from turbine vendor data. Emission rates were calculated for both liquid (diesel/distillate) and natural gas fuels. The higher emission rate of the two fuel types for each pollutant was input to provide a worst-case scenario. The carbon monoxide emission rate was found to be higher on gas; the other rates result from liquid fuel use. Differences in emissions from the two fuel types are discussed in Section 10.3.

Table 2 Worst case emission rates

Source	Emission rate (g/s)			
	NO_2	SO_2	CO	PM
Pump Driver Turbines (each)	2.30(1)	1.54(2)	1.94	0.50

(1)Assumes 50% of NOx is NO_2 (see Section 1.3, NOx Chemistry)
(2)Based on 0.1 wt% sulphur content of fuel

1.1.4 Stack parameters

Stack heights were calculated from a series of test runs to investigate the effect of increasing the stack height on dispersion. The stacks are square in cross-section. An effective diameter was calculated from dimensions provided by the engineering design team. Other parameters were derived from data provided by the turbine vendor.

The stack parameters could be subject to review by the design engineers, in which case further modelling will be undertaken to ensure pollutant dispersion remains sufficient.

Table 3 Stack parameters of emission sources

Source	Height Above Grade (m)	Effective Diameter (m)	Volumetric Flow Rate (m^3/s)	Exhaust Gas Exit Temp (°C)
Pump driver turbines on liquid fuel (each)	25	2.17	78.8	511

1.1.5 Site layout / coordinates

Table 4 below presents the grid coordinates for each source of combustion gas emissions. Each of the turbines are located approximately 2.2km from the settlement of Yaldily.

Table 4 Grid coordinates of emission sources

Emission Source	Easting	Northing
Turbine 1	8667159	4499246
Turbine 2	8667156	4499260
Turbine 3	8667153	4499273

1.1.6 Surface roughness

A surface roughness length is used in the model to characterise the surrounding area in terms of the effect it will have on wind speed and turbulence. A value of 0.2 m has been used in this study, representative of agricultural land.

1.1.7 Meteorological data

Three one year sets of hourly sequential meteorological data were obtained. The nearest station that measures the required parameters is located at Ganja. Data from 1999 were obtained from the UK Met Office for this station. The number of recorded data points is low at approximately 36%, indicating that the station was inoperative for much of the time. The next nearest station for which data could be obtained is at Tbilisi, Georgia. More than 90% of data was recorded at this station. Datasets from 1998 and 1999 were used. Windroses derived from all three datasets are presented below.

Figure 1 Wind rose – Tbilisi 1998

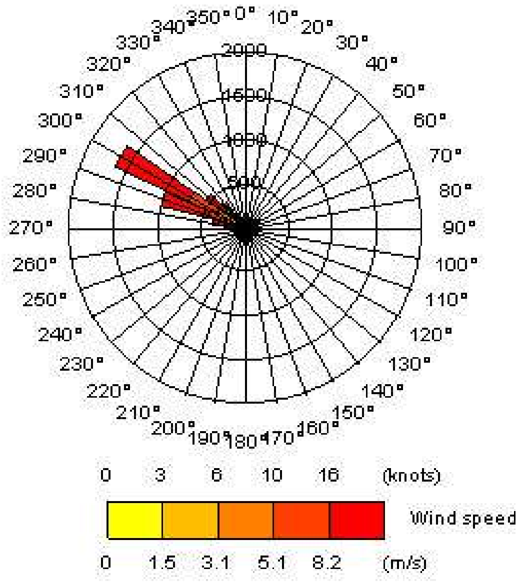


Figure 2 Wind rose – Tbilisi 1999

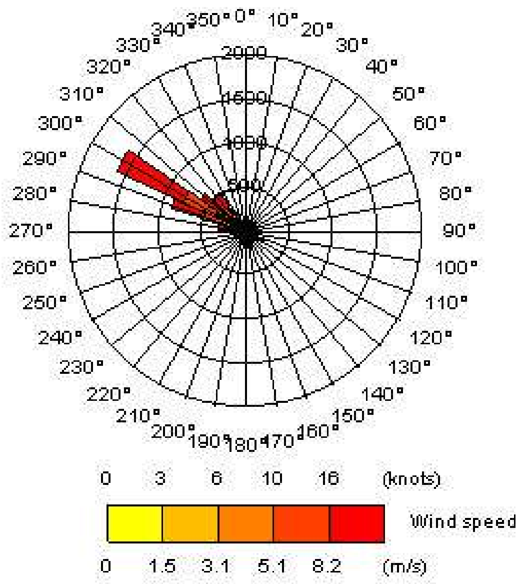
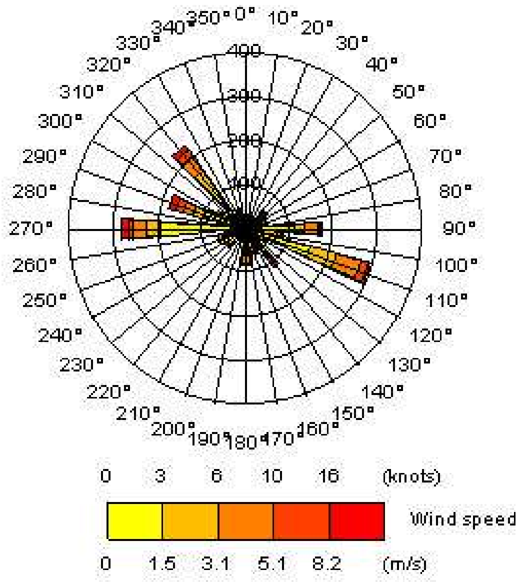


Figure 3 Wind rose – Ganja 1999



1.1.8 Buildings

ADMS is capable of calculating the effect of buildings on dispersion. It takes all building data input and creates one 'idealised' building. For this reason, only the pump shelter was input as it will have the greatest effect on dispersion. Dimensions are derived from the engineering design contractor's drawings. The parameters input were as follows:

- Height to centre ridge: 11 m
- Length: 74 m; Width 26 m
- Grid coordinates of building centre: (8667158, 4499271)
- Angle building length makes with north, measured clockwise: 168°

1.1.9 Topographical data

CERC, the developers of ADMS, recommend that it is only necessary to include the effects of surrounding terrain in a modelling calculation if the gradient exceeds 1:10. This does not apply to PS A2, therefore terrain data were not input.

1.1.10 Output grid

Concentrations were calculated on a 4 x 4 km grid, centred on the pump shelter, with 80 calculation points in each axis, therefore the distance between output points was 50 m along the west-east and north-south axes.

1.2 BACKGROUND AIR QUALITY DATA

Background air quality is discussed in Section 8.2. An extract from the summary table is reproduced here for convenience.

Table 5 Baseline air quality at the proposed site of pump station A2

Substance	Average concentration (μg/m^3)
Oxides of nitrogen (total NOx as NO_2)	6.5
Nitrogen dioxide	2.6
Sulphur dioxide	3.4

1.3 NOx CHEMISTRY

NOx emissions arising from combustion processes consist largely of nitrogen monoxide (NO). On release to the atmosphere, NO is partially and gradually oxidised to NO_2, which is of greater concern in terms of air quality. The chemistry of NO_2 formation is complex and depends on a number of factors including the presence of oxidants such as ozone.

Extensive studies have been undertaken (Janssen *et al*) to determine the percent oxidation of NO to NO_2 in power station plumes. Empirical relationships have been developed that relate the oxidation process to:

- Downwind distance of the plume
- Ozone concentration
- Wind speed
- Season of the year

The modelling exercise was undertaken assuming that immediate, 50% oxidation of NO to NO_2 takes place. This is a conservative assumption, thus maximum ground level NO_2 concentrations arising from the compressor station are likely to be less than the values predicted by ADMS.

1.4 MODEL RESULTS: PREDICTED GROUND LEVEL POLLUTANT CONCENTRATIONS

The tables below present the maximum ground level concentrations (glc) resulting from all three met datasets.

Table 6 Maximum ground level concentrations – met data: Tbilisi 1998

Pollutant	Averaging period	Percentile	Maximum glc (μg/m^3)	Distance from source (m)	Bearing
Nitrogen dioxide NO_2	1 year	N/A	12	159	116
	1 hour	100th	135	159	116

Table 6 Maximum ground level concentrations – met data: Tbilisi 1998

Pollutant	Averaging period	Percentile	Maximum glc (μg/m^3)	Distance from source (m)	Bearing
	1 hour	99.79th	111	159	116
Sulphur dioxide SO_2	1 year	N/A	8	159	116
	24 hours	100th	47	82	149
	24 hours	99.18th	43	159	116
	1 hour	99.73rd	72	159	116
Carbon monoxide CO	8 hr running	100th	75	82	149
	1 hour	100th	114	159	116
Particulate matter PM	1 year	N/A	3	159	116
	24 hours	98.08th	12	159	116

Table 7 Maximum ground level concentrations – met data: Tbilisi 1999

Pollutant	Averaging period	Percentile	Maximum glc (μg/m^3)	Distance from source (m)	Bearing
Nitrogen dioxide NO_2	1 year	N/A	9	159	116
	1 hour	100th	123	82	149
	1 hour	99.79th	104	159	116
Sulphur dioxide SO_2	1 year	N/A	6	159	116
	24 hours	100th	43	159	116
	24 hours	99.18th	34	159	116
	1 hour	99.73rd	69	159	116
Carbon monoxide CO	8 hr running	100th	69	82	149
	1 hour	100th	104	82	149
Particulate matter PM	1 year	N/A	2	159	116
	24 hours	98.08th	11	159	116

Table 8 Maximum ground level concentrations – met data: Ganja 1999

Pollutant	Averaging period	Percentile	Maximum glc (μg/m^3)	Distance from source (m)	Bearing
Nitrogen dioxide NO_2	1 year	N/A	1	252	106
	1 hour	100th	113	159	116
	1 hour	99.79th	76	159	116
Sulphur dioxide SO_2	1 year	N/A	1	252	106
	24 hours	100th	17	159	116
	24 hours	99.18th	4	252	106
	1 hour	99.73rd	49	159	116
Carbon monoxide CO	8 hr running	100th	76	222	140
	1 hour	100th	95	159	116
Particulate matter PM	1 year	N/A	0.2	252	106
	24 hours	98.08th	0.5	448	99

Table 9 below compares the maximum predicted results to the appropriate limits and guidelines:

Table 9 Comparison of modelling results with limit and guideline values

Pollutant	Averaging period	Percentile	Max glc ($\mu g/m^3$)(1)	Background ($\mu g/m^3$)(2)	Total glc ($\mu g/m^3$)	Limit ($\mu g/m^3$)(3)
NO_2	1 year	N/A	12	2.6	15	40 / 30
	1 hour	100th	135	-	135	200
	1 hour	99.79th	111	-	111	200
SO_2	1 year	N/A	8	3.4	11	50 / 20
	24 hours	100th	47	-	47	125
	24 hours	99.18th	43	-	43	125
	1 hour	99.73rd	72	-	72	350
CO	8 hr running	100th	76	-	76	10,000
	1 hour	100th	114	-	114	30,000
PM	1 year	N/A	3	-	3	20
	24 hours	98.08th	12	-	12	50

(1) Maximum across all three met data sets
(2) Note that background concentrations were not measured over a full year and thus are not directly comparable to the long term modelling results but can be used as a guide.
(3) Refer to Table 1

The Figures in Section 1.6 present contour plots of selected model results – the highest results over the three met datasets for each different averaging period of NO_2 and SO_2.

1.5 DISCUSSION AND CONCLUSIONS

The model results predict that none of the EU/WHO standards and guidelines, set to protect human health and vegetation/ecosystems will be exceeded. The maximum long-term glc, including background, is NO_2 at 15μg/m^3 – 50% of the limit protecting vegetation and ecosystems, 38% of the limit protecting human health. The maximum short term predicted glc is 135μg/m^3 (NO_2, 100th percentile), which is 68% of the WHO guideline. Background concentrations have not been added, as short term baseline monitoring has not been undertaken. It should also be noted that the modelling scenario did not include the generator engines or the crude topping plant due to insufficient design data being available at this stage.

Modelling with met data from Tbilisi gave significantly higher results than those that arose from using the Ganja 1999 dataset, particularly for annual averages. This is probably due to the greater annual variation in wind direction at Ganja and the higher average wind speeds at Tbilisi. High winds speeds are good for dispersion of ground level sources but can reduce the plume height of elevated sources. In strong winds, close to the source the increased effect of dilution can be outweighed by the lower plume height and thus increased glcs.

1.6 CONTOUR PLOTS OF MODELLING RESULTS

Figure 4 NO_2 annual average concentrations (µg/m^3) – Met Data: Tbilisi 1998

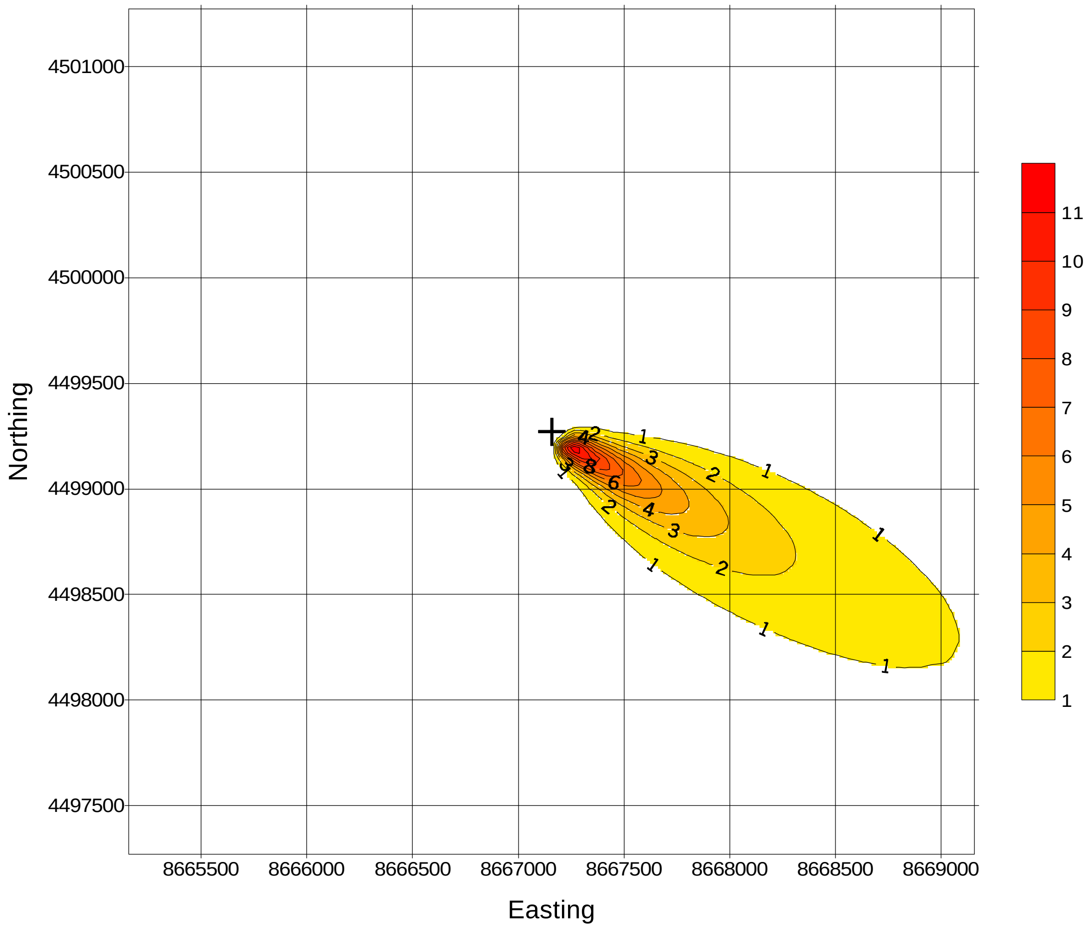


Figure 5 NO_2 1 hour average (100th percentile) concentrations (mg/m^3) – Met Data: Tbilisi 1998

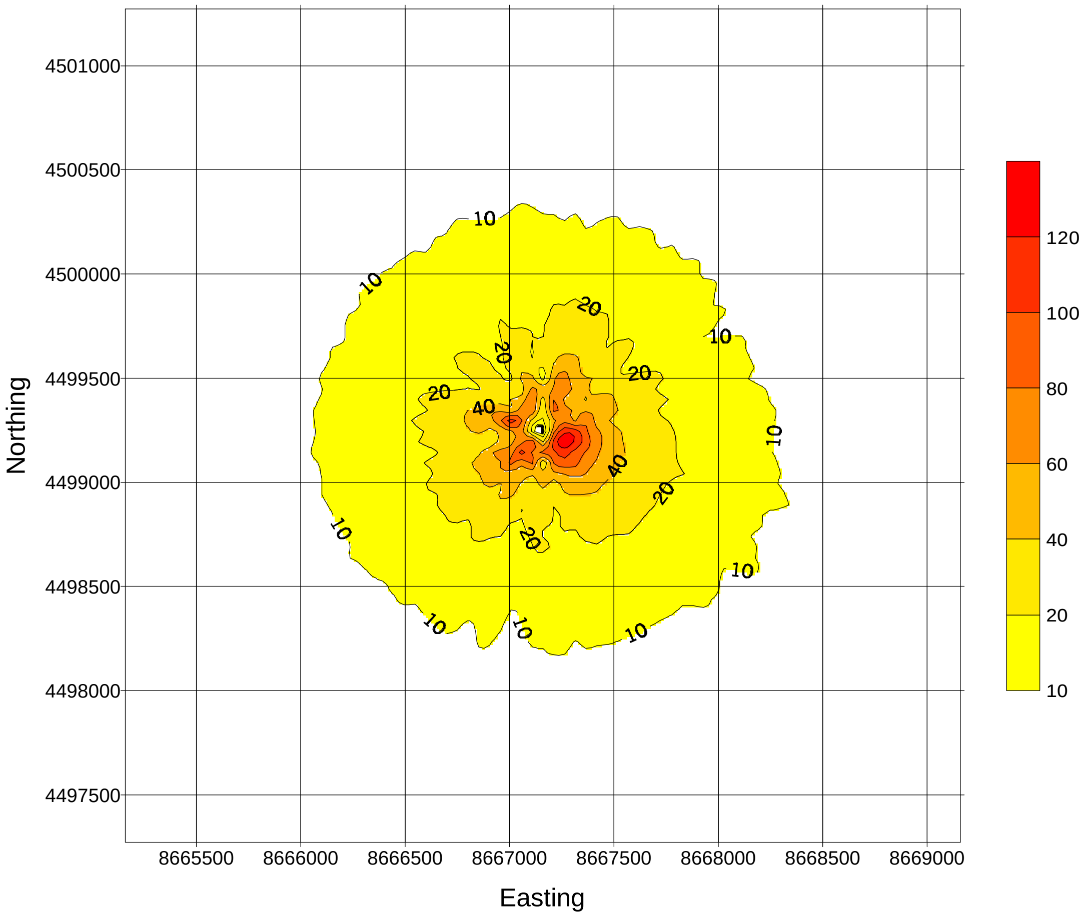


Figure 6 NO_2 1 hour average (99.79th percentile) concentrations (mg/m^3) – Met Data: Tbilisi 1998

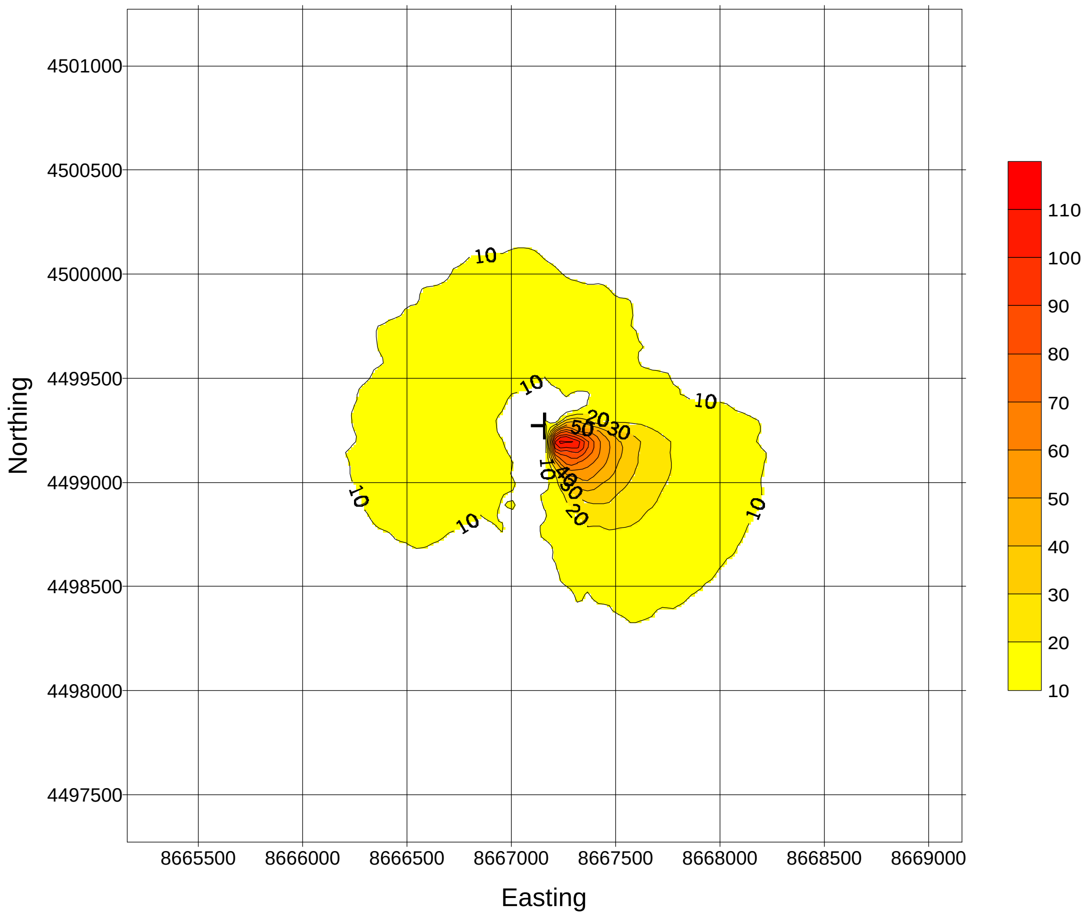


Figure 7 SO_2 annual average concentrations (mg/m^3) – Met Data: Tbilisi 1998

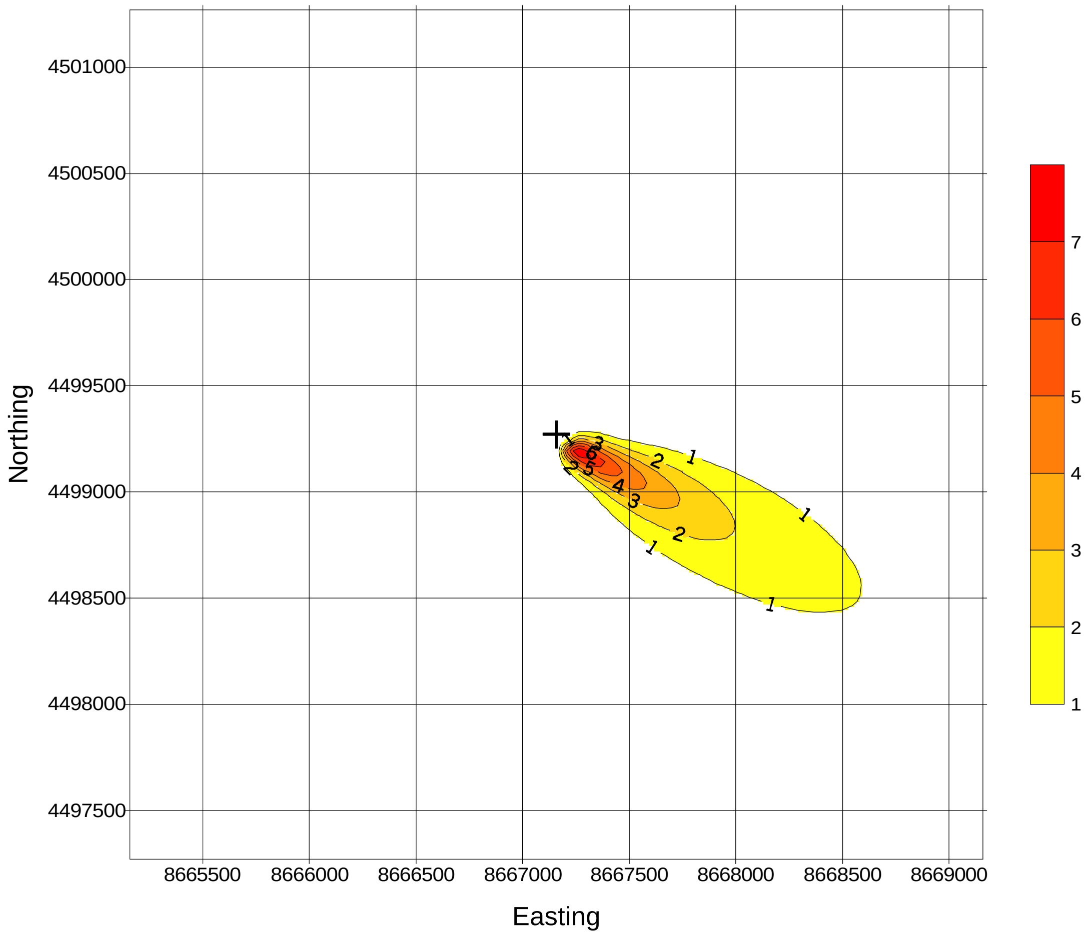


Figure 8 SO_2 24 hour average (100th percentile) concentrations (mg/m^3) – Met Data: Tbilisi 1998

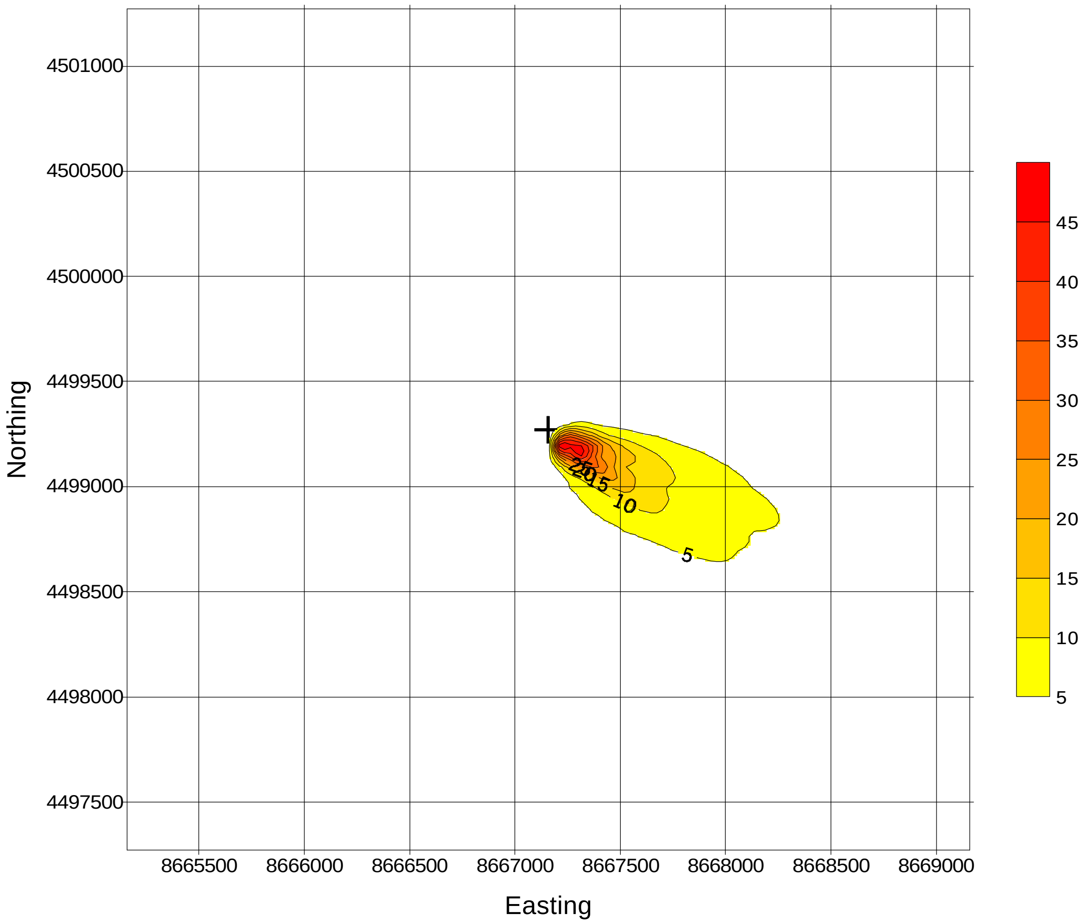
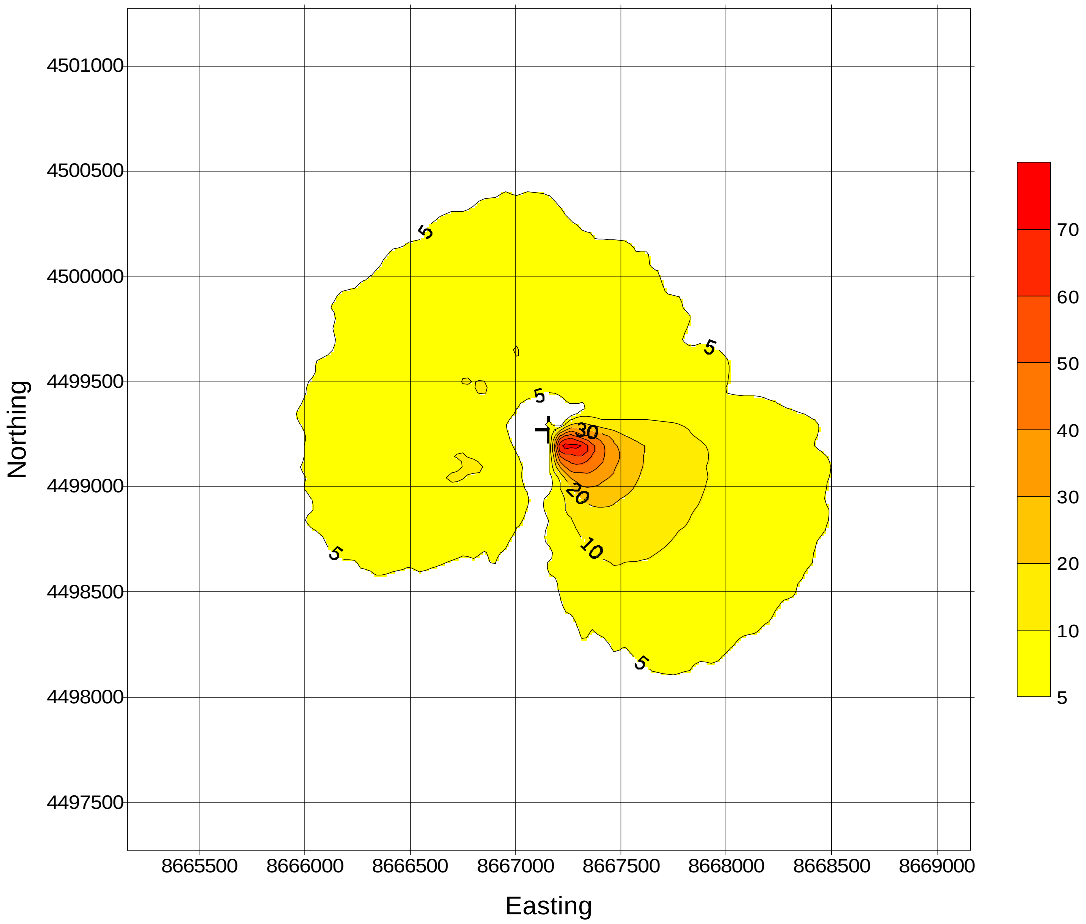


Figure 9 SO_2 1 hour average (99.73rd Percentile) concentrations (mg/m^3) – Met Data: Tbilisi 1998



SUMMARY OF REINSTATEMENT PLAN

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TABLES

1 INTRODUCTION

Reinstatement of land disturbed by pipeline construction activities (eg ROW, construction camps, pipe yards, etc.) to a condition similar to its original pre-construction character is a specific project objective designed to meet BP's goal of 'no harm to the environment'. This objective has associated benefits that include:

- Minimised risk to pipeline integrity because the erosion risk is reduced
- Maintenance of natural landscapes and consequently their value as a tourism resource
- Preservation of soil fertility in both natural and agricultural environments
- Protection of water catchments and water quality
- Sustained bio-diversity
- Reduced risk of desertification

This plan summarises the specific requirements that have been developed for reinstatement of areas disturbed by the project, and takes into account the anticipated subsequent development of the SCP project. Issues addressed include topographic reinstatement, erosion control and bio-restoration, as well as requirements for the extraction, re-use and, if necessary, disposal of material excavated from the pipeline trench.

The reinstatement specification is based on the following principals:

- Use of erosion classes as targets for reinstatement
- Identification of bio-restoration targets
- Definition of final reinstatement conditions
- Protecting topsoil resources by ensuring separation and storage in a manner that maximises the ongoing integrity of soil structure, seedbank resources and vegetative material and minimises the risk of topsoil loss
- Achieving key bio-restoration objectives, including:
  (a) restoration of the pre-existing ecology (ie that existing prior to construction), so far as is practicable, particularly in terms of the variety and distribution pattern of indigenous plant species
  (b) establishment of sufficient vegetation cover to reduce erosion and achieve the performance target of Erosion Class 3 (see Section 3) or better through restoration of the local plant communities, where practicable
- Use of indigenous flora for long-term cover. The bio-restoration strategy is based on supplementing the topsoil seedbank and vegetative material resource within the reinstated topsoil
- Disposing of excess spoil in a environmentally acceptable manner
- Minimising adverse impacts on sensitive habitats outside of the ROW from construction activities, in particular when forming cuts on side slopes

This summary plan describes the reinstatement of the ROW and all other temporary project areas which are used to support construction, including (but not limited to) construction camps, pipe dumps, maintenance areas, roads and other transport facilities, waste management and disposal sites.

2 DOCUMENTATION

The contractor will produce method statements, inspection plans and record portfolios for all erosion control and reinstatement works for approval by BTC Co. The documentation will comply with project specifications, pre-entry agreements and the requirements of the ESIA and relevant Authorities.

The contractor will prepare a photographic / video record of condition of the ROW before works commences and after final reinstatement is complete.

The contractor will prepare site-specific method statements and schedules for reinstatement of:

- Environmentally Sensitive Areas ie those areas with high ecological sensitivity, landscape value or erosion risk
- Watercourse crossings that have detailed crossing drawings associated with them, or occur in environmentally sensitive or special agricultural, sections
- Special agricultural areas that support more complex agricultural systems such as canals and irrigation systems.

The contractor's documentation will also detail temporary and permanent measures to stabilise and control erosion.

3 EROSION CLASSES

Erosion classes have been used as the basis for determining erosion targets for temporary and permanent reinstatement. Table 3-1 defines these erosion classes. The objective is to achieve erosion class 3 or better, wherever practicable. This represents moderate erosion, which is defined as the release of < 10tonnes of sediment per hectare during a one hour, 10 year return period, storm.

As a minimum the following standards will be achieved:

- No risk of reduction of the depth of cover above the pipeline
- Very low risk of release of eroded soil beyond the confines of the ROW (Note: sediment interception devices will be installed at locations where there is a risk of such sediment significantly impacting water bodies)
- Low risk of damage to bio-restoration schemes through washing-out of seeds and plants

An erosion risk assessment has been undertaken along the route. This assessment identified areas of potential erosion and assigned erosion control measures for each area of the route.

Table 3-1 Erosion classes

EROSION CLASS	VERBAL ASSESSMENT	EROSION RATE ($t\ ha^{-1}$)	VISUAL ASSESSMENT
1	Very slight	< 2	No evidence of compaction or crusting of the soil. No wash marks or scour features. No splash pedestals or exposed roots or channels.
2	Slight	2-5	Some crusting of soil surface. Localised wash but no or minor scouring. Rills (channels <1m^2 in cross-sectional area and < 30cm deep) every 50-100m. Small splash pedestals where stones or exposed roots protect underlying soil.
3	Moderate	5-10	Wash marks. Discontinuous rills spaced every 20-50m. Splash pedestals and exposed roots mark level of former surface. Slight risk of pollution problems downstream.
4	High	10-50	Connected and continuous network of rills every 5-10m or gullies (> 1m^2 in cross-sectional area and > 30cm deep) spaced every 50-100m. Washing out of seeds and young plants. Reseeding may be required. Danger of pollution and sedimentation problems downstream.
5	Severe	50-100	Continuous network of rills every 2-5m or gullies every 20m. Access to site becomes difficult. Revegetation work impaired and remedial measures required. Damage to roads by erosion and sedimentation. Siltation of water bodies.
6	Very severe	100-500	Continuous network of channels with gullies every 5-10m. Surrounding soil heavily crusted. Integrity of the pipeline threatened by exposure. Severe siltation, pollution and eutrophication problems.
7	Catastrophic	> 500	Extensive network of rills and gullies; large gullies (> 10m^2 in cross-sectional area) every 20m. Most of original surface washed away exposing pipeline. Severe damage from erosion and sedimentation on-site and downstream.

4 SITE CLEAN-UP

On completion of construction activities the contractor will clean-up all areas affected by construction operations in preparation for the replacement of stockpiled materials (subsoil and rock from grading and benching, topsoil from topsoil stripping). Clean-up includes removal of all plant, equipment and materials not required for replacement of soil or for subsequent bio-restoration activities.

In agricultural and industrial areas the condition achieved following clean-up will be equivalent to, or better than, the condition prior to construction.

No waste materials, other than excess soil and rock, will be left, buried or disposed of on any project area. All waste will be disposed of at approved waste disposal sites that will be selected by the project and approved by the relevant authorities.

5 INTERIM REINSTATEMENT OF THE ROW

If construction and installation of the SCP follows directly after installation of the BTC pipeline, full reinstatement will generally only be carried out on those sections of the ROW that will not be disturbed by SCP construction activities. Interim reinstatement (primarily temporary erosion control) will be carried out over the remaining portion of the shared ROW to cover the period between installation of the two pipelines. However, full erosion control measures and reinstatement will be performed over the whole of the working width if there is a delay of more than 12 months between installation of the two pipelines. Full reinstatement will also be undertaken along specific sections of the ROW as follows:

- Where there is a potentially severe or very severe erosion risk (ie the land has an erosion classification of 4, 5, 6 or 7)
- In Environmentally Sensitive Areas
- Within 25m of watercourse crossings

In those areas where interim reinstatement is undertaken, final reinstatement of the ROW will be the responsibility of the SCP project.

Interim reinstatement measures will vary depending on the erodability of the area. Some of the specific tools used for interim reinstatement are described in Section 7.6.

The following briefly describes the activities for land in each of the erosion classes in Table 3-1. Throughout it is assumed that the BTC pipeline trench has been suitably backfilled with the stockpiled spoil resulting from trench excavation, and that, where appropriate stripped topsoil has been stored during construction for use during reinstatement. These requirements are discussed further in Section 7.

5.1 Land in erosion classes 1, 2 and 3

The erosion risk on land in these classes is low and interim control measures will be limited to those necessary to maintain class 3. Temporary erosion control measures will be implemented as required and maintained *in-situ* in a functional state until the SCP is installed.

5.2 Land in erosion classes 4, 5, 6 and 7

Reinstated topsoil will be covered with erosion matting and other temporary erosion control measures will be installed as required.

By the time the SCP is installed, the mat should have deteriorated sufficiently so as to not to present any hazard to subsequent construction operations. Any residue of the mat after the SCP is installed will be buried within the subsoil and below the topsoil and will decompose.

5.3 Watercourses

Interim reinstatement will generally not apply to watercourse crossings. After installation of the BTC pipeline, stabilisation work will begin within 48 hrs where practicable and the land for 25m either side of the watercourse will be restored as appropriate.

The contractor will minimise environmental impact by installing appropriate measures to minimise sediment entering the watercourse at each crossing.

6 REINSTATEMENT OF LAND OTHER THAN ROW

6.1 Land at construction support facilities

Temporary construction support facilities include construction camps and pipe dumps and together with other areas used, or affected by construction support activities. Such areas will be reinstated to a condition as good as, if not better than that existing prior to establishment of the facilities and will be reinstated to the satisfaction of the owner and/or relevant Authority. In environmentally sensitive areas, as far as practicable, the original conditions and character will be restored.

6.2 Waste disposal sites

The contractor will be required to ensure that all waste disposal sites are appropriately closed, capped and landscaped prior to demobilisation, unless otherwise agreed with BTC Co. and the relevant Authorities. With the exception of waste soil/rock sites, this will be in accordance with the relevant requirements of the European Community relating to the management and reinstatement of waste disposal facilities. Bio-restoration will be undertaken as necessary to ensure that the reinstated site is in keeping with the local surroundings.

Sites that are used only for the disposal of excess soil and rock will also be closed, capped and landscaped. Each site will be vegetated as necessary to meet the erosion control requirements and to ensure that the reinstated site is in keeping with the local environment.

6.3 Roads and access tracks

Existing roads will be reinstated to their original condition or better following completion of construction activities.

New and upgraded roads or tracks and other project areas in Environmentally Sensitive Areas will be removed and the land re-instated to its original condition, unless otherwise agreed following consultation with all interested parties.

7 REINSTATEMENT PROCEDURES

The following subsections discuss activities that will take place prior to and during reinstatement of the disturbed areas.

7.1 Topsoil stripping and storage

Topsoil, can be defined as the upper layer of material on the land surface, which is capable of supporting plant growth; it contains the seedbank and vegetative material resources. Maintenance of topsoil quality, structure and integrity is vital to both bio-restoration and erosion control.

The following principles will apply to removal and storage:

- In general, the width to be topsoil stripped will be the working width required for construction and installation of the BTC pipeline, but will exclude the area that will be used to store topsoil. The contractor may apply for relaxation of this requirement where the ground is solid rock (ie where there is no soil) taking into consideration the local conditions, pre-entry agreements and the need to satisfactorily reinstate the pipeline route
- Where topsoil stripping is necessary, the depth of the topsoil will be established and up to 300mm will be removed and stored. Topsoil below 300mm will only be stripped if this is specifically required. Topsoil will generally be stored on areas where the topsoil has not been removed
- storage locations will be sited so that they are not compacted by vehicles, or contaminated, or otherwise treated in a manner that will cause losses and/or degradation
- Stored topsoil will not be mixed with subsoil. In general topsoil will be stored on the opposite side of the ROW to subsoil. In cases where there is insufficient storage space, both topsoil and subsoil may be stored on the same side provided mixing is prevented by physical means eg geotextile sheeting
- Topsoil stacks will be structured to ensure that they are free draining and do not impound water. Where possible, topsoil stacks will not more than 2m high with side slopes of <45° and will be drained with open ditches and berms as necessary.
- Gaps will be left in the topsoil stack to permit reasonable access across the ROW
- The surface of the topsoil stacks may be compacted to restrict rainfall penetration, but not so much that anaerobic conditions will occur
- The stockpile will be treated where appropriate to prevent weed growth
- Under no circumstances will topsoil be used as padding material or for trench breakers
- Topsoil handling during inappropriate ground / weather conditions will be avoided for soils that are susceptible to damage (eg soils with a high clay content)

7.2 Subsoil removal and storage

During construction, subsoil will be excavated from the pipe trench and, at some locations, from the cutting of level working platforms ('benches') on the side of slopes. Subsoil will be managed so that it does not contribute directly or indirectly to excessive erosion or sedimentation. The following principles will be applied to the removal and storage of sub-soil:

- Subsoil will be stored separately from topsoil, and will not be mixed
- Stockpiles will be kept stable from collapse and will drain freely
- Drainage will be provided to manage appropriately the water and sediment loads emanating from the subsoil stacks (eg gaps will be left or flumes installed, etc)
- Subsoil will be returned to the area from which it was excavated, as far as practicable
- Subsoil which cannot be reused, ie returned to the trench or corridor ROW, will be placed in stockpiles pending disposal. The disposal of excess subsoil is discussed in the Section 7.4

7.3 Trench excavation and pipeline padding

The creation of excess excavated material will be minimised and excess material will be recovered and re-used to the greatest extent possible.

Fill materials will not be imported unless it can be demonstrated that such fill is required and that it cannot be won from the project areas (eg by crushing trench arisings). All importation of fill will be approved in advance by BTC Co.

Generally, all excavated materials will be returned to the excavated areas. Where materials are unsuitable for return to the trench (eg certain types of rock) they will be disposed of safely in accordance with environmental requirements.

7.4 Management of surplus spoil and rock

Priorities for managing excess spoil are as follows:

1st priority - ROW Reuse:
Where generated spoil is suitable for use as a construction material it will re-used on the ROW or temporary works areas.

2nd priority - ROW / Project-Area Disposal:
- Localised increase in finished surface height of ROW
- Increase in finished level of AGIs

All disposal/reuse in the project areas will be done without environmental impact to off-project areas.

3rd priority - Off ROW Reuse:
Transfer to a third party for re-use purposes as raw or semi-finished materials, eg crushed rock may be suitable for road construction materials or for rail ballast.

4th priority - Off ROW Disposal: (All sites to be agreed prior to use with BTC Co.)
Potential disposal sites will be identified and any necessary consents obtained. These sites will be planned, designed, developed, operated and re-instated as appropriate by the contractor. The contractor will be responsible for the technical and environmental assessment of such sites and for obtaining regulatory approval.

In principle, excess material disposal sites will not be:

- in Environmentally Sensitive Areas (except with prior project approval)
- in areas adjacent to special agricultural sections
- in watercourses or valley bottoms
- in windrows over the pipe
- on side slopes below benches or ridge cuttings where the side slope exceeds 45°
- where they will potentially interrupt concentrated overland flow
- in such a way as to cause unacceptable landscape (visual) impact
- on any open area where the slope exceeds 30°

Sites for the disposal of excess excavated material will, in general, comply with the requirements for 'inert' waste disposal sites. However, provided a number of conditions are met, a reduced specification for the design of the site may apply. Conditions include the requirements that:

- the site is stable and appropriately drained
- only natural materials are deposited and
- the transport vehicles do not transport other types of wastes

7.5 Reinstatement of soils

7.5.1 Reinstatement of subsoil

Two situations are considered: standard reinstatement and special reinstatement.

- **Standard reinstatement:** On return of the subsoil to the trench or ROW, the subsoil will be compacted to levels similar to the adjacent undisturbed area. The depth of subsoil after settlement will not be above that within the surrounding ground. After the subsoil has been returned and the land levelled, the subsoil will be ripped to a depth of 350-400mm, rendered to a loose and workable condition and contoured in keeping with the adjacent undisturbed ground.

- **Special Area reinstatement:** Special Area Reinstatement will be applied where it has been necessary to cut a bench into the hillside in order to lay the pipe and the intention is to restore the original contours. This will be achieved by filling-in the bench, thereby removing any visual impact on the landscape. Locations where this is required relate to defined Environmentally Sensitive Areas and special agricultural areas.

Upon completion of reinstatement of subsoil, disturbed areas will be inspected jointly by the contractor and BTC Co. for slope stability, relief, topographic diversity, acceptable surface water drainage capabilities and compaction.

7.5.2 Reinstatement of topsoil

Topsoil will not be mixed with subsoil during replacement. Only topsoil (and equivalent materials as permitted by the Reinstatement Specification) will be re-spread over the surface. Topsoil will not be used for bedding material in the trench and topsoil from unstripped/undisturbed areas will not be used to cover adjacent disturbed areas. Topsoil will not be handled under wet conditions or at times when the ground or topsoil is frozen.

All disturbed areas will be graded and left sufficiently rough to promote new vegetation growth which will protect the stability of the topsoil.

7.6 Temporary erosion control measures

7.6.1 General

Temporary erosion control measures will be installed by the contractor to provide protection to the local environment and to achieve the required performance standards. The measures will facilitate stabilisation of reinstated areas, minimise erosion and ensure that watercourses are not adversely impacted. Such measures include:

- Flow breakers, or plugs of material (hard and soft) installed at appropriate intervals within trenches on longitudinal slopes to prevent scouring of the trench bottom
- Water bars constructed on the ROW to control surface water runoff and erosion. Water bars will be designed to simulate the slope contour and direct and diffuse surface water away from the disturbed area
- Flumes or other similar methods to allow drainage and migration of water where cross drainage is necessary (ie where slopes are cut)

The ROW will be monitored for:

- Subsidence of the pipeline trench
- Slope wash
- Slumping and soil movements
- Loss of stored topsoil, subsoil or cuttings
- Areas of disturbed ground off the ROW
- Status and success of re-vegetation

7.6.2 Erosion matting

Erosion matting will be installed to:

- provide immediate protection to the ROW on slopes, etc.
- minimise washing-out of seeds
- enhance the micro-climatic conditions of the soil for plant germination and growth

Once installed, erosion mats will be regularly inspected for degradation and installation integrity. Mats will be maintained and replaced as required to achieve project requirements.

7.6.3 Sediment control

Where the ROW intersects or is parallel to an environmental receptor (eg watercourse, wetland, water body or other environmentally sensitive area), sediment controls will be installed to prevent sediment run-off significantly affecting the receptor. Sediment control will be used and maintained until the ROW has been stabilised and project requirements are achieved.

Sediment interception devices include:

- Silt fences - installed in areas of low sheet flow
- Straw bale barriers - installed in areas where small amounts of sediment require temporary interception
- Filter berms - installed where there is a requirement to temporarily retain runoff water after a storm event to allow sediment to settle
- Sediment traps - installed as required at outlets of ROW drainage systems, at the outlet of any structure which concentrates sediment-laden runoff and above storm water drains which are in line to receive sediment-laden runoff

7.6.4 Soil stack control

In certain instances, such as in areas of side slope and along steep ridges, wooden fences will be installed and maintained alongside the ROW to retain stockpiled topsoil and arisings during construction and reinstatement. Fences will be designed for the anticipated and will be removed during final reinstatement of the ROW.

7.7 Permanent erosion control devices

Permanent erosion control measures are outlined in this section. They will be installed to:

- facilitate maintenance of stability in reinstated areas
- minimise erosion
- ensure that watercourses are not adversely impacted.

7.7.1 Diverter berms

Diverter berms will be placed across the slope of the ROW to intercept runoff and direct it to a safe outlet. Berms will be constructed in accordance with a detailed specification.

7.7.2 Berm outlets

Water outlets will be provided to allow controlled disposal of runoff generated along the ROW. The runoff will be managed so as to not cause erosion or sediment transportation.

Outlets will be installed at the end of each diverter berm. Outlets will effectively dissipate the energy of runoff from the ROW and take the water to a disposal point that is both safe and minimises environmental impact.

7.7.3 Gabions

Gabions will be used where there is a requirement to form large, flexible but permeable structures such as retaining walls and revetments for earth retention. Gabion walls may be constructed to facilitate permanent recovery of the ROW and associated areas and to prevent or stabilise landslides.

Gabions structures will be designed and constructed in accordance with the manufacturer's specifications and project approved method statements.

7.7.4 Trench breakers

Trench breakers will be installed within the trench at locations along the pipeline route where the natural profiles, drainage patterns and backfill materials may cause the trench to act as a drain. They may also be required at the base of slopes adjacent to watercourses and wetlands and where it is necessary to prevent the BTC trench acting as a drain.

7.8 Watercourses

International best practice will be used for watercourse crossings. For significant crossings, in environmentally sensitive or special agricultural sections, special section designs and method statements will be developed and implemented to ensure site-specific environmental and social issues are considered appropriately.

The disturbed portion of the watercourse, the bed and banks, will be returned to pre-construction contours where possible with the backfill over the pipe at least as scour-resistant as the original bed material. Where practicable, watercourse banks will be stabilised within 48 hours of backfilling. Erosion and sediment control devices will be installed and maintained until new vegetation is sufficiently established. Where unstable channels exist downstream in the vicinity of the pipeline crossings, bed stabilisation work will be carried out to minimise the risk of bed erosion compromising the integrity of the pipeline.

Watercourse crossings will be regularly inspected until adequate stability has been achieved. After this, routine inspections will be made approximately every three weeks until the end of the maintenance period.

8 BIO-RESTORATION

8.1 Objectives

The objectives of bio-restoration are to:

- Restore the ecological characteristics, and in particular the variety and distribution pattern of plant species
- Achieve sufficient vegetation cover to reduce erosion to meet the performance target of Erosion Class 3 or better

In areas of natural and semi-natural habitat, the aim will be to achieve long-term vegetation cover comprised of the native flora. The strategy for achieving this will be the use the native seedbank and vegetative material resource that will remain in the topsoil when it is replaced, supplemented by re-seeding and planting with local species.

8.2 Targets

The original percentage vegetation cover will be estimated from the photographic record of the route, or, in case of doubt, by reference to adjacent undisturbed areas. Against this record appropriate targets and timeframes for achieving established growth will be set in agreement with the specialist bio-restoration contractors. In this context 'established' means showing an initial healthy growth that would be expected for the particular species.

Soil, slope, perspective, and climatic conditions all affect rates of growth. Aftercare (watering, weeding, application of fertiliser, etc) will be carried out during the maintenance period in order to meet the re-vegetation targets.

The bio-restoration progress for each section of the route, and other project areas, will be reported quarterly against the performance criteria agreed. Where the criteria are not met, or it appears that they will not be met within the reasonable timeframes, corrective action will be taken, that may include watering, weeding, over-seeding, fertiliser application, replacement of failed trees, etc.

8.3 Scheduling

Bio-restoration work will be carried out during the appropriate growing seasons. Sowing or planting will be scheduled for a period that is likely to be followed by sufficient rain to promote germination and establishment.

8.4 Procedures to be followed by the contractor

Preliminary approaches for seeding and planting and have been developed as guidance for the construction contractor. However, these are optional and may be developed or substituted by other procedures by the construction contractor. The procedures developed relate to various habitat types (eg meadows, desert) as well as to specific locations or species that are encountered along the route. The procedures include guidance on factors such as:

- Seed storage
- Seed bed preparation
- Seeding/planting rates
- Seeding/planting methods eg trenches, pit planting, slot planting
- Soil additives, eg fertiliser
- Watering requirements
- Use of erosion matting
- Optimum planting/seeding times

9 SPECIAL AREAS

Special Areas will be considered separately within the reinstatement plan and method statements. Special areas include:

- **Side Slopes & Cuttings -** At environmentally sensitive locations or special agricultural areas, the side slope will be restored, as far as practicable to the original contours.
- **Special agricultural areas** – where canals, or irrigation channels, etc. are encountered these will be addressed in land use / system method statements.

10 RESTRICTING ACCESS

Measures will be taken to prevent unauthorised use of the ROW as a roadway to prevent rutting, subsequent erosion problems, damage to riparian areas and disturbance of the reinstated areas. Access will be blocked at specific locations defined by the project.

11 HANDOVER AND POST-CONSTRUCTION MAINTENANCE

Before it relinquishes responsibility for the reinstated areas to the operating company, the project will:

- Complete a final inspection of all project areas in conjunction with land owners to ensure that the pre-agreed standards of reinstatement have been met
- Undertake remedial work to the satisfaction of the landowners where any shortfalls exist.

During the contract maintenance period the project will be responsible for maintaining the standard of reinstatement and ensuring that the required erosion class and bio-restoration targets are met.

Environmental Simulations International

Modelling of subsurface migration of crude oil

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1 INTRODUCTION

1.1 Background

Environmental Simulations International Ltd. (ESI) have been commissioned by RSK Environment Ltd. (RSK) to undertake modelling of subsurface crude oil migration resulting from a hypothetical pipeline breach in Azerbaijan. The modelling will contribute to a quantitative assessment of risks to groundwater associated with such a pipeline spillage. This work forms one component of a broader environmental impact assessment performed by RSK in Azerbaijan.

Crude oil is a mixture of many hydrocarbons which forms an essentially immiscible fluid that is lighter than water. However, many components are sparingly soluble in water, often at concentrations that are many orders of magnitude greater than water quality standards based on toxicological and/or aesthetic criteria. As such, a leakage of crude oil into the subsurface poses a potential source of contamination to groundwater.

The proposed route of the pipeline crosses geological strata with highly varying hydrogeological and geological properties and RSK consider that it is not realistic to simulate the consequences of a leakage in all of these scenarios. RSK have therefore instructed ESI to simulate initially three generic scenarios that incorporate the major features and processes likely to be encountered in the most vulnerable parts of the pipeline route (the Gyandja-Kazakh pre-mountain plain and the Karayazi plain - a large area of aquifer strata comprising alluvial outwash sediments from the Caucasus).

1.2 Scope

The purpose of this modelling exercise is to

- investigate the characteristics of the crude oil migration in the subsurface,
- understand the significance of the different flow and transport processes occurring, and
- explore the sensitivity of the behaviour to parameters and processes, taking into account data uncertainty.

The key objective is to identify a zone or strip adjacent to the pipeline route within which the groundwater receptors may be at risk from the consequences of a leakage, and for which a mitigatory action plan should be devised.

1.3 Approach to the Risk Assessment

RSK have collated data and formulated hydrogeological conceptual models for the environmental impact assessment, including:

- characterising the geological and hydrological setting;
- generating leakage scenarios and collating the relevant chemical and physical characteristics of the crude oil;
- collating hydrogeological properties to characterise migration pathways;
- mapping groundwater receptors.

Three geological settings, which incorporate the major features and processes likely to be encountered, have been identified. Additionally, RSK have identified three leakage scenarios. Data and information issued by RSK and used in the analysis have been incorporated into this report in sections entitled ‘Background Information’. Data given in sections entitled ‘Additional data required for the risk assessment’ have been supplied by ESI.

The framework for the risk assessment follows a conceptual model of contaminant linkage between:

- the contaminant ***source*** (crude oil free phase), which, since it is less dense than water, may be present as a floating lens at the water table and/or as residual in the unsaturated zone.
- the transport ***pathway*** through the subsurface, where at least a portion of the pathway is as dissolved phase in groundwater.
- the potential ***receptors***, which may include wetland nature reserves, wells, springs or karizes (qanats). Compliance with international water quality standards is assessed.

Given the complex nature of the migration of crude oil through the subsurface, this work adopts a number of different analytical and numerical approaches to examine various aspects of the combined problem and understand the governing processes. In particular, the migration of the crude oil free phase and the transport of components dissolved in water are treated separately. The analysis focuses on key contaminants, including the BTEXs (benzene, toluene, ethylbenzene and xylene). The impact of uncertainties in the system is explored using sensitivity analysis and probabilistic techniques.

Only the risk to groundwater quality has been assessed. Other risks such as risk to human health or risk related to other transport pathways, such as vapour transport alone, are not considered.

1.4 This Report

The processes involved in subsurface migration of crude oil are described in Section 2, together with an overview of the modelling approach.

Data concerning the natural hydrogeological system is contained in Section 3.

Section 4 focuses on the source area and the migration of the crude oil phase, whilst Section 5 looks at the solute transport downgradient of the source area. Both sections contain details of the modelling approaches adopted, the required data, and results of the risk assessment.

A brief assessment of the impact of an abstraction well is contained in Section 6.

Section 7 contains a summary of the overall results and conclusions. Some recommendations for further data acquisition and analysis are presented in Section 8.

2 RISK ASSESSMENT APPROACH FOR PIPELINE BREACH

2.1 Introduction

The pipeline crosses geological strata with highly varying hydrogeological and geological properties. The three generic scenarios selected by RSK for initial consideration incorporate the major features and processes likely to be encountered in the most vulnerable parts of the pipeline route (the Gyandja-Kazakh pre-mountain plain and the Karayazi plain). Further details are given in Section 2.2.

A conceptual model for the flow and transport processes relevant to the migration of crude oil through the subsurface is illustrated schematically in Figure 2.1, and described in terms of the free phase source, the transport pathways, and the potential groundwater receptors in Sections 2.3 to 2.5.

2.2 Geological setting

The generic geological scenarios selected by RSK vary primarily in their representation of the grain size distribution of aquifer sediments, and the thickness of the unsaturated zone (Table 2.1).

Table 2.1 Characteristic hydrogeological settings for risk assessment

	Hydrogeological Setting		
	A	**B**	**C**
Geological column (unsaturated zone)	Gravel 3 m	Gravel 15 m	Gravel 2 m Silt 4 m Gravel 9 m
Geology (saturated zone)	Gravel (no base of aquifer specified)	Gravel (no base of aquifer specified)	Gravel (no base of aquifer specified)

2.3 Contaminant source

As crude oil is essentially an immiscible fluid, it migrates through the subsurface principally in its own phase, i.e. as a nonaqueous phase liquid (NAPL). A conceptual understanding of the NAPL bulk phase migration in a leakage scenario comprises the following stages (Figure 2.1).

1. Breach of the pipeline, and subsequent actions to recover lost crude oil. This is not modelled in this report: the three leakage scenarios identified by RSK specify the loss to the subsurface in terms of volume of oil, duration and affected area.
2. Infiltration of the lost NAPL into the subsurface.
3. Migration of the NAPL through unsaturated zone, where it may be retained in small pores at residual saturation for oil in an oil air mixture, or accumulated above areas of low permeability.
4. If the leaked volume is more than can be retained in the unsaturated zone, the NAPL will reach the water table and float as a lens on the capillary fringe, often partially depressing the water table at the centre of the spill area.
5. If the gradient of the water table is significant, the NAPL flow down the gradient due to gravitational forces.
6. If there are seasonal variations in the water table NAPL may become entrapped in the large pores in the saturated zone at residual saturation from water oil mixtures.

At all stages, different components of the crude oil may dissolve into pore water or groundwater, or evaporate. These dissolved and vaporised components may be transported away from the bulk phase source area by a variety of routes. Potential pathways are discussed in the following section.

2.4 Contaminant pathways

There are several potential subsurface pathways linking the contaminant source with potential groundwater receptors, as illustrated in Figure 2.1. They include, in order of likely significance of impact on groundwater:

- Dissolution of NAPL at the capillary zone above the water table, and diffusion into the groundwater flowing beneath it;
- Dissolution of NAPL into pore water in the unsaturated zone, and transport to the water table by infiltrating percolation;
- Vapour phase transport through the unsaturated zone by diffusion and partitioning of vapour phase into the underlying groundwater.

Each of these pathways brings dissolved components of crude oil to the groundwater, which transports the solute as it flows towards a potential receptor.

When transported as a solute in either the unsaturated or saturated zones, a contaminant may undergo the transport processes of dispersion, molecular diffusion, retardation due to sorption and partitioning into other immobile phases, and biodegradation. The relative importance of these processes depends on the properties of individual constituents of crude oil. This risk assessment is based on constituents selected on the basis of their mobility and toxicity.

1. BTEX group (benzene, toluene, ethylbenzene and xylene): representative of the aromatic components.
2. cyclohexane: representative of the cycloalkanes.

2.5 Receptors

As the modelling exercise is of a generic nature, no specific receptors can be identified. However, it is understood that potential receptors may include the following:

- wetland nature reserves of national importance, fed by unconfined gravel groundwater;
- shallow dug wells used for drinking water supply;
- karizes (or qanats, i.e. long underground adits) used for irrigation and/or drinking water;
- pumped boreholes;
- natural springs used for drinking water or watering of herds.

The objective of the modelling exercise is to identify a zone or strip adjacent to the pipeline route within which the above receptors may be at risk from the consequences of a breach of the pipeline and for which a mitigatory action plan should be devised.

The influence of abstraction from a well on the hydrogeological regime is briefly assessed in Section 6.

2.6 Water quality standards

There are no drinking water limits developed specifically for Azerbaijan for hydrocarbon related parameters. Table 2.2 details different international standards identified by RSK, and shows the compliance criteria specified for this study.

Table 2.2 Selected water quality standards (in µg/l) (RSK, 2001)

	Minzdrav	WHO (H)	WHO (C)	EC	VROM (target)	VROM (intervention)	**Compliance criterion specified**
Benzene		10		1	0.2	30	**10**
Toluene	500	700	24 - 170		7	1000	**20**
Ethylbenzene	10	300	2 - 200		4	150	**10**
Xylene(s)	50	500	20 - 1800		0.2	70	**20**
Cyclohexane	100						**100**

Minizdrav: Drinking water standards of former Soviet Ministry of Health and other organisations;
WHO: World Health Organisation, (H) = standards based on health criteria, (C) = standards based on aesthetic criteria
EC: Drinking water standards of European Community
VROM: target and intervention concentrations for contaminanted land - Dutch Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, (M) = values for mineral oil

2.7 Modelling approach

The migration of crude oil together with its vapour and dissolved components through the subsurface is a highly complex combination of processes which occur at different spatial and temporal scales and in three dimensions. Simulation of the system as a whole would be time consuming, and difficult to interpret. Therefore the approach taken in this work is to examine different simplified components of the complete system at reduced dimensionality. The aim is thereby to aid understanding of the key parameters and processes, and indicate the effect of the system uncertainties.

In particular, the problem has been divided into two components:

1. The behaviour of the source (NAPL) (Section 4). The objective of this component of the assessment is to address questions such as: Is the depth of unsaturated zone and retention capacity such that all the NAPL will be retained in the unsaturated zone? Are potential silt horizons in the unsaturated zone of low enough permeability to prevent further penetration of the NAPL? What size of NAPL lens might form at the water table?

2. Solute transport in the aquifer (Section 5). The objective of this component of the assessment is to address questions such as: What is the capacity of the aquifer to attenuate the solute plume? What is the length of the plume above water quality standards of each of the selected contaminants?

In this study the impact of the third pathway, vapour transport in the unsaturated zone and partitioning to groundwater, is not assessed.

Most parameters used to characterise and model the system have some degree of uncertainty attached to them. The significance of this uncertainty is assessed in this work using the techniques of sensitivity analysis and probability (Monte Carlo method). Other parameters or scenarios are chosen as worst cases. Therefore caution should be taken in interpretation of probabilistic results, which may not be translated into likelihood of representing the true behaviour of the system.

3 HYDROGEOLOGICAL CONDITIONS

3.1 Introduction

The purpose of this section is to present the data describing the natural hydrogeological conditions of the region of interest. These data are required for modelling of the migration of the crude oil phase (the source) as well as transport of dissolved phase. Section 3.2 presents data provided by RSK on the basis of their understanding of the hydrogeological situation on site. A summary of the data used in the assessment is given in Section 3.3.

3.2 Background data

3.2.1 Hydraulic conductivity

Figures 3.1a and 3.1b present typical grain size distribution curves for gravel and silt strata from the project area. Note that BH-A61 (Figure 3.1a) is atypical of much of the aquifer. It probably represents re-washed gravel/ pebble strata, occurring in a river valley. The Beyer method (Langguth and Voigt 1980) was applied to grain size analyses of sediment samples, giving the distribution of estimated hydraulic conductivities shown in Figure 3.1c. The upper end of the distribution (> 0.1 m/s) can be ignored as it probably falls outside the limits of application of the Beyer method. The histogram shows a bimodal distribution with peaks at 10^{-8} to 10^{-7} m/s corresponding to silt strata, and at around 10^{-3} m/s, corresponding to gravels. These values are discussed in more detail below.

<u>Gravels</u>

Analysis of the grain size distributions suggests that gravel strata be characterised by a distribution with a modal value between 1×10^{-3} and 2×10^{-3} m/s (86 to 170 m/d), and a median closer to 5×10^{-3} m/s. McMahon et al. (2001) suggest that hydraulic conductivity data are typically log-normally distributed and that this can be approximated by a log-triangular distribution in cases where data are scarce. Data from field testing in the report by Tagiev and Alekperov (2001) suggest that strata of the upper aquifer complex have typical hydraulic conductivities between 0.1 and 13.4 m/d. Furthermore, discussions by D. Banks with A. Alekperov and F. Aliyev of the Committee for Hydrogeology of the Azerbaijan Ministry of Environment (minutes of meeting, 3/9/01) suggest that the hydraulic conductivity of coarse proluvial aquifer sediments is mostly in the range 20-100 m/day (typically 20-40 m/day). The values derived from field testing are likely to be more representative than estimates derived from grain size distributions from small point samples of sediment. Therefore the following log triangular distribution over uncertainty of effective hydraulic conductivity is selected for the gravelly strata for application in the modelling:

Minimum = 20 m/d; Most likely = 50 m/d; Maximum = 170 m/d

3.2.2 Porosity

The porosity and effective porosity have been estimated from grain size distributions by the Beyer method (Langguth and Voigt 1980) of gravel samples from trial pits and boreholes west of the River Geranchai (30 samples). The distribution of values (Figure 3.1d) suggests that gravelly strata have a median porosity of some 28 %, with a range from 26 % to 36 %. The hydraulically effective porosity ranges from 24 to 36 %, with a median of 27 %. McMahon et al. (2001) suggest that porosity is best represented as a normal distribution which, in the case of a limited number of samples, can be estimated by a triangular distribution.

No reliable determinations of porosity for the silty/clayey sediments are available. However, as the sediments tend to be over-compacted (pers. comm. between K. Richardson and D Banks), a mean porosity of around 30% is assumed. The distribution is assumed to be triangular, with minimum and maximum values of 27% and 36 %.

3.2.3 Hydraulic gradient

The published hydrogeological map (Aliyev et al. 1992) suggests a regional head gradient for the upper, unconfined aquifer of some 100 m in 7500 m (or 0.013). This figure agrees with the ranges cited in Tagiev and Alekperov (2001) for the various portions of the Gandja-Kazakh piedmont plain. A maximum gradient of 0.03 is estimated from Tagiev and Alekperov's (2001) report, while a minimum value of 0.002 is taken from the hydrogeological map of the western part of the Karayazi plain.

As the hydraulic gradient is likely to be, to some extent, dependent on hydraulic conductivity (McMahon et al., 2001), a single value of 0.013 is more appropriate when modelling dissolved phase transport in order to avoid an unwarranted degree of uncertainty arising from unphysical combinations when parameters are independently sampled.

3.2.4 Rainfall and infiltration

Average annual precipitation increases from 150 mm in the east to some 400 mm in the Karayazi wetland area to the west. As the region of interest is in the west annual precipitation can be assumed to be 350-400 mm. Typical potential evapotranspiration rates are generally high along the whole pipeline route at some 600-800 mm/a. In view of the high potential evapotranspiration, an annual effective rainfall of 50 mm is used in the risk assessment (pers. comm. with D Banks, using information from Kashkay and Aliyev, Ali-Zadeh et al.).

Recharge from rivers also appears to be important (Tagiev and Alekperov (2001) report it forming 32% of recharge). Transport pathways involving infiltrating water will not be taken into account in this study.

3.2.5 Temperature

Monthly average air temperatures for Gyandja for 1999 are shown in Table 3.1. It is assumed that the subsurface temperature approximately reflects annual average air temperature, therefore a subsurface temperature of around 15°C is expected.

Table 3.1 Average near-surface monthly temperatures, Gyandja, for the year 1999

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp. (°C)	5.1	7.8	8.8	14.3	18.4	23.8	27.3	28.2	20.7	15.2	8.4	7.3

3.3 Data summary

The data describing the natural hydrogeological conditions which are used in the risk assessment analyses are summarised in Table 3.2.

Table 3.2 Summary of hydrogeological parameters

Parameter	Unit	Min.	Most likely	Max.	PDF	Justification
Gravel						
Saturated hydraulic conductivity	m/s	2×10^{-4}	6×10^{-4}	2×10^{-3}	Log triangular	Section 3.2.1
Porosity	fraction	0.26	0.28	0.36	Triangular	Section 3.2.2
Effective porosity saturated conditions	fraction	0.24	0.27	0.36	Triangular	Section 3.2.2
Silt						
Saturated hydraulic conductivity	m/d	1×10^{-9}	4×10^{-8}	4×10^{-6}	Log triangular	Section 3.2.1
Porosity	fraction	0.27	0.30	0.36	Triangular	Section 3.2.2
Other						
Hydraulic gradient	dimesion -less		0.013		Single value	Section 3.2.3
Infiltration rate	mm/a		50		Single value	Section 3.2.4
Subsurface temperature	°C		15		Single value	Section 3.2.5

PDF: *probability distribution function*

4 ASSESSMENT OF NAPL MIGRATION

4.1 Introduction

The analysis contained in this section relates to the migration of the crude oil phase (NAPL). The primary aim of the calculations is to determine what would happen to the NAPL: whether it would be retained in the unsaturated zone, or whether it would reach the water table and spread. As the NAPL infiltrates the subsurface, dissolution of components into the water occurs, as does vaporisation. However, these processes, which will act to reduce the volume of NAPL, are not taken into account in this section. This makes this assessment conservative.

In this section the spill scenarios assumed and approach to modelling are first described. A summary of the site specific data provided by RSK and additional generic data used in the risk assessment are provided in Section 4.4. The results of the assessment are presented in Section 4.5.

4.2 Spill scenarios

Three possible leakage scenarios have been developed by RSK (Table 4.1). Based on statistics presented by CONCAWE (the oil companies' European organisation for environment, health and safety) and other unreferenced literature sources, assumptions have been made concerning likely percentage recoverable by surface clean-up, and the area of ground subject to oil infiltration (Table 4.2), leading to a net loss per unit area. The actual losses and affected areas will depend on mode of spillage, ground conditions and rapidity of cleanup response.

Table 4.1 Pipeline leakage scenarios

Scenario No.	Description
1	Leakage from a 5 mm hole: 2 l/s for a period of 200 hrs = 1440 m^3
2	Leakage from a 50 mm hole: 100 l/s for a period of 8 hrs = 2880 m^3
3	Full rupture: 1800 l/s until pipe is emptied = 20 000 m^3 total

Table 4.2 Net losses to the subsurface and areas of ground subject to oil infiltration for each spill scenario

Scenario No.	Rate (l/s)	Duration (hrs)	Gross volume (m^3)	Surface clean-up (%)	Net loss (m^3)	Area (m^2)
1	2	200	1440	30	1008	3000
2	100	8	2880	65	1008	10000
3	1800	3.1	20000	65	7000	80000

4.3 Modelling approach

4.3.1 Scoping calculations

The following are simple scoping calculations which enable the comparison of the impact of the three different spill scenarios on the three geological settings defined in Section 2.2. They take into account the capillary forces and the retention capacity of the porous media.

A conceptual model for the calculations is shown in Figure 4.1. The pipeline leakage affects an area of land (A_s), over which a volume (V_L) is lost, and infiltrates the subsurface. The NAPL sinks due to gravitational forces, however a residual saturation (s_{ro}) is left behind in the smaller pores. When the NAPL reaches the water, it floats and begins to form a lens. The lens will spread until the threshold entry pressure of the porous medium resists further spreading.

If the NAPL reaches a low permeability stratum, the same process of ponding and increase in capillary pressure would occur. The low permeability stratum will not be penetrated by the NAPL if:

- there are no barriers to lateral (horizontal) spreading;
- the viscous forces do not inhibit the ability of the porous medium to transmit the NAPL in the time scale of leakage (i.e. high infiltration rates are likely to build up a large enough capillary pressure to penetrate the low permeability stratum).

These two conditions are assumed in these initial scoping calculations.

Further assumptions in these calculations are:

- the leakage area is square;
- no transverse spreading occurs whilst the NAPL migrates vertically through the gravel before encountering the water table;
- the spreading calculation is based on capillary forces; gravitational and viscous forces are not taken into account;
- the regional hydraulic gradient (and hence the gradient of the water table) is not significant for the capillary forces, therefore its direction does not affect the spreading of the lens at the water table.

The volume retained in a geological column of area A_s and depth h_{UZ} of unsaturated zone is

$$h_{UZ}\ A_s\ s_{ro}\ n$$

where

s_{ro} is the residual saturation of the porous medium
n is the porosity of the porous medium.

The threshold entry pressure P_d for the NAPL in a porous medium is given by

$$P_d = \frac{2s_{ao}\cos q}{r}$$

(Cohen and Mercer, 1993), where:

s_{ao} is the surface tension of the NAPL
q is the wetting angle (air-NAPL-solid)
r is the pore radius, which can be approximated by $d/8$, d being the grain diameter (Hubbert, 1953).

The NAPL requires a lower capillary pressure to enter the larger pores. As the capillary pressure increases, the NAPL is able to enter the smaller pores. The depth of a NAPL (h_L) on an impermeable barrier or the water table is given by:

$$h_L = \frac{2s_{ao}\cos q}{(r_a - r_o)\,g\,r}$$

where

r_o is the density of the NAPL
r_a is the density of the air
g is gravitational acceleration
r here refers to the host porous medium, therefore the gravels in the case of the NAPL spreading at the water table.

The same formula can be used to calculate the head required to penetrate a region of lower permeability. Then r refers to the low permeability pore radius.

Assuming that the NAPL is fully saturating the pores in the lens above the water table, the volume contained in the lens is:

$$h_L \, A_L \, n$$

where A_L is the area of the lens. Adjusting the depth of the unsaturated zone at residual saturation to account for the lens, the volume leaked to the subsurface, V_{loss}, can be accounted for as follows:

$$V_{loss} = (h_{UZ} - h_L)\, A_s \, s_{ro} \, n + h_L \, A_L \, n$$

so that the area of the lens is

$$A_L = \frac{V_{loss} - (h_{UZ} - h_L)\, A_s \, s_{ro} n}{h_L n}$$

Again, a square dimension of the lens is assumed, so that the length is the root of this expression.

The spreading of a pool on top of a silt layer is calculated in the same manner.

4.4 Data for the assessment of NAPL migration

4.4.1 Data provided by RSK

Table 4.3 shows properties of the crude oil required for consideration of the migration of the NAPL that have been provided by BP (2001).

Table 4.3 Properties of the crude oil (BP, 2001)

Property	Unit	Value	Comments
Density	kg/m^3	852	
Dynamic viscosity	cP	12	at 30°C; approximate
		20	at 20°C; approximate
Dynamic viscosity	kg/(ms)	0.012	at 30°C; approximate
		0.020	at 20°C; approximate

4.4.2 Additional data required for the risk assessment

4.4.2.1 Properties of air and water

The properties of pure air and water are given in Table 4.4. It is assumed the presence of crude oil vapour and solute does not alter the properties of the gaseous and water phase significantly.

Table 4.4 Properties of water and air (Batchelor, 1967)

Property	Unit	Air at 15°C	Water at 15°C
Density	kg/m^3	1.225	999.1
Dynamic viscosity	kg/(ms)	1.78×10^{-5}	1.137×10^{-3}

4.4.2.2 Surface and interfacial tensions

The surface tension of water, σ_{aw}, is 72.8 dyn/cm (mN/m) at 20°C (Batchelor, 1967). The surface and interfacial of ACG crude oil is unknown. Three examples of surface and interfacial tensions are shown in Table 4.5, together with the corresponding spreading coefficient. The contact angle of the crude oil on the aquifer material is unknown. Pristine aquifers are generally water-wetting (contact angle water-NAPL-solid<70°). Cohen and Mercer (1993) tabulate the results of contact angle measurements for different dense NAPLS and materials. These tend to vary between 30° and 50° for water-NAPL-solid, and between 150°and 170° for air-NAPL-solid.

Table 4.5 Surface and interfacial tension of selected crude oils (Jokurty et al., 2000)

Property	Unit	Crude oil samples		
		Iran Heavy	Kominheft, Russia	Sakhalin, Russia
Surface tension σ_{ao}	dyn/cm or mN/m	26.1	23.7	24.4
Interfacial tension σ_{ow}	dyn/cm or mN/m	22.5	18.0	16.3
Spreading coefficient σ_{aw}-σ_{ow}-σ_{ao}	dyn/cm or mN/m	24.2	31.1	32.1

4.4.2.3 Sediment retention capacity of crude oil

The retention capacity, R_c, of a porous medium quantifies the volume of NAPL that may be held in the pores by capillary forces under drainage (unsaturated zone) or under the natural hydraulic gradient (saturated zone). R_c is expressed in litres per m^3 of porous medium. An alternative is the residual saturation, s_{ro}, which is the proportion of the pore space occupied by the immobile NAPL. The two are related by $R_c = 1000\ s_{ro}\ n$, where n is the porosity.

The retention capacity depends on many factors, including fluid properties and pore size distributions. Values in the saturated zone generally exceed those in the unsaturated zone (Cohen and Mercer, 1993). In the unsaturated zone the immobile NAPL, which is the wetting phase with air, is likely to be left in the smaller pores. As the non-wetting fluid in the saturated zone the NAPL is likely to be in trapped in the larger pores. We are not aware of any methods to estimate the retention capacity from, for example, the grain size distribution. In published studies this parameter is either measured or is a calibration parameter in modelling.

No site-specific information on the retention capacity of the ACG crude oil is available. Table 4.6 summarises data available from the literature. On the basis of these values the following ranges of uncertainty in volumetric retention capacity appear plausible:

<u>Gravel</u>

Minimum = 8 l/m^3
Most likely = 15 l/m^3
Maximum = 20 l/m^3

<u>Silt</u>

Minimum = 40 l/m^3
Most likely = 60 l/m^3
Maximum = 80 l/m^3

Table 4.6 Volumetric retention capacity and residual saturation for assorted NAPLs and media: literature values

NAPL		Medium	Minimum Value		Mean or Single Value		Minimum Value	
			s_{ro}	R_c (l/m^3)	s_{ro}	R_c (l/m^3)	s_{ro}	R_c (l/m^3)
Crude oil[(a)]	UZ, SZ	sand			0.2	56		
Gasoline[(b)]	UZ	coarse sand and gravel			0.014	4		
Gasoline[(b)]	UZ	silt to fine sand			0.07	20		
Middle distillates[(b)]	UZ	coarse sand and gravel			0.03	8		
Middle distillates[(b)]	UZ	silt to fine sand			0.05	15		
Fuel oils[(b)]	UZ	coarse sand and gravel			0.06	16		
Fuel oils[(b)]	UZ	silt to fine sand			0.29	80		
Mineral oil[(b)]	UZ	alluvium			0.19	53		
Crude oil[(c)]	NK	gravel	0.036	10	0.54	15	0.7	20
Crude oil[(c)]	NK	silt	0.14	40	0.21	60	0.29	80
Crude oil[(b)]	SZ	sandstone	0.16	44.8			0.47	131.6
Crude oil[(b)]	SZ	sandstone	0.26	72.8			0.43	120.4
Benzene[(b)]	SZ	sand (92% sand, 5% silt, 3% clay)			0.24	67.2		
o-Xylene[(b)]	SZ	sand (92% sand, 5% silt, 3% clay)			0.19	53.2		
p-Xylene[(b)]	SZ	medium aeolian sand	0.2	56			0.27	75.6

UZ = Unsaturated
SZ = Saturated Zone
NK = Not known
(a) = Essaid et al. (1993)
(b) = Cohen and Mercer (1993)
(c) = RSK (2001)

4.5 Risk assessment results

4.5.1 Retention capacity

Table 4.7 shows the range in volumes of NAPL (per unit area affected) that may be retained in the unsaturated zone, taking into account the retention capacity of the gravel and the silt (if present) for the three geological settings. The volumes of NAPL spilt (per unit spill area) are shown for the three spill scenarios in Table 4.8. Whilst Scenario 1 is spread over a smaller area (Table 4.2), the loss per unit area is significantly higher than the other two cases. Comparison of Table 4.7 and Table 4.8 shows the following.

- 3 m of gravel (Setting A) cannot retain all the volume of any of the spills; a lens will form at the water table in all cases.
- 15 m gravel (Setting B) should be sufficient to retain the Spill Scenarios 2 and 3 in the unsaturated zone. A lens would form at the water table for the first scenario.
- The gravel/silt/gravel combination (Setting C) appears capable of retaining the NAPL for Spill Scenarios 2 and 3. For Spill Scenario 1, the NAPL would be retained if the retention capacity were at or above its most likely value, but a lens would be formed at the water table if the retention capacity were near its minimum possible value. Here the additional spreading that may occur above the silt layer has not been taken into account.

Table 4.7 Retention capacity for the three geological settings per m^2 of spill area

		Geological Setting (Unsaturated Zone)		
		A (3m Gravel)	**B (15m Gravel)**	**C (2m Gravel, 4m Silt, 9m Gravel)**
Min retention capacity	l/m^2	24	120	248
Likely retention capacity	l/m^2	45	225	405
Max retention capacity	l/m^2	60	300	540

Table 4.8 Leakage scenarios in litres per unit area

		Spill Scenario		
		1	**2**	**3**
Net loss per unit area	l/m^2	336	101	88
Net loss per unit area	m	0.336	0.101	0.088

4.5.2 NAPL ponding

Calculating a depth of ponded NAPL on the water table leads to a maximum value of 2.88 mm (based on a contact angle of 160°, surface tension s_{ao} = 23.7 dyn/cm, and a grain size of 15 mm, corresponding to the average d_{50} grain size of the gravel). This lens thickness is very low, due to the apparent large size of the pores, and would imply that the crude oil can spread very thinly on top of the water table. The value is likely to be an underestimate, since viscous forces are not taken into account. The NAPL would also depress the water table to some extent before spreading. Heterogeneity at the pore and larger scales could also increase the height of the NAPL lens and hence reduce its final area. Although neither the surface tension nor the contact is known, the figures in the table show that they do not appear to be very important. Far more significant is the grain size. Table 4.9 shows that a much deeper lens must form before the pores corresponding to the d_{10} grain sizes of the gravel are filled. It is, however, unlikely, that these would control the spreading unless the connectivity of the larger pores is poor. The grain sizes for silt lead to estimates of the depth of NAPL required to penetrate the silt. However, before this depth is reached, the NAPL will move laterally in the overlying gravel.

Table 4.9 Sensitivity of NAPL ponding head to wetting angle, surface tension and grain size

Wetting angle (air-NAPL-solid) q (degrees)	NAPL Surface tension s_{ao} (dyn/cm)	Grain size (mm)	Head of ponded NAPL (m)	Comments
160	23.7	15	0.0028	Base case $d=d_{50}$ gravels
160	**26.1**	15	0.0031	
150	23.7	15	0.0026	
170	23.7	15	0.0030	
160	23.7	**0.9**	0.047	$d=d_{10}$ gravels
160	23.7	**0.03**	1.4	$d=d_{50}$ silt
160	23.7	**0.0025**	17.0	$d=d_{10}$ silt

BOLD FONT: parameter altered from base case

4.5.3 Preliminary assessment of the location of the NAPL in the subsurface

Based on the estimates of retention in the unsaturated zone, and spreading due to capillary forced at the water table, an estimate of the location of the NAPL in the subsurface is given for each combination of geological setting and spill scenario in Table 4.10. The subscript ‘spill’ refers to the area over which the oil is leaked; ‘source’ indicates that the NAPL is retained in the unsaturated zone, but the affected area is not expected to spread significantly beyond the spill area; ‘pool’ indicates size of a pool that may form as lateral spreading on a low permeability layer occurs and the NAPL is retained in the unsaturated zone; ‘lens’ refers to the dimensions of a lens at the water table. The figures are based on the minimum retention capacity of the porous media. As mentioned in the previous section, the dimensions of the NAPL lenses at the water table are likely to be overestimates, but provide an indication of upper limits. For comparison, the calculations corresponding to the thicker depth of the NAPL lens supported by the d_{10} grain size are given in Table 4.11. These may, in fact, be nearer to the actual degree of spreading, taking into account heterogeneity and viscous forces, however this should be explored by further modelling, supported by laboratory measurement of the retention capacity of the aquifer material.

From it is seen that:

- for Geological Setting A (3m gravel) the first two spill scenarios appear to result lens at the water table of similar dimensions. Spill scenario 3 creates a much larger lens.
- for Geological Setting B (15m gravel) the more localised spill scenario 1, with its high volume/area, causes the greatest problem. Otherwise the NAPL may be retained in the unsaturated zone in the area of the spill.
- for Geological Setting C (gravel/silt sequence), it is likely that the NAPL would be retained in the unsaturated zone. The worst case would be with significant lateral spreading above the silt layer, as this would increase the contaminated area in the unsaturated zone, leading to a larger area through which infiltration takes dissolved phase down to the saturated zone.

Table 4.10 Estimate NAPL location based on capillary forces (grain size = d_{50} gravel)

	Geological Setting (Unsaturated Zone)		
	A (3m Gravel)	**B (15m Gravel)**	**C (2m Gravel, 4m Silt, 9m Gravel)**
Spill scenario 1	Residual in UZ, Lens at water table	Residual in UZ, Lens at water table	Residual in UZ, Spreading above silt
A_{spill} = 0.003 km^2	A_{lens} = 1.27 km^2	A_{lens} = 1.27 km^2	A_{pool} = 1.30 km^2
L_{spill} = 0.055 km	L_{lens} = 1.13 km	L_{lens} = 0.95 km	L_{pool} = 1.14 km
Spill scenario 2	Residual in UZ, Lens at water table	Residual in UZ	Residual in UZ, Spreading above silt
A_{spill} = 0.010 km^2	A_{lens} = 1.06 km^2	A_{source} = 0.010 km^2	A_{pool}= 1.16 km^2
L_{spill} = 0.100 km	L_{lens} = 1.03 km	L_{source} = 0.100 km	L_{pool} = 1.08 km
Spill scenario 3	Residual in UZ, Lens at water table	Residual in UZ	Residual in UZ, Spreading above silt
A_{spill} = 0.080 km^2	A_{lens} = 7.05 km^2	A_{source} = 0.080 km^2	A_{pool} = 7.86 km^2
L_{spill} = 0.283 km	L_{lens} = 2.66 km	L_{source} = 0.283 km	L_{pool} = 2.80 km

Table 4.11 Estimate NAPL location based on capillary forces (grain size = d_{10} gravel)

	Geological Setting (Unsaturated Zone)		
	A (3m Gravel)	**B (15m Gravel)**	**C (2m Gravel, 4m Silt, 9m Gravel)**
Spill scenario 1	Residual in UZ, Lens at water table	Residual in UZ, Lens at water table	Residual in UZ, Spreading above silt
A_{spill} = 0.003 km^2	A_{lens} = 0.076 km^2	A_{lens} = 0.055 km^2	A_{pool} = 0.078 km^2
L_{spill} = 0.055 km	L_{lens} = 0.28 km	L_{lens} = 0.23 km	L_{pool} = 0.28 km
Spill scenario 2	Residual in UZ, Lens at water table	Residual in UZ	Residual in UZ, Spreading above silt
A_{spill} = 0.010 km^2	A_{lens} = 0.064 km^2	A_{source} = 0.010 km^2	A_{pool} = 0.070 km^2
L_{spill} = 0.100 km	L_{lens} = 0.25 km	L_{source} = 0.10 km	L_{pool} = 0.27 km
Spill scenario 3	Residual in UZ, Lens at water table	Residual in UZ	Residual in UZ, Spreading above silt
A_{spill} = 0.080 km^2	A_{lens} = 0.43 km^2	A_{source} = 0.080 km^2	A_{pool} = 0.47 km^2
L_{spill} = 0.283 km	L_{lens} = 0.65 km	L_{source} = 0.28 km	L_{pool} = 0.69 km

4.5.4 Base cases of NAPL source area

From the different combinations of geological settings and spill scenarios, the following base cases are taken forward to the next stage of analysis:

A. Retention of the NAPL in the unsaturated zone over a source area of width and length each 283 m.

B. Formation of a NAPL lens of at the water table of width and length 2660 m.

The transport of dissolved contaminants in a plume downgradient of each of these source areas is modelled in Section 5, both deterministically (with single parameter sets) and probabilistically, applying the range of uncertainty in the transport parameters, as discussed in the following section.

In our conclusions we extrapolate the results of the transport modelling to the other source dimensions corresponding to each of the geological settings and spill scenarios.

5 ASSESSMENT OF SOLUTE TRANSPORT

5.1 Introduction

This section considers the transport of dissolved crude oil constituents in the saturated zone. These may have entered the saturated zone by a number of different processes including the following:

A. Partitioning into infiltrating water in the unsaturated zone from NAPL retained at residual saturation or accumulated above regions of low permeability. The source length of the base case modelled in this section is 283 m.

B. Partitioning into water directly in contact with a NAPL lens floating at the water table, or entrapped NAPL below the water table. The source length of the base case modelled in this section is 2660 m.

It is assumed that if the NAPL does penetrate the full depth of the unsaturated zone and form a lens at the water table, the second source of dissolved phase will dominate. The two scenarios for equilibrium distribution of the NAPL source area are illustrated schematically in Figure 5.1. The figure also shows the formation of a solute plume down hydraulic gradient from the source area.

This section contains two sets of analyses corresponding to the above cases. In this section the approach to modelling is first described. A summary of the site specific data provided by RSK and additional generic data used in the risk assessment are presented in Section 5.3. The results of the assessment are presented in Section 5.4.

5.2 Modelling approach

The analytical methods used to represent the transport of solute are represented in this section. Most are standard techniques used in analysis of contaminated land under, for example, the tiered framework of the Remedial Targets Methodology (Environment Agency of England and Wales, 1999).

5.2.1 Partitioning from NAPL to water phase

The partitioning of a hydrocarbon from its own immiscible phase is limited by its solubility in water. In the presence of multiple components dissolution is further inhibited. The effective solubility of a component given by Raoult's Law:

$$S_i^{eff} = c_i S_i$$

where

S_i is the solubility of component i in water
c_i is the molar fraction of component i in the NAPL mixture
S_i^{eff} is the effective solubility of component i in water.

Often, a good approximation to the molar fraction c_i is the volumetric fraction.

It is assumed that water will be in contact with the NAPL long enough to achieve equilibrium partitioning. In the unsaturated zone, velocities of infiltrating water are likely to be slow due to the low infiltration rates (Section 3.2.4) and low pore water saturation. In the case of a lens at the water table, it is assumed that concentrations in the groundwater flowing at the water table is at the effective solubility.

5.2.2 Representation of processes in the source area

Case A: Retention of the NAPL in the unsaturated zone

The percolation infiltrating through the source area is assumed to be at the effective solubility. On reaching the water table it mixes with the groundwater flowing in the saturated zone. Thus the concentrations are reduced by dilution before the contaminants are transported downgradient of the source area. Aquifer dilution occurring in the mixing zone below the source is represented by a balance of mass fluxes (Figure 5.2a), so that the concentration C_g of a contaminant in the groundwater leaving the mixing zone is given by

$$C_g = \frac{C_s \, Inf \; S_x}{Inf \; S_x + K \, i \, S_x M_z}$$

where

C_s is the concentration in the water infiltrating from the unsaturated zone (mg/l)

Inf is the infiltration rate (m/d)

S_x is the length of the source area in the direction of groundwater (m)

K is the hydraulic conductivity of the aquifer (m/d)

i is the hydraulic gradient (dimensionless)

M_z is the depth of the mixing zone below the source area.

The mixing depth is unknown, but is estimated based on a llength scale arising from the solution to the equation for vertical transverse dispersion: $M_z = Ö(D_z t)$ where D_z is the dispersion coefficient (m^2/s) and t is the travel time of groundwater passing through the mixing zone. The vertical transverse dispersivity is assumed to be given by $D_z = a_z v$, where a_z is the transverse dispersivity in the vertical direction (m) and v is the average linear velocity of the groundwater, and it is assumed that a_z is $L/1000$, where L is the travel distance. The mixing depth is therefore given by $M_z = L/32$. We may take a typical travel distance in the mixing zone to be half the length of the contaminated region of the unsaturated zone (i.e. dimension in the direction of groundwater flow in order to derive the mixing depth associated with the average concentration in groundwater flowing out of the mixing zone. The length of unsaturated zone contaminant source area is taken from the size of the unsaturated zone source calculated in Section 4.

As a conservative assumption, any dilution (though lateral spreading of percolating water) or attenuation that might occur in the unsaturated zone is not taken into account. Significant levels of attenuation may, however, occur in scenarios with thick unsaturated zones, or low levels of spill.

<u>Case B: Formation of a NAPL lens at the water table</u>

In the second case of a NAPL lens existing at the water table, whilst the water infiltrating through the unsaturated zone will still leach contaminant from the residual phase into the groundwater, the lens is a more significant source of groundwater contamination. Therefore the former process will be ignored.

The concentration profile in the groundwater flowing below a lens at the water table can be approximated using the solution by Hunt et al. (1988) and Johnson and Pankow (1992) for DNAPL pools, as presented in Grathwohl (1998). The conceptual model for application to an LNAPL is shown in Figure 5.2b. The concentration at a distance z below the water table at the downgradient end of a lens is given by:

$$C(z) = C_0 \; erfc\left(\frac{z}{2\sqrt{D \frac{L_{lens}}{v}}} \right)$$

where

C_0 is the equilibrium concentration of the solute at the interface between the source and groundwater, i.e. the effective solubility

L_{lens} is length of the lens in the direction of groundwater flow.

The mass flux per unit width of lens is

$$2\,C_0\,n v\,\sqrt{\frac{a_z L_{lens}}{p}}$$

Assuming an average concentration of $C_g = C_0/2$ over an equivalent profile of constant concentration, the mixing depth is estimated as:

$$4\,\sqrt{\frac{a_z L_{lens}}{p}}$$

The length of lens is taken from the results of the scoping calculations in Section 4. The expression is very similar to that used for Case A, however dilution is provided by the groundwater flow. Here there is only a factor 2 reduction in the concentration. In this calculation we apply a vertical transverse dispersivity of the $L_{lens}/33000$, following field measurements of dispersion at the Borden test site (Canada; Rivett et al., 2001).

5.2.3 Modelling solute transport downgradient of the source area

It is assumed that the groundwater flow is unidirectional and may be described by Darcy's Law. Then the average linear velocity of the groundwater (and hence the unretarded velocity v of contaminants) is

$$v = \frac{K\,i}{n}$$

where n is the effective porosity of the porous medium.

The Ogata-Banks equation is an exact solution to the three-dimensional transport equation (Ogata & Banks 1961: Domenico and Robbins 1984; Domenico 1986). It assumes a source of concentration C_g over a vertical plane of dimensions S_y and M_z at the top of the unsaturated zone (axis at the water table) (Figure 5.3). Then the maximum point concentration a distance downgradient of the source is given by:

$$C = \frac{C_g}{2}\left[\begin{array}{l} \exp\left\{\frac{x}{2a_x}\left[1-\sqrt{1+\frac{4\,l\,a_x}{u}}\right]\right\} erfc\left\{\frac{1}{2\sqrt{a_x ut}}\left[x-ut\sqrt{1+\frac{4\,l\,a_x}{u}}\right]\right\} \\ \quad +\exp\left\{\frac{x}{2a_x}\left[1+\sqrt{1+\frac{4\,l\,a_x}{u}}\right]\right\} erfc\left\{\frac{1}{2\sqrt{a_x ut}}\left[x+ut\sqrt{1+\frac{4\,l\,a_x}{u}}\right]\right\} \end{array}\right] erf\left(\frac{M_z}{2\sqrt{a_z x}}\right) erf\left(\frac{S_y}{4\sqrt{a_y x}}\right)$$

where,

the rate of contaminant movement due to retardation is $u = \frac{K\,i}{n\,R_f} = \frac{K\,i}{n + K_d\,r_b}$,

C is the concentration at a point distance x on the centreline, downgradient of the source, evaluated at time t (mg/l);

C_g is the contaminant concentration in the mixing zone below the source (mg/l);

λ is the decay coefficient (day^{-1});

α_x, α_y, α_z are the dispersion lengths in the longitudinal (x), horizontal transverse (y) and vertical transverse (z) directions (m);

S_y, M_z are the width and thickness of the mixing zone (m);

R_f is the retardation factor;

K_d is the partition or distribution coefficient (l/kg);

r_b is the bulk density (g/cm^3);

t is the time since start of release from groundwater source (day).

This representation assumes linear equilibrium sorption; no consideration of competitive sorption is made. Decay of contaminants is represented by a first-order term (exponential decay) on both sorbed and dissolved components. Molecular diffusion in water is assumed negligible, since is it only likely to be of significance in very low permeable material. Spreading of the contaminant plume is represented by a dispersion coefficient that empirically found to be good representation when the coefficient is taken to be proportional to the groundwater velocity. At large time the concentration tends to a steady state which is all that has been modelled.

It should be noted that this maximum concentration and does not represent the concentration averaged over a depth. For instance it will therefore overestimate the concentration detected in water abstracted from a borehole at that location. The greatest plume length perpendicular to the pipeline occurs when the regional hydraulic gradient is oriented perpendicular to the pipeline.

Evaluation of the concentration at location x for steady state gives the deterministic result for one possible combination of parameters. The Monte Carlo approach is adopted to provide a probabilistic assessment of the whole ensemble of possible combinations (realisations). The concentration is evaluated at a given location for many different parameter sets chosen at random from the specified distributions of the input parameters.

5.3 Data used in the assessment of solute transport

5.3.1 Data provided by RSK

5.3.1.1 Organic carbon content

A limited number of analyses of organic material content have been carried out on dominantly finer grained sediments by Gibb (2001) along the pipeline route (Table 5.1). The chainage 281-322.5 km is geographically closest to the area of groundwater interest.

Table 5.1 Organic content of sediment samples taken along pipeline route by Gibb (2001), expressed as % organic matter

Chainage (km)	Range (%)	Median (%)	Location
129	0.62[a]	(0.62)	BVA5
153	0.43[a]	(0.43)	BVA6
90-216	0.43-0.90	0.48	
216-226	0.28-0.62	0.45	
226-244.5	0.22-0.32	0.27	
281-322.5	0.14[a]	(0.14)	

(a) single species only

Natural organic matter (NOM) can be converted to organic carbon (OC) either by:

- assuming a formula for organic matter of CH_2O, yielding OC/NOM = 0.4, or
- using Ranville and Macalady's (1997) empirical determination of OC/NOM = 0.5-0.6 on aqueous NOM.

Additional analyses have been performed on gravel and silt samples (Az10 to Az24) collected from near-surface exposures of sediments in October 2001, and analysed at

Caspian Environmental Laboratories (CEL). Due to a preponderance of large clasts in the gravel/cobble samples, obtaining definitive contents of organic carbon has proven difficult. However, in general, these analyses returned organic matter contents of:

- around 1% for gravels, with a range of some 0.4 to 2.3%. In terms of organic carbon, this corresponds to around 0.5% OC with a range 0.2 to 1.1%.
- around 4.4% for silts, with a range of some 2.8 to 6.1%. In terms of organic carbon, this corresponds to around 2.2% OC with a range 1.4 to 3.1%.

The two sets of determinations do not agree. One possible reason is that the samples analysed at CEL were near-surface samples, possibly contaminated by humic soil material, whereas the Gibb (2001) samples were recovered from trial pits or boreholes. The CEL results were therefore not used.

Where direct measurements of the partition coefficient K_d do not exist for a given contaminant, the following triangular distribution over uncertainty for the organic carbon in gravel:

Minimum: 0.025%; Most likely: 0.1%; Maximum: 0.5%

is used in the approximation $K_d = f_{oc} K_{oc}$, where K_{oc} is the organic carbon – water partition coefficient of the contaminant.

5.3.1.2 Sediment - water partition coefficient K_d

Sediment - water partition coefficients were determined at Caspian Environmental Laboratories (Baku) at three aqueous concentrations of benzene (100, 500 and 1000 µg/l) using a batch method. A sediment-water mass ratio of approximately 2:1 was used. The benzene solution-sediment mixture was agitated in sealed vessels for 14 hours, following which the sediment was allowed to settle for 1 hour before the aqueous phase was filtered. The filtrate was analysed by GC-FID. Process blanks were included to determine benzene losses and recovery, and the data in Table 5.4 have been corrected accordingly. These results suggest a distribution over uncertainty for the gravels aquifer of:

Minimum: 0.15 l/kg; Most likely: 0.41 l/kg; Maximum: 0.8 l/kg.

These values are slightly higher than the estimate from product of the organic carbon - water partion coefficient (K_{oc} = 62 l/kg; USEPA, 1999) and the fraction of organic carbon (Section 5.3.1.1):

Minimum: 0.015 l/kg; Most likely: 0.062 l/kg; Maximum: 0.31 l/kg.

Given the availability of site-specific data, the first probability distribution is used in the risk assessment.

Table 5.2 Sediment - water partition coefficients for benzene (l/kg) for four different sediment samples

Sample	Type	Benzene conc. (µg/l)	K_d (l/kg)	Average K_d (l/kg)	Soil characteristics
Az13	Gravel/cobbles	100	0.52	0.36	83.5% >4mm
		500	0.20		
		1000	0.35		
Az18	Silt	100	1.13	1.16	80% <63 ìm
		500	1.71		0% > 4mm
		1000	0.63		
Az20	Gravel/cobbles	100	0.27	0.25	85%>4mm
		500	0.15		
		1000	0.33		
Az21	Gravel/cobbles	100	0.61	0.63	44.8% > 4 mm
		500	0.53		
		1000	0.76		

5.3.1.3 Composition of crude oil

The composition of the ACG crude oil is unknown. Nyer and Skladany (1989) reports that the gasoline fraction (60-200°C) of Baku crude oil has a relatively high content of cycloalkanes (63%) and a low content of alkanes (29%) and aromatics (8%) compared with other crude oils from around the world.

5.3.2 Additional data required for the risk assessment

5.3.2.1 Effective solubility

The proportion of a crude oil constituent is required in order to estimate the reduction in solubility due to the presence of other hydrocarbons. Since only general information was available (Section 5.3.1.3), estimates have been made (Table 5.3). This parameter can readily be constrained by measurement. The resultant effective solubility is compared with the target water quality standards, and a ratio of the former to the latter is shown in the last column. This figure indicates the factor by which dilution and attenuation must reduce concentrations from the source area by the time the water reaches the receptor.

Table 5.3 Solubility, effective solubility and target water quality standards of selected contaminants

	Solubility (mg/l)	Percentage composition of crude oil (mole fraction)	Effective solubility (mg/l)	Target water quality standard (mg/l)	Effective solubility/ Target
Benzene	1780[a]	0.02[c]	35.6	0.01	3560
Toluene	558[a]	0.02[c]	11.2	0.02	560
Ethylbenzene	173[a]	0.02[c]	3.46	0.01	346
Xylene	186[a]	0.02[c]	3.72	0.02	186
Cyclohexane	55[b]	0.10[c]	5.5	0.1	55

(a) USEPA (1999)
(b) USEPA (1994)
(c) Estimate

5.3.2.2 Sorption and degradation properties

Since the partition coefficient (K_d) between the aquifer material and water is only available for benzene, K_d is estimated for the other contaminants as the product of the fraction of organic carbon (f_{oc}) and the partition coefficient between organic carbon and water (K_{oc}). Values for K_{oc} are given in Table 5.4. The minimum value, for m-xylene, is used to represent the modelled xylene, as a conservative assumption. Minimum and maximum half lives in aerobic groundwater are also presented in Table 5.4. It is uncertain whether these values apply to decay of total contaminant (dissolved and sorbed phases) or just contaminant in the dissolved phase. We applied the degradation process to the dissolved phase only, but also carried out a calculation to assess the sensitivity of the results to applying the degradation to immobile phases as well.

Table 5.4 Organic carbon/water partition coefficient and minimum and maximum half lives of selected contaminants

	K_{oc} (l/kg)	Min half life (d)	Max half life (d)
Benzene	62 [a]	10 [c]	720 [c]
Toluene	140 [a]	6 [c]	228 [c]
Ethylbenzene	204 [a]	7 [c]	28 [c]
m-Xylene	196 [a]	14 [c]	360 [c]
o-Xylene	241 [a]	14 [c]	360 [c]
p-Xylene	311 [a]	14 [c]	360 [c]
Cyclohexane	482 [b]	56 [b]	360 [b]

(a) USEPA (1999)
(b) USEPA (1993)
(c) Howard et al. (1991)

5.3.2.3 Bulk density

Since direct measurements of dry bulk density r_b are not available, the value is estimated on the basis of a grain density r_g of 2.65 g/cm^3, using the formula $r_b = r_g(1-n)$, where n is the porosity.

5.3.2.4 Dispersivity

Dispersion coefficients are generally unknown. They have been found to be dependent on the distance of travel L (e.g. Gelhar, 1993), and are often approximated by $a_x = L/10$, $a_y = L/100$, $a_z = L/1000$ in the longitudinal, horizontal transverse and vertical transverse directions, respectively. However at very large travel distances the dispersion appears to reach a limit. Due to the relatively high velocities in the aquifer, it is assumed that dispersion will not be large, therefore the dispersion coefficients are set to a_x = 10 m, a_y = 1 m and a_z = 0.1 m.

5.3.3 Base case parameter sets

The following table presents the central values for the base cases used in the transport modelling. The ranges of uncertainty used in probabilistic transport modelling are centred on these values and documented above.

Table 5.5 Base case parameters for transport modelling

Parameter	Symbol	Value	Unit
General hydrogeochemical parameters			
Hydraulic conductivity	K	50	m/d
Effective porosity	n	0.27	dimensionless
Hydraulic gradient	i	0.013	dimensionless
Bulk density	r_b	1.93	g/cm^3
Partition Coefficient Benzene	K_d	0.41	l/kg
Longitudinal dispersivity	a_x	10	m
Horizontal transverse dispersivity	a_y	1	m
Vertical transverse dispersivity	a_z	0.1	m
Case A Retention of the NAPL in the unsaturated zone (UZ source)			
Source width and length	S_y, S_x	1000	m
Infiltration rate	$\mathrm{I}nf$	50	mm/a
Effective solubility	S_{eff}	35.6	mg/l
Mixing zone depth	M_z	S_y/64 (=15.6)	m
Case B Formation of a NAPL lens at the water table (groundwater source)			
Source width and length	S_y, S_x	2660	m
Effective concentration in mixing zone	C_g	17.8	mg/l
Mixing zone depth	M_z	S_y/80 (=33.3)	m

5.4 Risk assessment results

5.4.1 Case A: Retention of the NAPL in the unsaturated zone

Run A0 Base case deterministic analysis

The analyses in this section are based on a source in the unsaturated zone of width and length 283 m. This is the dimension of source area that might occur with Spill Scenario 3 in the geological settings with the capacity to retain the leaked NAPL in the unsaturated zone (Geological Setting B and C). . It is the worst combination that can occur without spreading over the silt. The ‘base case’ parameters are shown in Table 5.5.

The base case has a groundwater velocity of 2.4 m/d. The mixing depth is estimated at 4.4 m. The dilution factor for this case is 75, i.e. dilution of the leachate by the groundwater flow brings about a reduction in concentration of 75.

Figure 5.4 shows the steady-state concentration profiles down the centreline of the plume for each of the chosen contaminants. The concentrations are divided by the concentration in the mixing zone (C_g) to provide a non-dimensionalised concentration. For each profile, the point at of first compliance with the target concentration is marked. These are at different fractions of the mixing zone concentration, reflecting the differing ratios of effective solubility to target water quality standard (Table 5.3). The concentration of benzene must be reduced by the greatest factor, whilst at the other extreme cyclohexane is already reduced to concentrations below the target water quality standard by dilution alone. For risk assessment purposes the length of the plume is the distance from the source area to the point at which the target concentration is achieved. Figure 5.4 shows that benzene has the longest plume for the base case parameters. Probabilistic analysis showed that this was also the case for the worst cases scenarios. Therefore, estimates of the extent of the vulnerable area should be based on an analysis of the transport of benzene. The transport of the remaining contaminants is not considered further in this report. The profiles displayed in Figure 5.4 exhibit the strong influence of exponential decline due to decay. As a conservative assumption, the decay has only been applied to the dissolved phase and not to the sorbed contaminant. In this case the decay coefficient is given by

$$l = \frac{\ln 2}{R_f \ t_{½}},$$

where $t_{½}$ is the literature value of the half life. Note Howard et al. (1991) suggests that the half lives are derived from field measurements of concentrations and should be applicable to the total contaminant mass in the aquifer. In may cases, due to the limited bioavailability, degradation process can only occur in the aqueous phase. As a conservative approach we have applied the half lives cited by Howard et al. (1991) to contaminants in the aqueous phase only. For comparison, the results for benzene with additional decay of the sorbed phase are also shown. In this case it leads to the prediction of a plume of less than half the length of the more conservative assumption.

The simulated plumes are long, particularly when compared with BTEX plume studies from the United States of America, which found that 90 % of BTEX plumes in groundwater are less than 100 m in length, with only the top 2 % are greater than 300 m in length. The aquifer conditions represented in this study are notable because of their high conductivity, relatively high gradients, and low sorptive capacity.

<u>Deterministic sensitivity analysis</u>

The effects of uncertainty of parameters on the resultant plume characteristics have been explored by both sensitivity analysis and Monte Carlo simulation. Figure 5.5 presents the results of the sensitivity analysis. Parameters have been varied singly from the central values of the deterministic base case. The following calculation s were undertaken.

Run A1 Hydraulic conductivity was changed to the maximum and minimum of the range of uncertainty. The hydraulic conductivity affects the concentration in the mixing zone, since it determines the quantity of dilution afforded by the groundwater flowing into the mixing zone. It also determines the velocity in the aquifer. These two processes act against each other, so that in increase in hydraulic conductivity increases dilution, but decreases residence time, thus reducing attenuation.Run A2 Porosity was changed to the maximum and minimum of the range of uncertainty. There is very little sensitivity to porosity within the range of values given for the aquifer.

Run A3 The mixing depth was scaled by a factor 5 and 0.2 (arbitrarily). The mixing depth influences the concentrations the mixing zone and vicinity, but does not have much influence on the plume length.

Run A4 The infiltration rate was scaled by a factor 2 and 0.5 (arbitrarily). The plume length is relatively sensitive to the infiltration rate.

Run A5 The partition coefficient K_d was changed to the maximum and minimum of the range of uncertainty The predictions are not sensitive to the values of the partition coefficient. Similar results were also obtained with the lower K_d values derived from the organic carbon – water partition coefficient and the organic carbon coefficient (not shown in the figure).

Run A6 The transverse dispersion was switched off to show the likely plume length if the aquifer is shallow or there are nearby lateral boundaries which prevent transverse dispersion. The result for this case shows a significant lengthening of the plume, showing aquifer boundaries to be an important factor.

Run A7 The half life was changed to the maximum and minimum of the range of uncertainty. The predictions are extremely sensitive to the specified range of degradation rates. When literature values are used there is also added uncertainty about the applicability of the data, including whether the rate applied to dissolved and sorbed phases, or just the former.

Run A8 The source dimensions were changed to correspond to selected spill scenarios and geological settings. The last graph of Figure 3.8 gives an indication of the influence of the source length and width (i.e. mixing zone dimensions) on the length of the plume. This cases shown are

(a) Length 100 m (relating to Spill Scenarios 1 and 2, assuming there is no lateral spreading). This results in a plume length of 1250 m.

(b) Length 283 m (relating to Spill Scenarios 3, assuming there is no lateral spreading). This results in a plume length of 2500 m.

(c) Length 1000 m (relating to a spill scenario where there is significant lateral spreading in the unsaturated zone due to, for example, a low permeability band). This results in a plume length of 3875 m.

In general terms, it can be seen that the large ratio of effective solubility to target concentration for benzene means that many half lives of degradation are required to achieve target concentrations. The high travel velocity means that the point at which this is achieved may correspond to very large plumes.

These analyses provide some understanding of the way in which individual parameters affect the plume characteristics.

Probabilistic analysis

In order to examine probability distribution of the concentrations along the profile as a result of the distributions of input parameters Monte Carlo simulations have been carried out. Figure 5.6 shows the frequency distribution of the average linear velocity of the groundwater and the factor of dilution achieved in the mixing zone. The values of average linear velocity are relatively high, ranging from approximately 1 m/d to 6.4 /d. Figure 5.7 shows the probability distributions at selected locations along the centreline of the plume, together with the base case concentration profile. The percentiles of realisations complying with the target water quality standard are given. Whilst the length of the ‘base case’ plume is approximately 2500 m (coincident with the 50th percentile), the combination of parameters constituting the worst case is more than double that length, at nearly 5500 m. It is noted that the percentiles should not be interpreted as likelihood of occurrence, since a number of worst case assumptions are built into the specification of the scenarios. Since the deterministic sensitivity showed the degradation rate to be a key uncertain parameter a second probabilistic run was carried out to investigate the consequences of allowing degradation to take place in the sorbed phase as well as the dissolved phase. The result is a much shorter plume, with the worst case scenario having a plume length of just over 2000 m.

5.4.2 Case B: Formation of a NAPL lens at the water table

The results presented in this section are based on a source of length and width each 2660 m. This corresponds to the worst case estimate of the spread of a NAPL lens at the water table (for Spill Scenario 3 and the thinnest unsaturated zone (Geological Setting A).

The conclusions regarding the benzene plume length in comparison with the simulated lengths of the plumes of the other contaminants also apply for this scenario, therefore only the results of transport calculations for benzene will be presented.

Run B0 Base case deterministic analysis

In the base case the steady-state benzene concentration on the centreline of the plume first sinks below the target standard at a distance of 8875 m downgradient of the end of the NAPL lens. This is considerably longer than the length of the base case plume of the previous section, confirming that the case of formation of a NAPL lens at the water table poses a much greater risk to the groundwater than the scenario of retention in the unsaturated zone.

Deterministic sensitivity analysis

The sensitivity of the simulated concentration profile to the input parameters is shown in Figure 5.9. Several of the characteristics are consistent with the previous case, including the extreme sensitivity to the range of decay rates. However, the following differences are noticed:Run B1 Hydraulic conductivity was changed to the maximum and minimum of the range of uncertainty. Sensitivity to the hydraulic conductivity is greater than in Case A. This is because there are no longer the two counteracting effects on dilution and residence times. In this scenario the hydraulic conductivity does not affect the concentration in the mixing zone – it only affects the velocities, and hence the time available for biodegradation to take place.

Run B2 Hydraulic conductivity was switched off. Transverse dispersion is not important in this case. This is due to the large width of the source area: the transverse dispersion is only effective on a small proportion of the whole plume width.

Run A8 The source dimensions were changed to correspond to selected spill scenarios and geological settings. The influence of the source dimensions is shown in the last graph of Figure 5.9. The scenarios presented are:

a) Base case: source dimensions 2660 m, relating to maximum spread of the NAPL lens for Spill Scenario 3. For the parameter set of likeliest values, the corresponding plume length is 8875 m.

b) Source length and width = 1000 m, relating to the maximum spread of the NAPL lens for Spill Scenarios 1 and 2, should the NAPL reach the water table. The plume length is then 7800 m for the likeliest set of parameters.

c) Source length and width = 300 m, relating to the minimum spread of the NAPL lens for Spill Scenarios 3, should the NAPL reach the water table (i.e. assuming that there is limited spreading away from the spill area). The plume length is then 6200 m for the likeliest set of parameters.

Probabilistic analysis

Figures 5.10 and 5.11 show probability distributions at selected locations along the length of the plume, together with the base case concentration profile. When only decay of the dissolved phase is simulated, the worst case leads to a plume length of over 20 km, as opposed to the 50th percentile at around 8 km. If decay of both sorbed and dissolved phases can be assumed, then these lengths are reduced to 12 km (worst case) and just over 2 km (50th percentile), respectively.

6 ASSESSMENT OF THE INFLUENCE OF AN ABSTRACTION BOREHOLE

6.1 Introduction

This section briefly considers the impact of an abstraction borehole on the migration of the crude oil and its dissolved phase. In terms of the influence of an abstraction on the scenarios analysed in Sections 4 and 5, the main issues are as follows:

1. The drawdown in groundwater caused by the abstraction may result in NAPL floating on the water table to flow towards the borehole.
2. Drawing water to the borehole increases groundwater velocities and therefore reduces groundwater residence time and the capacity for attenuation in the aquifer by degradation.

On the optimistic side, if the capture zone of the well is not completely contained within the plume, the abstraction may provide dilution by:

3. Mixing the plume with deeper uncontaminated groundwater
4. Diluting the contaminated water with groundwater drawn in from another area of the aquifer.

The first two issues are examined quantitatively in the remainder of this section.

6.2 Modelling approach

The groundwater gradient and velocity are estimated by the steady state solution for a constant rate of abstraction (Q_{well}) from an unconfined aquifer. The groundwater head is given by solution of the differential equation

$$Q = 2p\ r\,K\,h\frac{\partial h}{\partial r}$$

Assuming a saturated thickness of H and a radius of influence of the well R_w, then the head h at distance r from the centre of the well is given by

$$h = \sqrt{H^2 - \frac{Q}{p\ K}\ln\left(\frac{R_w}{r}\right)}$$

where K is the hydraulic conductivity of the aquifer If the head near the well is approximately the same as the saturated thickness, then the drawdown in a thick aquifer can be expressed as

$$s = H - h = \frac{Q}{2p\ T}\ln\left(\frac{r}{R_w}\right)$$

The gradient of the water table in the vicinity of the well is given by

$$\frac{\partial h}{\partial r} = \frac{Q}{2p\ r\,K\,h}$$

The velocity of the groundwater is

$$\frac{K}{n}\frac{\partial h}{\partial r}$$

where n is the effective porosity of the aquifer. The solution does not include recharge to the aquifer. The aquifer is assumed to be unbounded, so that there is a constant flow to supply the abstracton. In theory, this solution therefore implies an infinite radius of influence.

However, as an approximation, the radius of influence is calculated as the radius of the area required to support the abstraction from recharge alone, i.e.

$$R_w = \sqrt{\frac{Q}{p \;\; Inf}}$$

where Inf is the infiltration rate.

Since the equations for unconfined groundwater flow are nonlinear, particularly for shallow aquifers, it is not always appropriated to superimpose the drawdown for the abstraction on the the natural hydraulic head distribution. To assess the impact of the well, the hydraulic gradient and groundwater velocity due to the well alone are compared with the natural gradient and velocity. The aim is thereby to simply quantify the distance from the well at which the influences are comparable.

6.3 Results of the risk assessment

The results in this section refer to an abstraction of 20 l/s (1700 m^3/d), as specified by RSK (2001).

The drawdown of well is largest for low values of hydraulic conductivity, however the effects are more localised than in aquifers with higher conductivity. Assuming an infiltration rate rate of 50 mm/a, the radius of influence is evaluated at 2000 m. As a result of the relatively high conductivity of the gravels the well has little influence on the groundwater conditions. Table 6.1 shows the distance from the well where the gradient of the water table is larger than the regional hydraulic gradient (when considering the well only). The effects are very local to the well, but increase in extent as the aquifer becomes shallower. The distances in the table are also the radii of the areas having groundwater velocities higher than the average linear velocity of the regional flow.

Table 6.1 Impact of abstraction on the water table

Saturated aquifer thickness (m)	Distance at which the hydraulic gradient due to well drawdown is greater than the regional gradient (m)	
	K **= 10 m/d**	***K*** **= 50 m/d**
20	61	23
50	22	9
100	11	4.5

Note the selected abstraction rate is not necessarily conservative. Large wells will capture water from a larger region of the aquifer, possibly benefiting from additional dilution, but this might be outweighed by higher concentrations in water captured by the well due to faster travel into the zone of drawdown and correspondingly less opportunity for degradation.

7 DISCUSSION AND CONCLUSIONS

7.1 Summary of results

The overall assessment of the impact of a pipeline breach on the groundwater must be based on

- the dimensions and location of the source area (Section 4)
- the length of the solute plume (Section 5),

as illustrated in Figure 5.1. The following sections summarise the results of the deterministic evaluation, sensitivity analysis and probabilistic analysis.

7.2 Probabilistic analysis of the two base cases of NAPL source location

The probabilistic analysis of the effects of parameter uncertainty calculates percentile of concentrations at a given location that comply with the target quality standard. In our analysis we have selected the 90th percentile to represent a conservative assessment of possible plume lengths. The results for the two base cases of NAPL source location are shown in Table 7.1.

Table 7.1 Results of probabilistic analysis

Base Case	**A**	**B**
Scenario Description	Retention of the NAPL in the unsaturated zone	Formation of a NAPL lens of at the water table
Source Width and Length (m)	283	2660
Plume length (based on compliance of 90th percentile concentration) (m)	4800	20000

7.3 Deterministic results showing sensitivity to source dimensions

Deterministic sensitivity calculations compared the length of the plume for different source sizes with all other transport parameters set to central values over uncertainty. The results for the two NAPL source location cases are shown in Table 7.2 and Table 7.3. On the basis of these results a plume scaling factor is calculated to extrapolate the probabilistic results to sources of other dimensions.

Table 7.2 Results of deterministic sensitivity analysis: NAPL Source Case A

Base Case	**A**			
Scenario Description	Retention of the NAPL in the unsaturated zone			
Source Width and Length (m)	100	283	1000	2800
Plume length (based on compliance of 90th percentile concentration) (m)	1250	2500	3875	4750
Plume scaling factor	0.5	1	1.55	1.9

Table 7.3 Results of deterministic sensitivity analysis: NAPL Source Case B

Base Case		**B**	
Scenario Description	Formation of a NAPL lens of at the water table		
Source Width and Length (m)	300	1000	2660
Plume length (based on compliance of 90th percentile concentration) (m)	6200	7800	8875
Plume scaling factor	0.70	0.88	1

Other deterministic calculations were summarised in Section 5.4 and showed that the key uncertainty affecting the plume length was the degradation rate.

7.4 Results for the geological settings and spill scenarios

In Table 7.4 the probabilistic results are extrapolated to the different combinations of geological setting and spill scenario. The source may be predominantly a NAPL lens at the water table, a pool above a low permeability layer or a residual source retained in the unsaturated zone. The lengths of the resulting solute plumes are derived (either directly or by extrapolation) from distance at which the 90th percentile concentration complies with the quality standard. The dimensions of the NAPL source area and plume length are translated into maximum distances of vulnerability upgradient (L_{up}) and downgradient (L_{down}) of the pipeline, under the assumption that the source are spreads out symmetrically under the pipeline.

Table 7.4 Overview of scenarios: estimates of upper bounds of extent of vulnerable aquifer

	Geological Setting (Unsaturated Zone)		
	A (3m Gravel)	**B (15m Gravel)**	**C (2m Gravel, 4m Silt, 9m Gravel)**
Spill scenario 1	Residual in UZ, Lens at water table	Residual in UZ, Lens at water table	Residual in UZ, Spreading above silt
L_{spill} = 0.055 km	L_{lens} = 1.13 km	L_{lens} = 0.95 km	L_{lens} < 1.14 km
	L_{plume} < 18 km	L_{plume} < 18 km	L_{plume} < 7.2 km
	L_{up} = 0.55 km	**L_{up} = 0.50 km**	**L_{up} = 0.55 km**
	L_{down} = 18.5 km	**L_{down} = 18.5 km**	**L_{down} = 4.0 km**
Spill scenario 2	Residual in UZ, Lens at water table	Residual in UZ	Residual in UZ, Spreading above silt
L_{spill} = 0.100 km	L_{lens} = 1.03 km	L_{source} = 0.100 km	L_{pool} < 1.08 km
	L_{plume} < 18 km	L_{plume} < 2.4 km	L_{plume} < 7.2 km
	L_{up} = 0.50 km	**L_{up} = 0.05 km**	**L_{up} = 0.50 km**
	L_{down} = 18.5 km	**L_{down} = 2.45 km**	**L_{down} = 4.0 km**
Spill scenario 3	Residual in UZ, Lens at water table	Residual in UZ	Residual in UZ, Spreading above silt
L_{spill} = 0.283 km	L_{lens} = 2.66 km	L_{source} = 0.283 km	L_{pool} < 2.80 km
	L_{plume} < 20 km	L_{plume} < 4.8 km	L_{plume} < 9.1 km
	L_{up} = 1.33 km	**L_{up} = 0.14 km**	**L_{up} = 1.4 km**
	L_{down} = 21.3 km	**L_{down} = 5.0 km**	**L_{down} = 10.5 km**

7.5 General discussion

The figures presented above should not be viewed in isolation: reference should be made to the data, modelling approach, assumptions, sensitivity to individual parameters, and probabilistic distribution of results.

The results are likely to be conservative for a number of reasons, including:

- the selected scenarios combine a number of worst case conditions and assumptions;
- the analytical solutions and scoping calculations make simplifying assumptions which are generally conservative and neglect process that may serve to limit the extent of the crude oil migration;
- the solute transport assumes a source of constant concentration, so that an infinite mass of contaminant is available for release from the source.

- the worst case for the solute transport is likely to be a parameter set combining the limits of plausible value ranges;
- the plume length is based on the maximum concentration at a given distance downgradient of the source area.

7.6 A note on finite plume volumes

The analyses are based on a steady state analytical solution which assumes that the concentration in the source area is at constant concentration for all time. For very large plume lengths the mass in the plume (as total of dissolved and sorbed contaminant) may be of the order of magnitude of the total mass of contaminant in the source area. In reality, the plume will become detached from the source area. Whilst the plume will reach the distance predicted, the peak concentration will be slightly reduced and the plume will degrade until the free product is depleted. Therefore the worst case plume may not be of very persistent concern.

7.7 Impact of an abstraction

Initial assessment of the impact of an abstraction on the above analysis showed that the well is unlikely to cause any alteration of the flow fields and contaminant migration unless it is located very near to a NAPL lens floating on the water table and/or the aquifer is very shallow (Section 6). Unless the capture zone of the well is wholly contained in the contaminant plume extra dilution by uncontaminated groundwater should occur.

7.8 Conclusions

The data and information describing the region of interest suggest that the natural groundwater velocities are relatively fast. The geological settings selected by RSK (2001) for the groundwater risk assessment mainly comprise highly conductive strata, which would allow fast infiltration, relatively little retention capacity in the unsaturated zone, and substantial lateral spreading of the crude oil at the water table. In such conditions, the aquifer is fairly vulnerable in the event of a pipeline leakage. Silt strata, where present, may serve to limit the depth of penetration of the crude oil, but could lead to wider near surface contamination of the unsaturated zone over a larger area than that of the initial spill.

In order to identify the extent of impact of an oil spill on the groundwater resources, this study has used:

- Initial scoping calculations to derive the location of the crude oil in the unsaturated zone, including the dimensions of the source area in terms of contaminated area of unsaturated zone and lens at the water table.
- Analytical solutions of solute transport in the saturated zone, assessing the travel distance over which the contaminants are attenuated to below water quality standards. Taking into account (a) the potential for dilution and attenuation in the aquifer and (b) the ratio of source concentration to target standard, benzene should be used in the determination of a maximum plume length.

The zone of aquifer vulnerability is the sum of the source area and the potential area of a groundwater plume. A summary for each of the individual geological settings and spill scenarios is given in Section 7.1. The maximum potential area affected is relatively large, and significantly higher than many known cases of contamination (c.f. plume length studies in the United States of America, where the majority of BTEX plumes were found to have lengths of less than 100 m, despite many different geological environments). It should be recognised that the scenarios simulated in this study do not constitute the whole range of possible outcomes: several worst case assumptions are made, in addition to the range of uncertain parameters for the solute transport consideration. In the same way, the probabilistic analyses should not be interpreted in terms of likelihood of representation of reality. In fact, the worst outcome, as the combination of several worst case scenarios and the extreme plausible value of various input parameters is very unlikely to happen.

8 RECOMMENDATIONS

8.1.1 Recommendations for further data collection

Reliability in predictions of the migration of the crude oil phase would be increased by measurement of the following:

- Retention capacity of gravels and silts, that is, the residual oil saturation that would be trapped in the pores under drainage in the unsaturated zone, or below the water table as levels fluctuate seasonally or in response to groundwater abstractions;
- Functional relationships for the capillary behaviour and mobility of the three fluids (air, water and oil), measurements of two-phase capillary pressure-saturation curves and relative permeability curves to aid the prediction of likely ponding depths greatly enhance the reliability of any numerical modelling;
- Properties of the ACG crude oil at the subsurface temperature (15 °C), including surface tension, interfacial tension and dynamic viscosity.

Probabilistic analysis of the transport of solutes in the saturated zone shows a wide range of possible plume lengths resulting from the uncertainty in the input parameters. Reducing the uncertainty in any of the parameters will reduce the spread of predicted plume lengths. In particular, the sensitivity analysis shows that the uncertainty in the degradation rates has enormous impact. Unfortunately this is likely to be specific to the site of a spill, including the geological, hydrogeochemical and microbial conditions. Data on the composition of the ACG crude oil would allow more accurate calculation of the concentrations of the individual components in the groundwater passing through the source area.

8.1.2 Recommendations for further modelling

Further assessment of the migration of the crude oil phase would be of benefit. Numerical modelling of selected scenarios would be able to explore the characteristics of the different spill scenarios and geological settings. In particular these should focus on the following:

- Geological Setting 1 (3 m gravel unsaturated zone) and Spill Scenario 3 (large area, but low volume/area). This combination has the potential for creating the largest NAPL lens at the water table.
- Geological Setting 2 (15 m gravel unsaturated zone) and Spill Scenario 1 (smaller area, but high volume/area). The geological setting can potentially retain the spills with lower volume/area. The first scenario has a much larger volume per unit area. The leak is at a lower rate, so that there may be increased lateral spreading in the unsaturated zone; a lens at the water may be formed.
- Geological Setting 3 (gravel/silt sequence) and Spill Scenario 3 (large area, but low volume/area). This has the potential for impact on the widest area of the unsaturated zone, through spreading above the silt horizon.

The effects of the gradient of the water table on the migration of the NAPL should be assessed within the framework of numerical modelling, so that the combined effect of capillary, viscous and gravitational forces can be taken into account.

In cases where the NAPL is only retained in the upper fraction of the unsaturated zone, the attenuation processes in the unsaturated zone should be considered.

The assessment of solute transport is based on the assumption that the aquifer is deep. If there are locations where the aquifer is shallow (under 50 m, say), there may be reduced potential for dilution through vertical mixing and dispersion; the effect of this on the plume length should be assessed.

The impact of vapour transport in the unsaturated zone and partitioning into the groundwater should be investigated. However, since groundwater velocities are so high, it is felt that this is unlikely to be the most significant source of groundwater contamination downgradient of the site, although it may be important at short time scales.

More detailed analysis integrating the representation of the source development and the transport process would account for the finite mass involved in the spill scenario and predict in more detail the time and duration of the impact at the outer edge of the zone of uncertainty.

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PART 6B: SUMMARY OF GROUNDWATER MODELLING IN THE GANJA-KAZAK-KARAYAZI AQUIFERS

List of Tables

1 PART 6B: SUMMARY OF GROUNDWATER MODELLING IN THE GANJA-KAZAK-KARAYAZI AQUIFERS

1.1 HYDROCARBON CONTAMINATION STATISTICS AND CASE STUDIES

Newell and Connor (1998) cite the results of 604 studies of dissolved hydrocarbon (mainly BTEX) groundwater plumes in the USA. The following statistics were noted:

- Around 75% of plumes were less than 61m long
- The maximum plume length encountered was 920 m
- The median length was 40m

These statistics suggest that plumes of dissolved hydrocarbon in excess of 1 km long are very rare. It must be noted that much of the data are based on relatively limited leakages from underground storage tanks, which are unlikely to be directly comparable to a major spill from a crude oil pipeline.

Probably the best-documented example of groundwater contamination from a major crude oil pipeline is that at Bemidji, Minnesota, USA (Eganhouse et al. 1994, Essaid 1994). A leakage in 1979 sprayed 1670 m^3 of crude oil over an area of some 6500 m^2. After surficial cleanup, an estimated 410 m^3 had infiltrated the ground (glacial outwash sediments: fine-to-medium sands with some gravel and clay and water table at 6-10m depth). The spill resulted in a non-aqueous phase liquid (NAPL) body in the subsurface some 7-8m high and some 70-80m long. The estimated groundwater flow velocity in the aquifer was 0.05 to 0.5 m/d in the fine and coarse layers respectively. By 1994, the plume of dissolved phase hydrocarbon contamination in groundwater had been stable for at least 8 years and was only some 200m long.

These historical figures can be used as "reality checks" for the findings of modelling described in the remainder of this section.

1.2 MODELLING OF GROUNDWATER CONTAMINATION

The potential for contamination of groundwater has been assessed (see Part 6a of the Technical Appendices) by applying the relatively simple concept of "retention capacity" in the unsaturated zone, in combination with analytical models for the transport of dissolved phase hydrocarbon (ESI 2002). *This modelling work was not designed to simulate specific geological conditions along the pipeline route. Rather it was designed to assess the implications of major spill scenarios in designated "worst case" geological situations and to investigate the significance of various parameters in controlling the size of the resultant contaminant plume.*

BP has suggested three plausible leakage scenarios to be considered (Table 1-1). Explanation of their derivation and assumptions made about these are documented in Part 6a of the Technical Appendices.

Table 1-1 Suggested net losses to the subsurface and areas of ground subject to oil infiltration for each of BP's three spill scenarios. Note that actual losses and affected areas will depend on mode of spillage, ground conditions and rapidity of cleanup response.

Scenario	Rate (l/s)	Duration (hrs)	Gross volume (m^3)	% Surface cleanup	Net loss (m^3)	Area (m^2)	Dimension =(Area)½ (m)	Spill density (l/m^2)
1	2	200	1,440	30	1,008	3,000	55	336
2	100	8	2,880	65	1,008	10,000	100	101
3	1,800	3.1	20,000	65	7,000	80,000	283	88

The major groundwater resources along the pipeline corridor occur in the region between Geranboi and the Georgian border, within proluvial and alluvial deposits, generally comprising alternating coarser grained gravels, pebbles and sands (aquifer horizons) and silts and clays (aquitards). The water table may range from very close to the surface (near river valleys or wetland areas) to depths of over 25 m. It is clearly not feasible to model the hydrogeological detail of all possible spill locations along the pipeline route.

For the purposes of modelling, three generic "worst case" scenarios have been chosen, involving a gravel aquifer, with differing geological conditions in the unsaturated zone (Table 1-2).

Table 1-2 Selected geological scenarios for modelling exercise.

SCENARIO	THICKNESS OF UNSATURATED ZONE	GEOLOGICAL COLUMN (UNSATURATED ZONE)	GEOLOGY (SATURATED ZONE)
i	3	Gravel (3 m)	Gravel (no base of aquifer specified)
ii	15	Gravel (15 m)	Gravel (no base of aquifer specified)
iii	15	Gravel 2m Silt 4m Gravel 9m	Gravel (no base of aquifer specified)

The objective of the modelling has been to identify a zone adjacent to the pipeline route within which receptors may be at risk from the consequences of a leakage and for which a mitigatory action plan should be devised. Migration of contaminants under ambient natural water table gradient has been assumed. Modifications of water table gradient by pumping boreholes were not considered, nor were dilution effects caused by mixing of clean and contaminated inflow in wells.

For reasons explained by ESI (2002), modelling of dissolved phase contamination has focussed exclusively on benzene (C_6H_6), with a compliance concentration of 10 µg/l being used for definition of the edge of a contaminated groundwater plume.

1.3 NAPL BEHAVIOUR IN THE UNSATURATED ZONE

The migration of oil within the unsaturated zone has been estimated using the concept of retention capacity R. The behaviour of the NAPL on encountering the water table or a low permeability layer (such as silt) has been assessed by two methods:

- The simple concept of retention capacity F at the capillary fringe (Pastrovich et al. 1979)
- The concept of pore threshold entry pressure, which is dependent on oil properties and grain size (ESI 2002).

A range of aquifer parameters was assessed using these methods, as detailed in Table 1-3.

Table 1-3 Input parameters used for simulation of NAPL behaviour in the unsaturated zone and on the water table

	RANGE INVESTIGATED	SOURCE OF DATA
Retention capacity (R) (l/m3)	Gravel: 5-20 l/m3 Silt: 40-80 l/m3	Literature sources including Bundesministerium Bonn (1970), Dietz (1971), Pastrovich et al. (1979), Kristiansen (1983), Testa and Paczkowski (1989), Storrø and Banks (1992), Brost and DeVaull (2000)
Retention capacity at the capillary fringe (F) (l/m2)	5-12 l/m2	
Air-NAPL-solid wetting angle	150-170°	ESI (2002)
NAPL surface tension (dyn/cm)	23.7-26.1	ESI (2002)
Grain size for calculation of pore opening (mm)	Gravel: 0.9 - 15 Silt: 0.0025 - 0.03	Grain size distribution curves for sediment (RSK 2002, ESI 2002) based on d10 to d50 grain sizes

Results obtained using the simple concept of retention capacity are presented in Table 1-4. Use of pore threshold entry pressures resulted in broadly similar findings, with similar or smaller pancake areas being found for a grain size of 0.9mm and considerably larger pancakes for a grain size of 15mm.

Table 1-4 Estimates of extent of LNAPL lens/pancake on the water table for each of the spill scenarios in Table 10.13.1 and hydrogeological scenarios in Table 10.13.2. The dimension of the pancake is defined as the square root of the area.

			HYDROGEOLOGICAL SCENARIO						
			I		II			III	
SPILL SCENARIO	R GRAVEL L/M3	F L/M2	AREA KM2	DIMENSION KM	AREA KM2	DIMENSION KM	R CLAY L/M3	AREA KM2	DIMENSION KM
1	5	5	0.19	0.44	0.16	0.40	40	0.07	0.27
							80	0	0
	15	12	0.07	0.27	0.03	0.17	40	0.003	0.05
							80	0	0
2	5	5	0.17	0.41	0.05	0.23	40	0	0
							80	0	0
	15	12	0.05	0.22	0	0	40	0	0
							80	0	0
3	5	5	1.16	1.08	0.20	0.45	40	0	0
							80	0	0
	15	12	0.28	0.53	0	0	40	0	0
							80	0	0

The following observations may be made:

- The largest LNAPL lens is produced by spill scenario 3 (full rupture) in geological scenario i (3m unsaturated zone comprised of gravels), with a low retention capacity of 5 l/m^3. This produces a lens of over 1 km^2. The most vulnerable sites are thus areas where the unsaturated zone is thin and comprised of coarse pebbly / gravelly material (e.g. river valleys and some parts of the Karayazi plain).
- In geological scenario i, all three spill scenarios result in a lens of LNAPL on the water table. In geological scenario ii (15 m gravel in unsaturated zone), spill scenario 1 results in a lens of LNAPL on the water table, due to the high oil loading per unit area. Spill scenarios 2 and 3 only result in LNAPL lenses if the retention capacity of the gravels is very low (5 l/m^3). The size of LNAPL lens predicted by most

combinations of parameters, where LNAPL penetrates to the water table, has a typical area of 0.03 to 0.28 km^2 (dimension 200 to 500 km). Where the water table is in finer-grained strata, thicker but less extensive lenses would be expected.

- In geological scenario iii (2 m gravel over 4 m silt over 9 m gravel), only spill scenario 1 in combination with low values of retention capacity results in a lens of LNAPL on the water table, due to the high oil loading per unit area. For all other spill scenarios, the silt layer offers very effective protection to the water table from LNAPL phase. In fact, for spill scenarios 2 and 3, typically only 2 m of silt is required to offer adequate retention capacity. Hydrocarbon may form a pool on the silt layer, whose size depends on the grain size distribution at the top surface of the layer.
- The modelling takes into account only capillary forces and hence has a tendency to overestimate the size (and potency) of LNAPL pancakes as a contaminant source. It does not take into account:
    - viscosity
    - depression of the water table by the LNAPL lens
    - changes in oil properties at the surface or in the unsaturated zone (increase in viscosity and depletion in volatile components such as benzene). Yaron (1989) notes an increase in viscosity of spilled Norwegian crude oil from 18.8 mm^2/s to 56.0 mm^2/s during 48 hours.

1.4 ANALYTICAL MODELLING OF DISSOLVED PHASE HYDROCARBON MIGRATION

ESI (2002) have considered two main scenarios for dissolved phase migration:

- Case A. NAPL phase retained in the unsaturated zone. Dissolved phase components leached down to the water table with recharge water
- Case B. LNAPL lens forms on water table. Hydrocarbon components dissolve in groundwater according to Raoult's Law and mix with underlying groundwater according to an algorithm presented by Grathwohl (1998)

Migration of the dissolved phase contaminant plume is simulated by the Ogata-Banks (1961) equation, also cited by Domenico (1987), for three dimensional transport, considering advection, dispersion, sorption and first order decay (biodegradation). Input parameters for the model are summarised in Table 1-5. Modelling results for the maximum distance of travel of dissolved benzene (at 10 µg/l), irrespective of time, for various combinations of input parameters are summarised in Table 1-6. The rate of transport of dissolved benzene contamination in groundwater is shown in Table 1-7.

Table 1-5 Input parameters used by ESI (2002) for modelling of migration of dissolved phase contamination.

PARAMETER	BASE CASE VALUE	RANGE INVESTIGATED
Hydraulic conductivity (gravel) (K)	50 m/d	20 -170 m/d
Effective porosity (gravel)	27%	24 - 36 %
Hydraulic gradient	0.013	/
Bulk density	1.93 g/cm3	/
Longitudinal dispersivity	10 m	/
Horizontal transverse dispersivity	1 m	/
Vertical transverse dispersivity	0.1 m	/
Biodegradation half life	365 days	10-720 days
Case A. Source = retained oil in unsaturated zone only (no lens at water table)		
Source width / length (Sy, Sx)	283 m	100-1000 m
Infiltration rate	50 mm/a	25-100 mm/a
Effective solubility (benzene)	35.6 mg/l	/
Mixing zone depth	Sy/64	
Case B. Source = lens at water table		
Source (lens) width / length (Sy, Sx)	2660 m	300-2660 m
Effective concentration in mixing zone	17.8 mg/l	/
Mixing zone depth	Sy/80	
Kinetics of Migration		
Benzene partition coefficient	0.41 l/kg	0.06-0.8 l/kg
Retardation factor for benzene	3.8	1.4-6.5

Table 1-6 Sensitivity analysis of modelling results for dissolved contaminant migration. The most likely scenarios are shown in italics

CASE A. SOURCE = NAPL RETAINED IN UNSATURATED ZONE	LENGTH OF PLUME (BENZENE > 0.01 MG/L)
Base case A	2,500 m
Base case A, but with Sxy = 100 m	1,250 m
Base case A, but with Sxy = 1000 m	3,875 m
Base case A, but K = 20 m/d	1,625 m
Base case A, but K = 170 m/d	2,875 m
Base case A, but t1/2 = 10 days	187 m
Base case A, but t1/2 = 720 days	4,125 m
Base case A, but infiltration = 25 mm/a	1,875 m
Base case A, but infiltration = 100 mm/a	3,188 m
Base case A, but with decay of sorbed phase	875 m
Base case A, but K = 20 m/d and infiltration = 25 mm/a	1,350 m
Base case A, but K = 20 m/d and decay of sorbed phase	525 m
Base case A, but K = 20 m/d, infiltration = 25 mm/a and decay of sorbed phase	450 m
Base case A, but with Sxy = 1000 m and decay of sorbed phase	1200 m
CASE B. SOURCE = LNAPL PANCAKE ON WATER TABLE	
Base case B	8,875 m
Base case B, but with Sxy = 1000 m	7,875 m
Base case B, but with Sxy = 300 m	6,250 m
Base case B, but K = 20 m/d	3,750 m
Base case B, but K = 170 m/d	> 10 km (0.95 mg/l at 10 km)
Base case B, but t1/2 = 10 days	375 m
Base case B, but t1/2 = 720 days	> 10 km (0.18 mg/l at 10 km)
Base case B, but with decay of sorbed phase	2,500 m
Base case B, but with Sxy = 300 m and decay of sorbed phase	1,875 m
Base case B, but with Sxy = 300 m and K = 20 m/d	2,875 m
Base case B, but with Sxy = 300 m and K = 20 m/d and decay of sorbed phase	875 m
Base case B, but with Sxy = 650 m and K = 20 m/d and decay of sorbed phase	1,000 m

For the following reasons, the italicised scenarios in Table 1.6 are regarded as being the most realistic worst case scenarios:

- The heterogeneity of the sedimentary facies suggests that K=20 m/d is a more realistic "worst case" bulk hydraulic conductivity, representative of the entire flow path of a contaminant plume, than the "base case" value of 50 m/d (derived from "point" determinations of gravel samples from individual boreholes or trial pits)
- The high potential evapotranspiration (600-800 mm/a) and modest rainfall (around 400 mm/a) suggest that direct infiltration is likely to be very modest (Kashkay and Aliyev (*undated*) and Ali-Zadeh et al (*undated*)), and close to the lower end of the range of uncertainty in Table 1-5
- Source sizes in the unsaturated zone are unlikely to exceed a dimension of 1 km
- Some decay of sorbed phase hydrocarbon is likely

Table 1-7 Average distances of migration of benzene contamination in groundwater assuming hydraulic conductivities of 20 and 50 m/d, a "worst case" retardation factor of 1.4, a hydraulic gradient of 0.013 and no dispersion.

K (m/d)	DISTANCE OF CONTAMINANT FRONT FROM EDGE OF LNAPL PHASE, NEGLECTING EFFECTS OF DISPERSION		
	After 90 days	After 6 months	After 1 year
20 m/d	62 m	126 m	252 m
50 m/d	155 m	314 m	628 m

1.5 CONCLUSION

Modelling of "realistic worst case" scenarios for contaminant migration in the subsurface, resulting from a pipeline leakage in the section between Geranboi to the Georgian border suggests that:

- Where the NAPL phase is retained in the unsaturated zone, concentrations of dissolved hydrocarbons are unlikely to exceed specified compliance criteria (10 µg/l for benzene) by 2km downstream of the NAPL phase, even if no intervention is undertaken
- Where NAPL forms a lens on the water table, concentrations of dissolved hydrocarbons are unlikely to exceed specified compliance criteria (10 µg/l for benzene) by 2.9km downstream of the NAPL phase, even if no intervention is undertaken
- Given the likely dimensions of LNAPL lenses, it is thus regarded as unlikely that non-compliant concentrations of hydrocarbons would travel more than 3.9km downgradient of the point of leakage in the subsurface (assuming there is no extensive surficial flow of NAPL), even if no remediation is undertaken
- A possible exception to these statements may be in river valley deposits, where transverse dispersion is limited, the unsaturated zone may be thin, and the hydraulic conductivity very high
- The maximum effective velocity of migration of the dissolved phase benzene is not expected to exceed some 250m/yr assuming a hydraulic conductivity of 20m/d for a flow pathway (or 630m/yr even assuming a worst case 50m/d for the bulk flow path conductivity). Given that, in the case of a major leakage, a mitigation plan should aim to implement some form of remediation (pump-and-treat capture boreholes) with a time-frame of weeks to months, it should be possible to prevent serious contamination migrating in the subsurface further than 1 km of a spill point

The above assessment is designed to yield some impression of the extent and speed of migration of groundwater contamination to assist in designing a mitigatory plan. However, it is important to take into account the historical figures provided at the beginning of this summary. These can be used as "reality checks" for the findings of modelling described above.

In the event of a serious spill, it is absolutely necessary to gather sufficient data, as rapidly as possible, to carry out a site specific modelling exercise and assessment of contaminant migration.

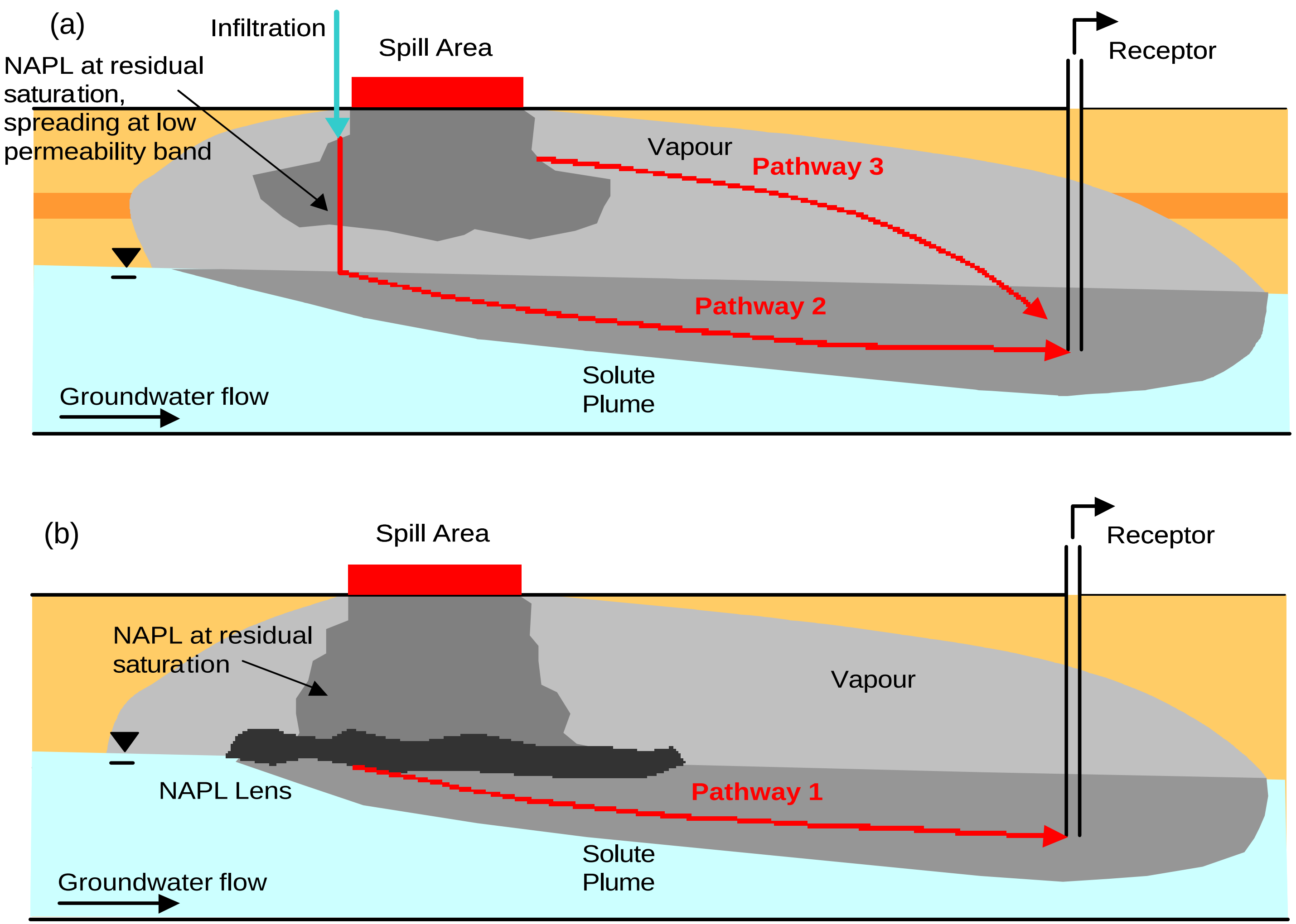

Figure 2.1

Conceptual models of crude oil migration and transport in the subsurface

(a) NAPL retained in the unsaturated zone

(b) NAPL reaches water table

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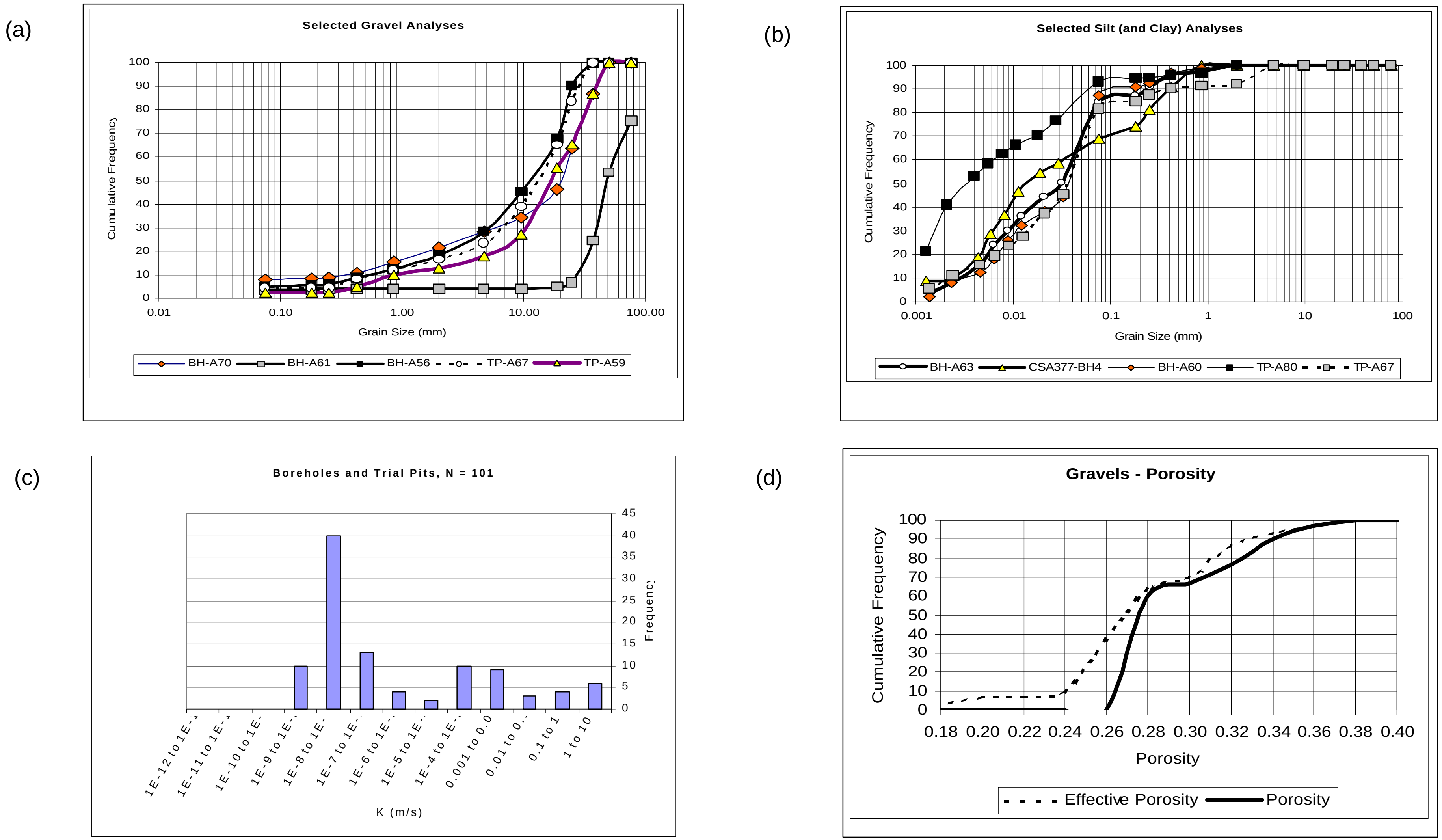

Figure 3.1

Hydrogeological data for the region of interest (RSK, 2001)

Selected grain size analyses: (a) gravel, (b) silt/clay,

(c) interpreted hydraulic conductivity, (d) interpreted porosity (gravel)

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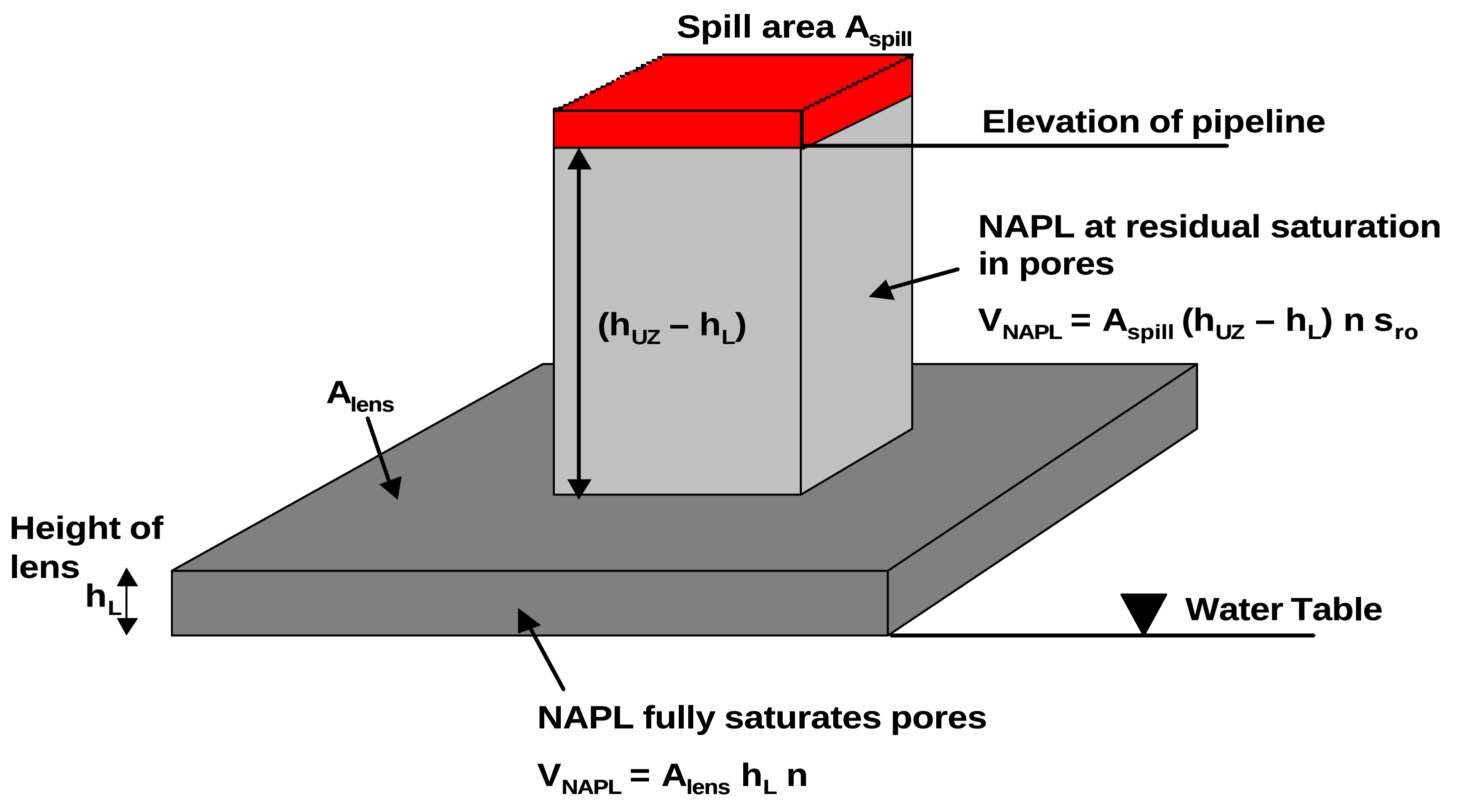

Figure 4.1

Conceptual model for scoping calculations of the location of NAPL in lens and residual phase

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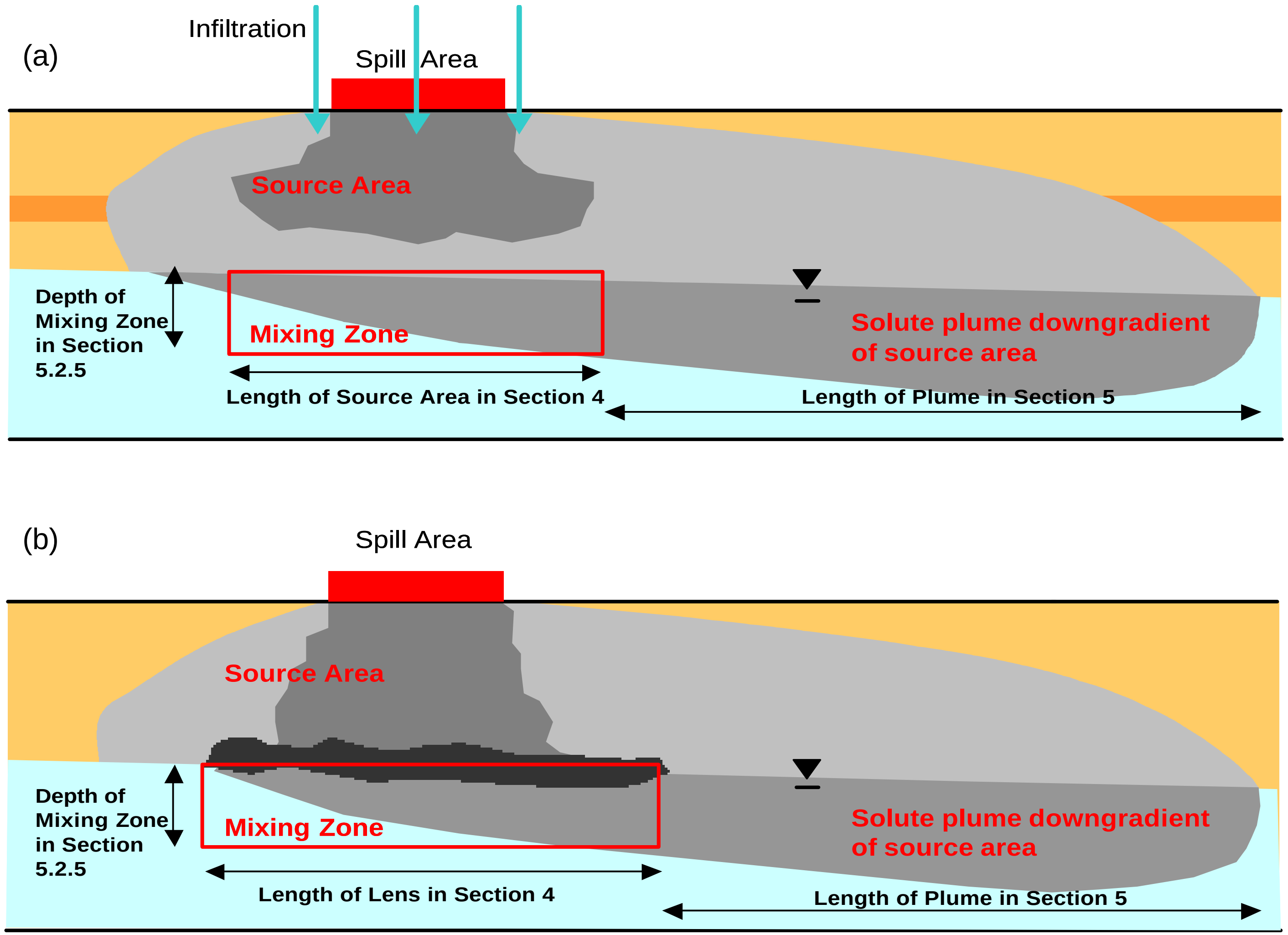

Figure 5.1

Estimating the dimensions of the zone affected by a leakage

(a) NAPL is retained in the unsaturated zone

(b) NAPL reaches the water table

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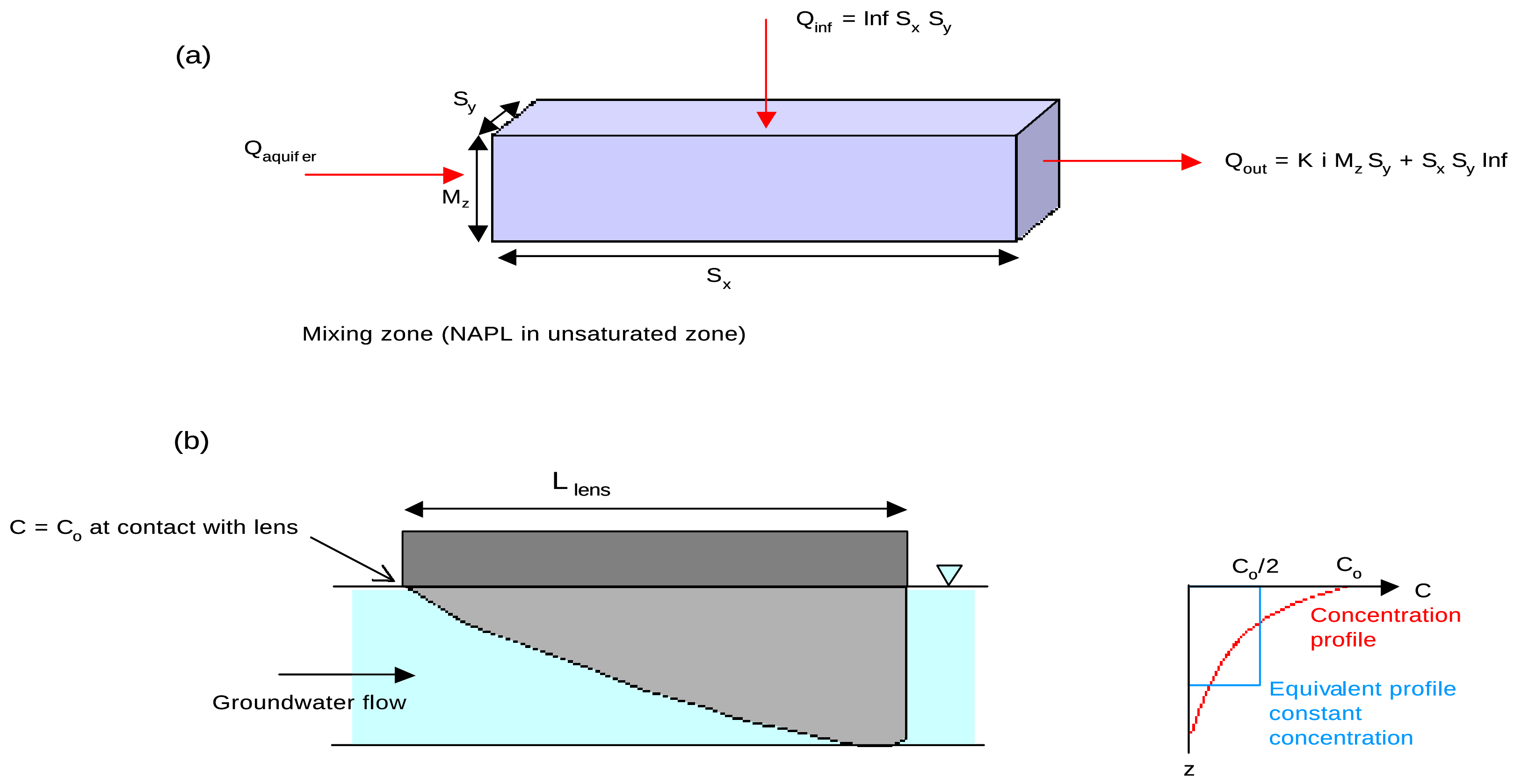

Figure 5.2

Conceptual models for the mixing zone

(a) NAPL retained in unsaturated zone

(b) NAPL reaches water table

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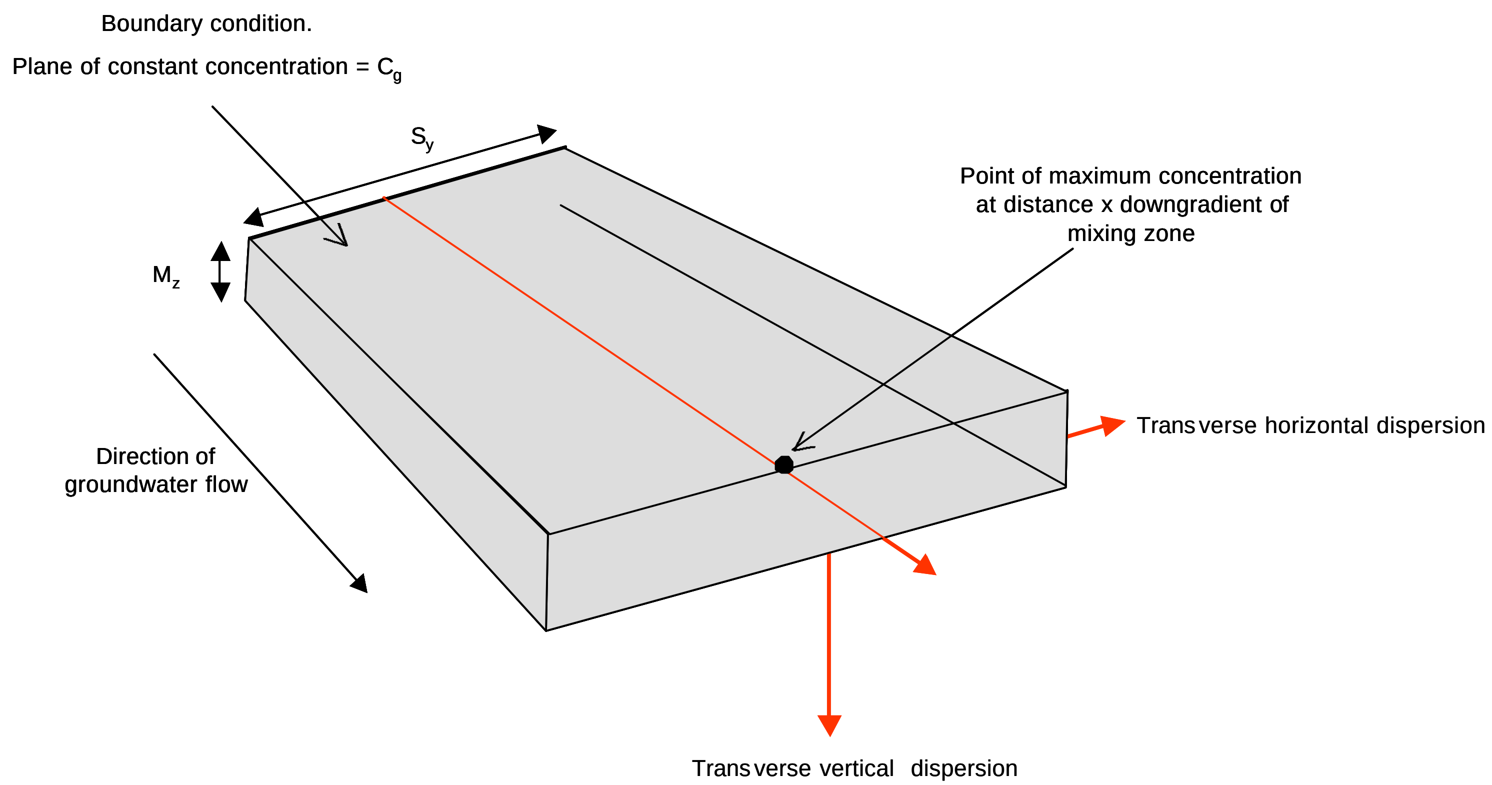

Figure 5.3

Conceptual model for solute transport downgradient of source area and mixing zone

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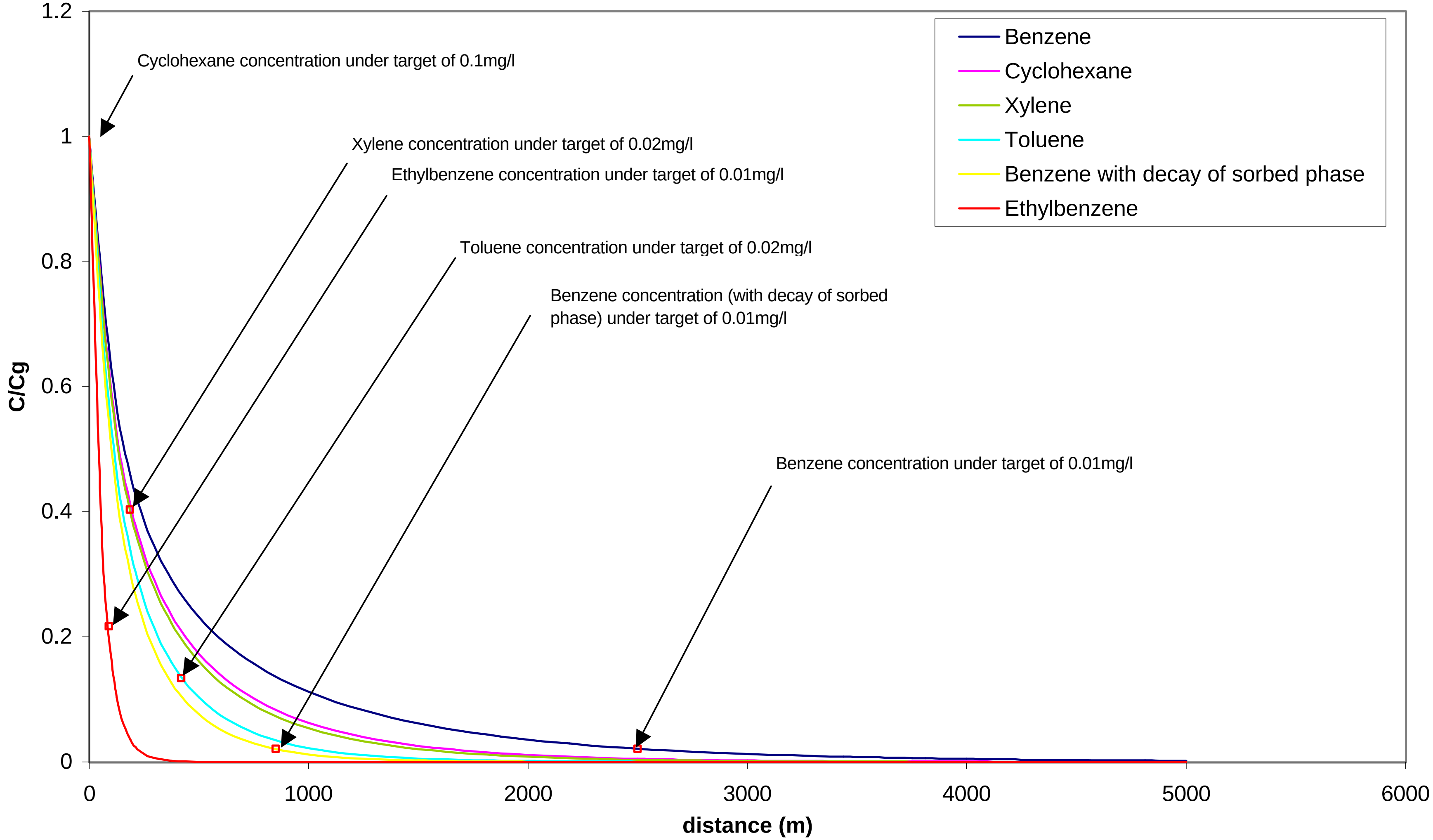

Benzene
Cyclohexane
Xylene
Toluene
Benzene with decay of sorbed phase
Ethylbenzene
Cyclohexane concentration under target of 0.1mg/l
Xylene concentration under target of 0.02mg/l
Ethylbenzene concentration under target of 0.01mg/l
Toluene concentration under target of 0.02mg/l
Benzene concentration (with decay of sorbed phase) under target of 0.01mg/l
Benzene concentration under target of 0.01mg/l
C/Cg
distance (m)
1.2
1
0.8
0.6
0.4
0.2
0
0
1000
2000
3000
4000
5000
6000

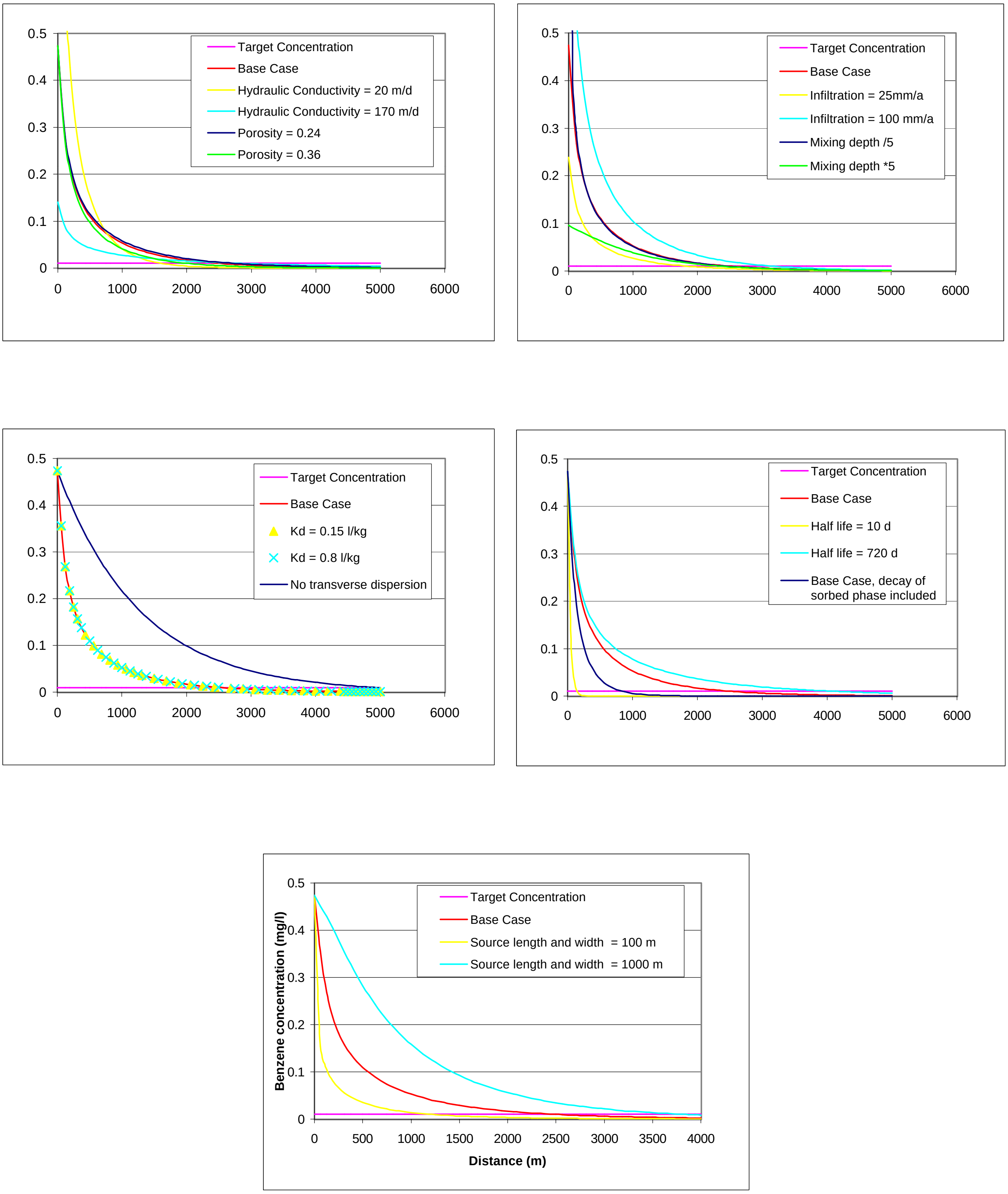

Figure 5.5

Sensitivity analysis of the benzene concentration profile: NAPL retained in unsaturated zone

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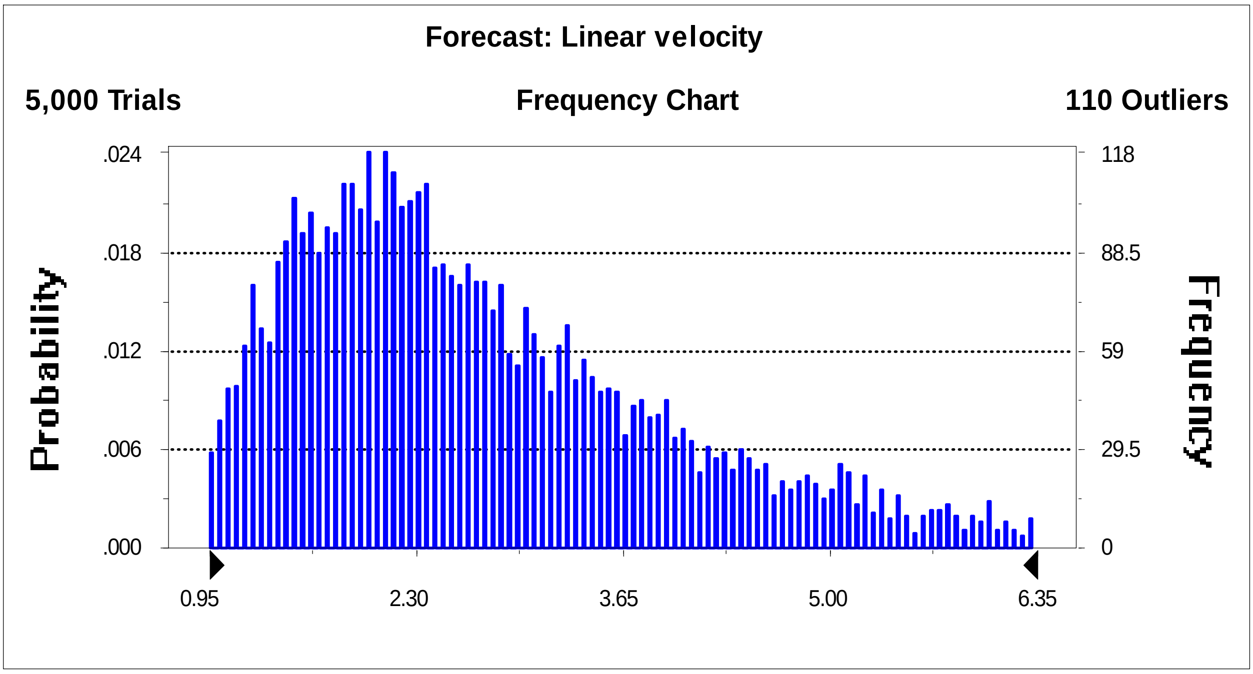

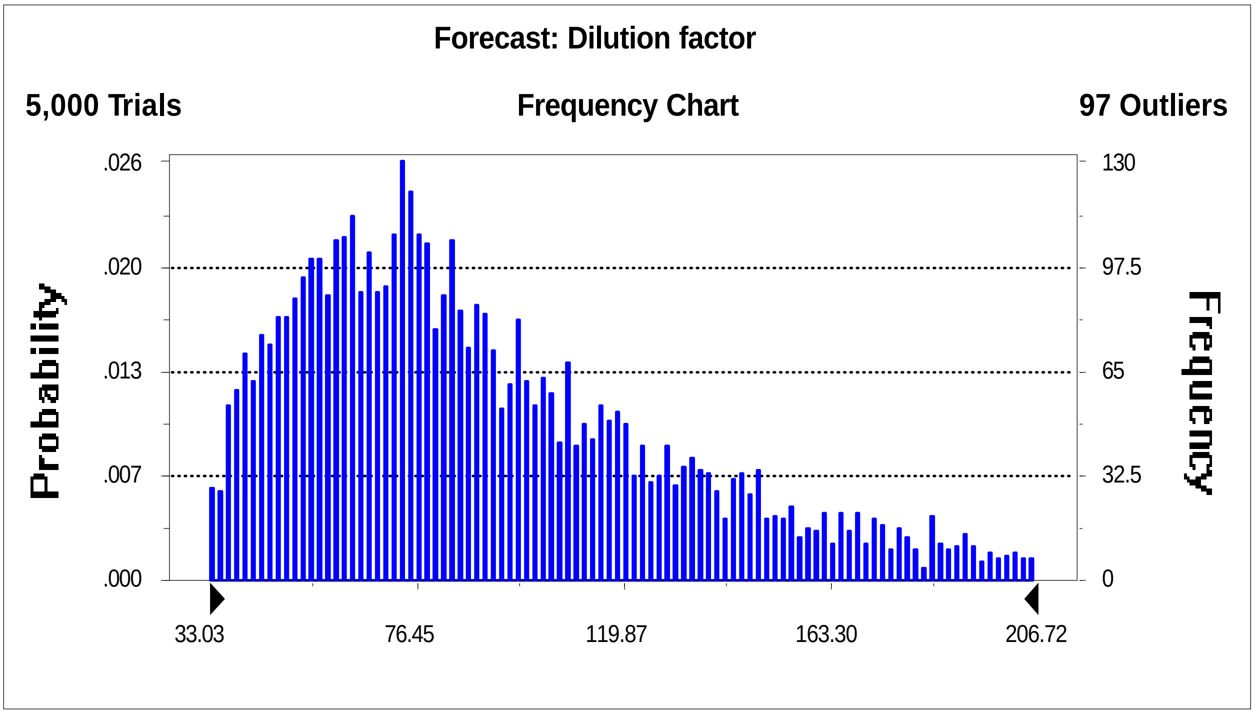

Figure 5.6

Probability distributions of average linear velocity of groundwater and dilution in the mixing zone

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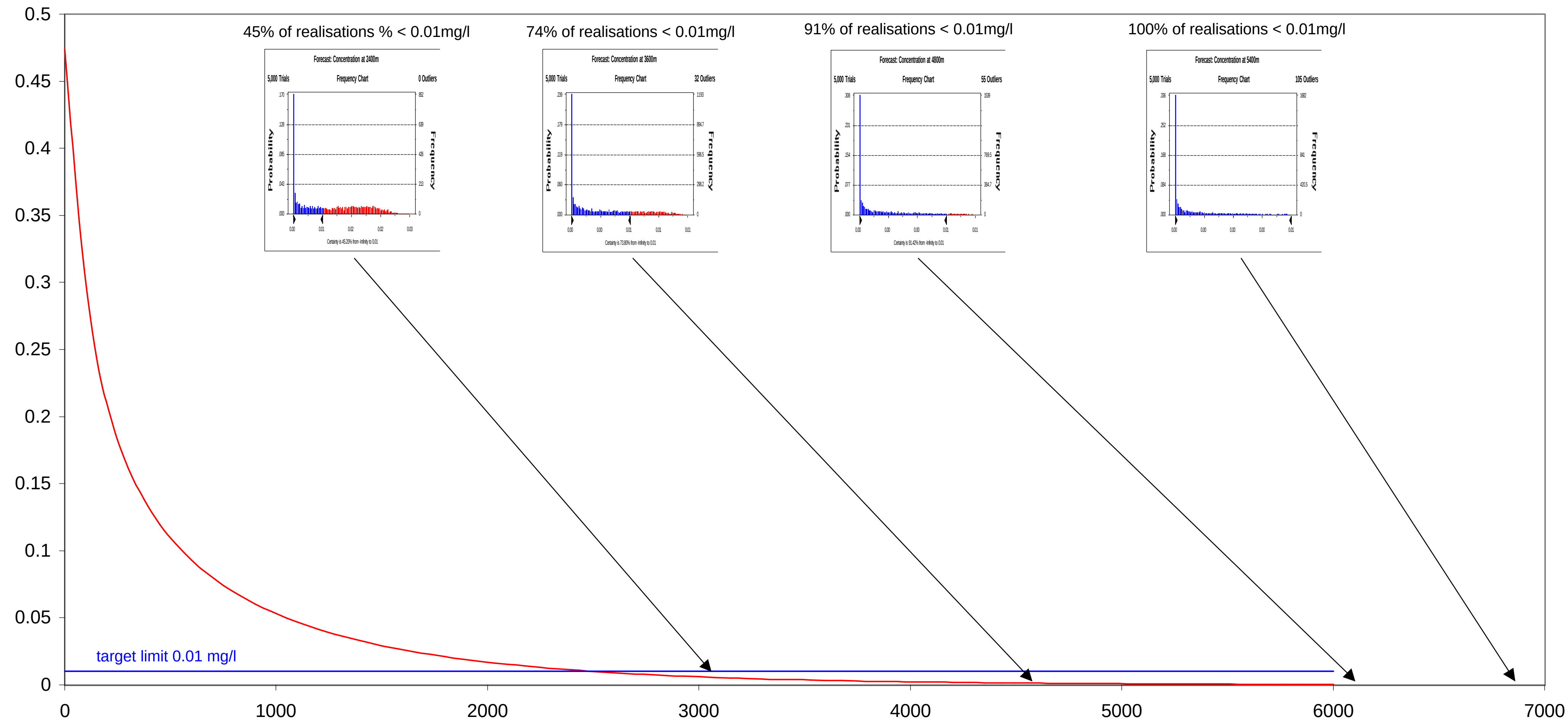

Figure 5.7

Base case benzene concentration profile and probability distributions at selected locations for the case of NAPL retained in the unsaturated zone. (Decay of dissolved phase only modelled)

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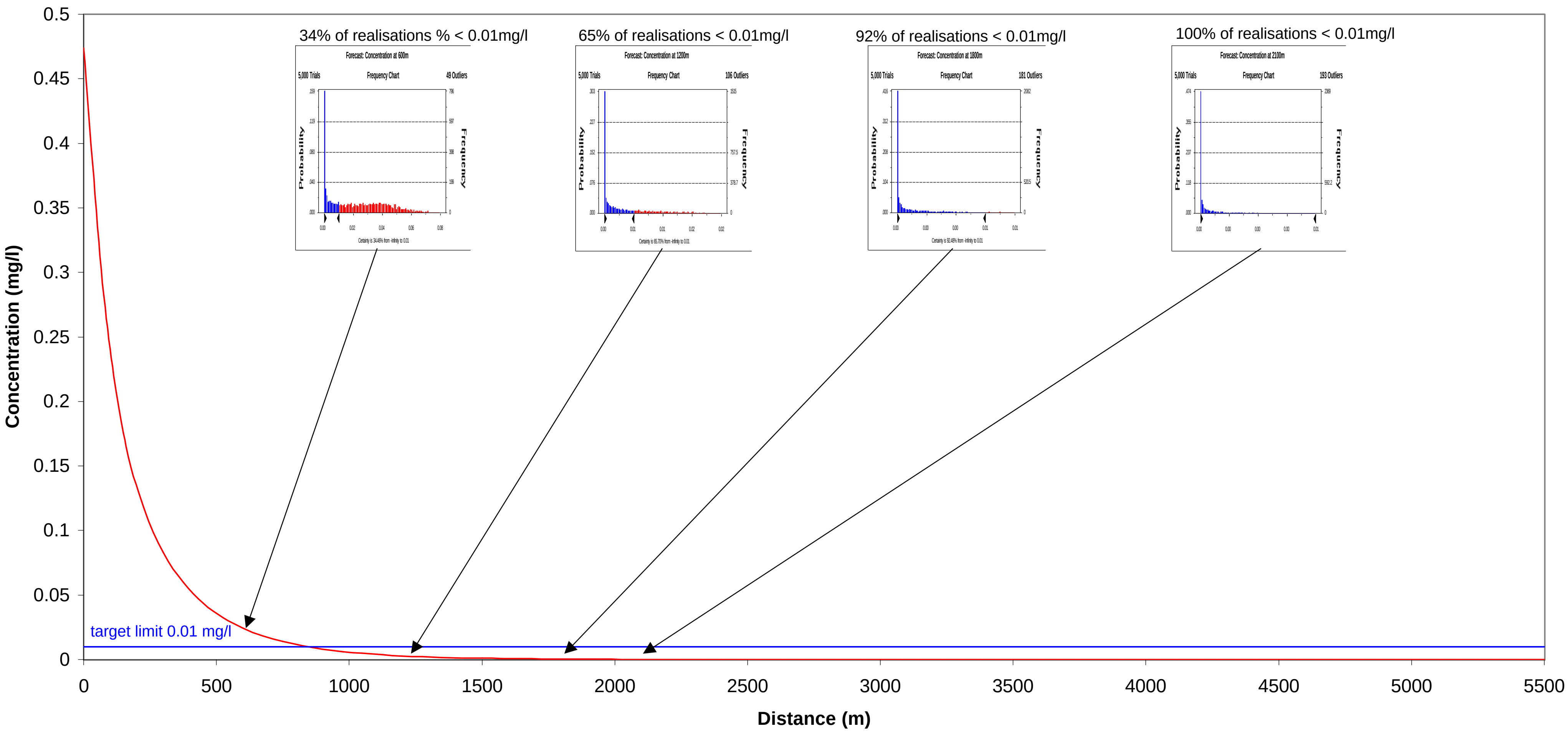

Figure 5.8

Base case benzene concentration profile and probability distributions at selected locations for the case of NAPL retained in the unsaturated zone. (Decay of dissolved phase and sorbed phases modelled)

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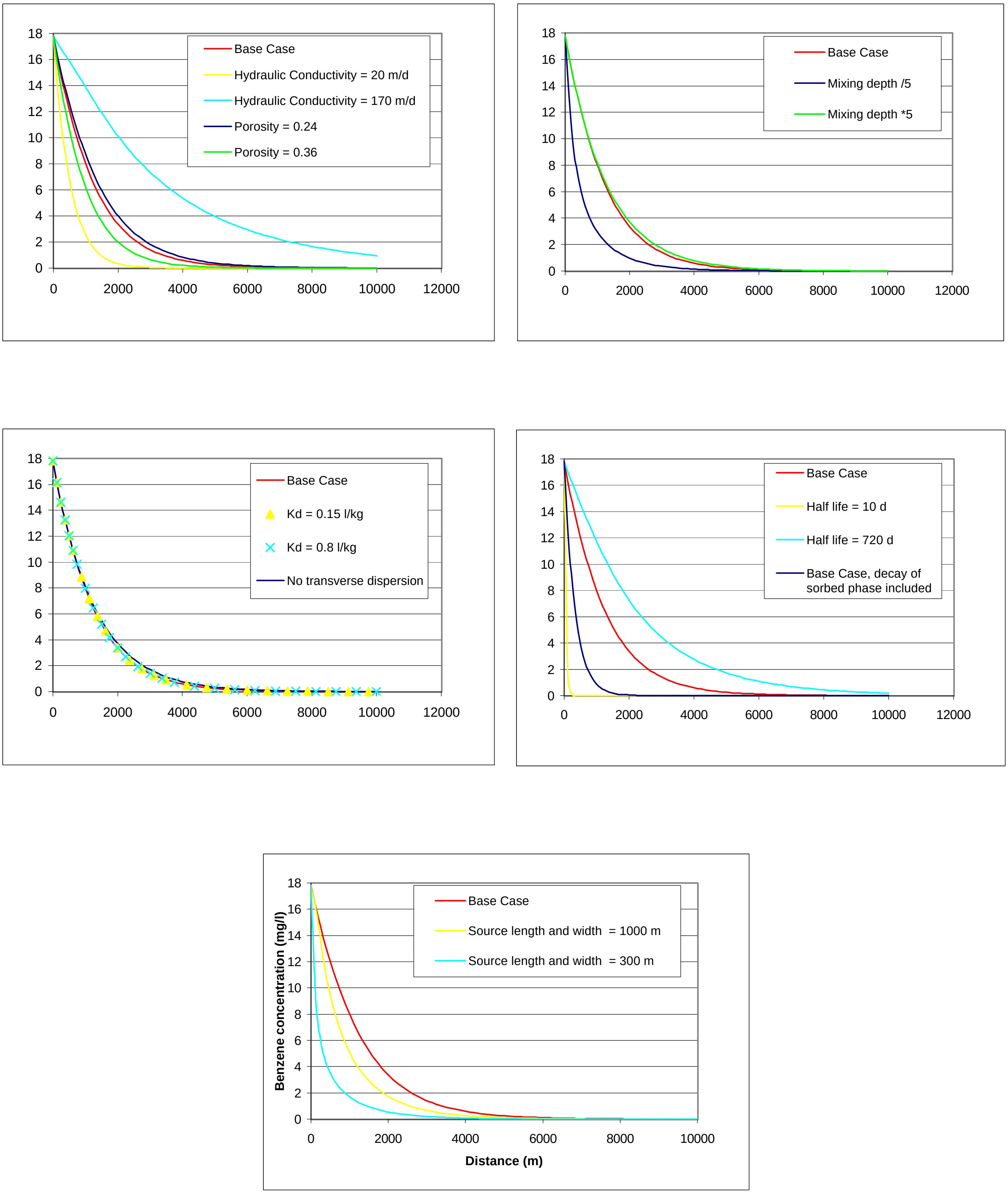

Figure 5.9

Sensitivity analysis of the benzene concentration profile: NAPL forming lens at the water table

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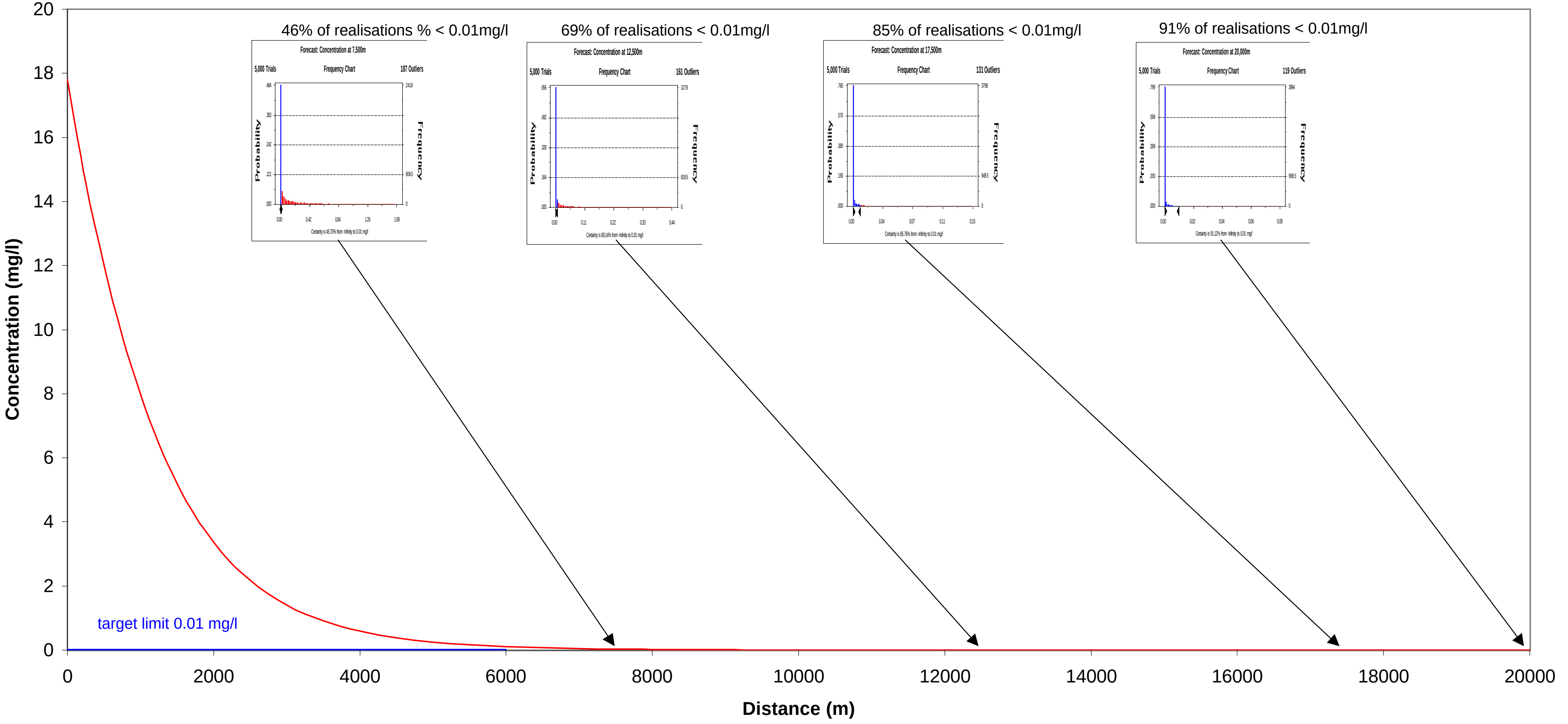

Figure 5.10

Base case benzene concentration profile and probability distributions at selected locations for the case of NAPL forming a lens at the water table (Decay of dissolved phase only modelled)

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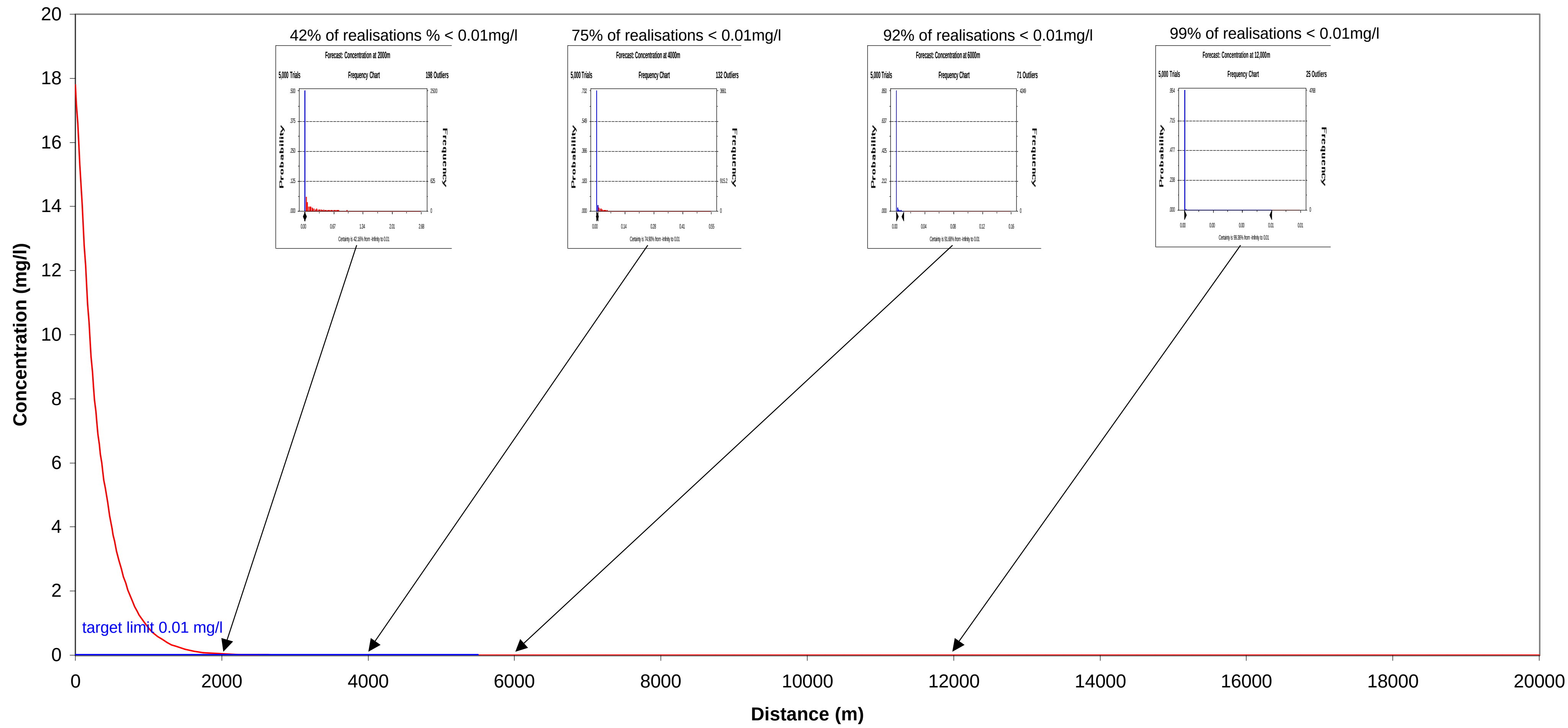

Figure 5.11

Base case benzene concentration profile and probability distributions at selected locations for the case of NAPL forming a lens at the water table (Decay of dissolved phase and sorbed phase modelled)

Date: Jan 02	Drawn: CH
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Environmental Simulations International

Groundwater Consulting and Software

PUBLIC CONSULTATION AND DISCLOSURE PLAN – BTC AND SCP PIPELINE PROJECTS, AZERBAIJAN

1 *INTRODUCTION*

The Azerbaijan Republic, Georgia and the Republic of Turkey have come to an agreement to support the implementation the Baku-Tbilisi-Ceyhan Pipeline Project. The project consists of an oil pipeline from the Caspian terminal at Sangachal in Azerbaijan, through Georgia, to Turkey where it will supply international markets. A second, gas pipeline, known as the South Caucasus Pipeline (SCP), is also planned to run from Sangachal to Erzurum, in Turkey, where it will feed the Turkish domestic gas market.

Having completed the Basic Engineering Phase, the Pipeline Projects have reached the Detailed Engineering Phase. One of the main objectives of this phase is to undertake a full Environmental and Social Impact Assessment (ESIA[1]) in accordance with national and international standards and practices. Within this context, extensive Public Consultation is being carried out according to World Bank standards.

1.1 *THIS DOCUMENT*

This document is a Public Consultation and Disclosure Plan (PCDP) for the environmental and social impact assessments (ESIAs) of the Azerbaijan section of the BTC and SCP pipeline projects. Although there are two pipelines each requiring its own ESIA, the consultation process has been combined as far as possible to ensure a consistent and coordinated approach to stakeholders. The PCDP is designed to outline a plan for public consultation which will: provide timely information about the projects and their potential impacts to pipeline affected communities[2] and other stakeholders[3]; provide opportunities to those groups to voice their opinions and concerns in a way which is most appropriate to their circumstances; and provide an opportunity for feedback to, and discussion with, those communities concerning measures proposed.

The PCDP presents the plan for public consultation through the project planning, construction, operation and decommissioning stages of the pipeline. The PCDP is a 'living' document and

[1]An Environmental and Social Impact Assessment is undertaken to examine the potential impacts of a project on the physical and human environments, to develop measures to reduce the potential negative impacts and to enhance the positive impacts. It is designed to ensure the implementation of those measures through changes in project design and the development of an environmental and social action or management plan for use during project implementation.

[2] Pipeline Affected Communities are defined for the purposes of this project as those within 2km of the pipeline or a pipe yard, within 100m of an access road, and within 5km of a Pump or metering station or a construction camp.

[3] For the purposes of this project, Stakeholders are defined as any persons or parties with an interest in the project as follows: 'Local ' refers generally to the pipeline affected communities and other interested parties close to the pipeline including local government; 'National' refers to interested parties within Azerbaijan who are not 'local' including regional and national NGOs, academics, Government, media etc; International includes international NGOs, World Bank and other IFIs, UN Agencies etc.

may be revised over time to reflect information gained through the consultation process. This draft has been developed for release to stakeholders with a particular interest in the project in May 2002 as part of the ESIA disclosure process.

Given the size of the project and the issues associated with it, BTC Owners and SCP Partners (hereafter, the sponsor companies) are committed to undertaking public consultation on three levels: international, national, and local. However, because of the potential interactions between, and cumulative effects of, the oil and gas projects in the Caspian region, separate terms of reference have been prepared for a strategic or macro level study titled “Environmental and Social Aspects of the ACG Full Field Development and Export in a regional context”. This additional study addresses the overall regional costs and benefits of the offshore and export developments, and includes some international consultation on related issues.

Information gathered through the consultation process, at both the route level and the international level, is being shared as far as possible within the timetables for the two studies. Significant policy developments emerging from the macro level study will influence the implementation of commitments in the ESIA reports.

This document therefore provides an outline for consultation at the national and local levels to address issues relating directly to the pipelines including:

- Identification of project stakeholders and mechanisms for stakeholder feedback and information sharing
- An outline for consultation at the local and national levels starting at the project planning stage, and continuing throughout construction, operation and decommissioning of the pipelines
- Ensuring that issues raised by project stakeholders are addressed in the ESIA reports as well as in project decision-making and design
- Identification of the resources required to implement the plan, and development of procedures to monitor implementation
- Grievance mechanisms for local stakeholders

This PCDP contains the following sections:

- *Section 2*: Brief description of the project and the project participants
- *Section 3*: Summary of the regulatory context for public consultation
- *Section 4:* Consultation Plan for ESIA and pre-construction phases
- *Section 5:* Consultation Plan for construction and operational phases
- *Section 6*: Summary Table of consultation and disclosure activities
- *Section 7*: Resource Issues related to implementation of the plan
- *Section 8*: Grievance Mechanism for local stakeholders

It also includes two Appendices:

Appendix 1 – Materials used in different phases of the consultation process
Appendix 2 – List of stakeholders

2 PROJECT DESCRIPTION

2.1 *ROLES AND RESPONSIBILITIES*

BP is leading work on the BTC and SCP Projects on behalf of the Sponsor companies. International consultants have been contracted to carry out ESIAs for both the BTC and the SCP pipelines, in association with national partners. As part of this work the national and international consultants are supporting the sponsor companies in carrying out consultation.

The sponsor companies are leading consultation with stakeholders in relation to the Pipeline Projects, and will participate in the design of all consultation activities. While the environmental and social components of the ESIAs have been contracted separately, consultation has been integrated, wherever appropriate, including during the production of a single ESIA report for each pipeline.

The international consultants for the social component of the ESIAs are the Social Strategies division of Environmental Resources Management (ERM). ERM's role is to assist in the co-ordination of the social impact assessment (SIA) and consultation process to ensure that they meet the required international standards. The national consultants, Synergetics, as well as being integrally involved in the SIA, have coordinated and facilitated field surveys and community meetings along the pipeline route.

The EIA contractor, AETC, in association with the sponsor companies, have carryied out consultation on environmental impacts. They have met with environmental stakeholders at the national level during project scoping, and will also participate in community consultation during disclosure.

2.2 *PROJECT COMPONENTS*

The BTC Pipeline will transport Caspian crude oil via Azerbaijan, Georgia and the Republic of Turkey to the Mediterranean Sea and international markets. The South Caucasus Pipeline (SCP) will be constructed to transport gas from the Shah Deniz off-shore gas field in Azerbaijan to markets in Georgia and Turkey. The Azeri section of both the gas and oil pipelines will start at the Sangachal Terminal in Eastern Azerbaijan and cross into Georgia in the province of Akstafa, a total of approximately 442 kms.

The entire pipeline route is shown in *Figure 1*. More detailed route maps can be found in both the BTC and SCP route level ESIAs.

Figure 1: Map of Routes for BTC, SCP, WREP and NREP

One alternative option studied during the project scoping of the SCP involved the refurbishment of the existing Azerigas pipeline from Hadgiqabul to the Georgian border. ESIAs were initially conducted on both options, prior to a decision on the preferred option.   The decision was made to build a new SCP pipeline adjacent to BTC and work has therefore progressed in parallel.

The proposed route follows a similar corridor to the existing Western Route Export Pipeline (WREP). Baseline survey data from the WREP dates from 1997 and is therefore relevant. For the BTC and SCP baseline, this data has been supplemented by a significant amount of additional survey work undertaken as part of the SCP and BTC ESIAs.

The following have also been considered in the ESIA and supporting consultation process:

- Permanent facilities and other Above Ground Installations for the oil line (e.g. a pump station, 2 intermediate pigging stations, approximately 21 valve stations, and permanent access roads)
- Permanent facilities and other Above Ground Installations for the gas line (e.g. approximately 5 valve stations, and permanent access roads)
- Temporary facilities (e.g. temporary access roads and construction facilities such as material yards, and worker construction camps)
- Effects on existing infrastructure and resources (e.g. use of existing roads, extraction of construction materials, use of water and disposal of waste)

2.3 PROJECT TIMETABLE

During the Basic Engineering Phase potential route options were analysed. Consideration of financial, security, technical, environmental and social factors led eventually to the identification of a preferred 500-metre pipeline corridor.

The next phase, Detailed Engineering will continue until 18th June 2002. Environmental and social impacts are being assessed and fed into the detailed engineering process through the ESIA.

Construction of the facilities is due to start in January 2003. The BTC pipeline is scheduled for commencement in early 2003, and SCP a year later. The design life of the pipelines will be 30-40 years.

3 REGULATORY CONTEXT

3.1 INTRODUCTION

Public consultation activities identified in this PCDP and undertaken to support the development of the BTC and SCP Pipelines Projects in Azerbaijan will conform to:

- The standards and practices set forth in Azerbaijan Host Government Agreements (HGAs) for the BTC and SCP pipeline projects
- Azeri regulations
- Guidelines established by international financing institutions, specifically the World Bank, International Finance Corporation (IFC), and the European Bank for Reconstruction and Development (EBRD)
- European Commission Directives (though not required by law)
- Relevant International Conventions for Public Participation

The main requirements are set out in the following sections.

3.2 HOST GOVERNMENT AGREEMENTS

Article 12 of the Azerbaijan Host Government Agreement for BTC sets forth the standards and principles for Public Consultations and Disclosure outlined in Appendix 3 of the Agreement.

Section 3.9 part (iii) of Appendix 3 sets forth the requirements for public review and comment in accordance with the following procedures:

- Affected public and non-governmental organisations will be notified about the nature of the operation of the Facilities during the development of the EIA through dissemination of information to these organisations through meetings and exhibitions

- Following the completion of the EIA, the public will be provided with information on the environmental aspects of the Project to enable it to comment with respect thereto. To facilitate this process, the EIA and an executive summary (in the Azeri language) will be made available in a public place for review and comments; additionally, an information copy of the executive summary shall be submitted simultaneously to the Government

- A maximum of sixty (60) days will be allowed for public comments, which will be provided to the Government by the project sponsors within thirty (30) days after the expiration of said sixty (60) day period. Demonstration that the Project Participants have reasonably addressed public concerns (through modification of the EIA, if necessary) will be included in a final executive summary that will be submitted to the Government

3.3 NATIONAL REGULATORY REQUIREMENTS

Environmental Assessment in Azerbaijan is based upon the 1996 UNDP Guidelines(1), which include requirements and systems for consulting the public. Although the Guidelines are adopted in practice, they have no formal status in law as they have not been through the ratification procedures of *Milli Mejlis* (Parliament).

3.3.1 REQUIREMENTS FOR PUBLIC CONSULTATION

The national system refers to the 'public' as anyone who is in any way affected by a specific proposal or shows a genuine interest in it. NGOs, as representative bodies of the public, have the right to request access to comprehensive information on the state of the environment and the use of natural resources in any part of the country.

The main requirements for public consultation are addressed under the following pieces of framework legislation:

- The *1999 Environmental Protection Act* (and its predecessor, the *1992 Act on the Protection and Utilisation of Nature Resources*)
- The *Health Act of 1992* which establishes the right of the public to participate in 'the protection of the environment' and have access to relevant information

If national legislation is in contradiction to international treaties to which Azerbaijan is a party, the provisions of international law are used.

Present requirements have evolved through the system of *Ecological Expertise*. This is addressed under articles 50-58 of the 1999 Environmental Protection Act. Article 50 states that '*Expertise is conducted by the relevant body of executive power and public organisations,'* while other Articles focus on the role of the state and the power in law of the *Expertise* decision.

However, Article 58 also provides for independent involvement in the process:

- Public organisations and other public groups can conduct public ecological review
- The organisation of the public ecological expertise and the responsibilities of public organisations in the field of ecological expertise are determined by legislation
- The conclusions of the public ecological expertise may only be used for information and recommendation purposes

The Act also states that citizens of Azerbaijan have the right to participate in discussion of issues related to projects which may have a harmful impact on the environment. The public also has the right to demand punishment for persons responsible for environmental pollution.

EIA requirements provide for public participation from the period when an operating permit is obtained until construction is completed as part of the environmental expertise process. Project proponents are required to advertise their proposed development in the printed media and to

(1) Handbook for the Environmental Impact Assessment Process in Azerbaijan. SCE, UNDP, Baku (1996).
The function of the Guidelines is to provide a framework for the EIA process in-line with international norms, though adapted to the Azeri context. In doing so, they lay out the basic principles for the EIA process, together with the relevant clauses of existing legislation in relation to the conduct of '*Environmental Expertise*'.

notify any person or organisation who will be directly affected by the project. It is also mandatory for the proponent to demonstrate how, and to what extent, the public has been consulted within its Environmental Impact Assessment Statement (EIS).

3.3.2 *ENFORCEMENT*

Compliance with the requirement for public participation is regulated by the Ministry of Environment and Natural Resources.

Compliance with legislation on information is monitored by the State Committee on the Press on the basis of *Law on the Mass Media.* Legislation on political and public organisations, as well the *Laws on Nature Protection and Nature Use Management* and on *Sanitary and Epidemiological Safety* provide for the use of all democratic mechanisms of public participation.

Concealment of information can lead to sanctions under the Administrative Code, the *Law on Sanitary and Epidemiological Safety, Article 39, Liability for Violation of Sanitary Legislation, and the Regulation for Investigation and Registration of Production Accidents, Resolution of the State Central Trade Union Council No 8-12 dated August 17, 1989.*

3.4 *INTERNATIONAL STANDARDS ON PUBLIC CONSULTATION*

3.4.1 *WORLD BANK GROUP (INCLUDING THE IFC)*

The World Bank Group's ***Environmental Assessment policy (OP 4.01, January 1999)*** requires that project-affected groups and local non-governmental organisations (NGOs) be consulted about the project's potential environmental and social impacts during the ESIA process. The purpose of this consultation is to take local views into account in designing the environmental and social management plans as well as in project design. For complex projects where the environmental impacts and risks are high, the policy requires public consultation at least twice: first, shortly after environmental screening and before the terms of reference for the ESIAs are finalised and secondly, once a draft ESIA Report has been prepared. Consultation during project execution is also required. *Section 6* of this PCDP summarises the consultation programme for the ESIAs, and confirms that the project meets and indeed exceeds these requirements.

The IFC's manual '***Doing Better Business Through Effective Public Consultation and Disclosure: A Good Practice Manual***' provides action oriented guidelines aimed at ensuring that consultation is both effective and meaningful. The guidelines emphasise the need for the project sponsor to ensure that the process of public consultation is accessible to all potentially affected parties, from national to local level. Emphasis is placed on the engagement of local stakeholders, namely people who are likely to experience the day-to-day impacts of a proposed project. On a practical level, the sponsor has to ensure that: i) all stakeholders have access to project information; ii) the information provided can be understood; iii) the locations for consultation are accessible to all who want to attend; and iv) measures are put in place which ensure that vulnerable or minority groups are consulted.

The consultation requirements for projects requiring physical or economic displacement are covered by the World Bank ***Operational Directive 4.30: Involuntary Resettlement*** and outlined in the IFC's '***Handbook for Preparing a Resettlement Action Plan'***. The pipelines do not involve any physical resettlement, but the project is developing a Resettlement Action Plan (RAP) to address the economic displacement associated with the projects.

The project sponsor is required to initiate and facilitate a series of consultations with project stakeholders throughout the planning and implementation of the RAP. The objective of these consultations is to ensure the participation of affected parties in their own resettlement planning and implementation. In particular, the following areas require consultation:

- Alternative project design
- Assessment of project impacts
- Resettlement strategy
- Compensation rates and eligibility for entitlements
- Choice of resettlement site and timing of relocation
- Development opportunities and initiatives
- Grievance redress procedures and dispute resolution
- Methods and mechanisms for monitoring and evaluation and implementing corrective actions

Other relevant World Bank Group policies include:

- ***Operational Policy 14.70: Involving Non-Government Organisations in Bank-Supported Activities***
- ***Operational Policy 4.04: Natural Habitats***
- ***Operational Policy 4.11: Safeguarding Cultural Property***

These also include provisions for public consultation. The requirements focus on early consultation with affected people and NGOs, early disclosure of information and providing information in a way that allows informed consultation with stakeholders.

In addition to the requirement for consultation with stakeholders, the World Bank Group has specific requirements for disclosure of documentation resulting from the ESIA process. This includes:

- Preparation and publication of a Public Consultation and Disclosure Plan (PCDP) for consultation
- Disclosure of the draft ESIA in public places in-country and the World Bank Infoshop (at least 60 days prior to the IFC board date[1]), including a non-technical summary in the local language to local stakeholders
- Preparation of an Environmental Action Plan (EAP) containing social as well as environmental measures designed to manage, mitigate and monitor the impacts identified during development of the ESIA. This must also be released to the World Bank Infoshop and be made available locally prior to presentation of the project to the IFC board

[1] The Pelosi amendment to the World Bank procedures for disclosure requires a 120 day disclosure period at the World Bank Info Shop prior to the project Board date to ensure a positive vote at the board from the US Executive Director.

3.4.2 *EUROPEAN BANK FOR RECONSTRUCTION AND DEVELOPMENT (EBRD)*

The EBRD's principles of public consultation are documented in the Bank's Environmental Policy (EP), Environmental Procedures (EPr), and the Public Information Policy (PIP). While the EBRD requirements reflect some of the other international financial institution requirements (e.g., World Bank for public sector and IFC for private sector), there are some important additional requirements with reference to European Union requirements and international conventions and treaties.

The EBRD standards require that projects are held to the more stringent of national and European Union standards. For those areas where there are not European Union standards, the EBRD relies on the more stringent of national and World Bank Group standards. In the area of public consultation, the European Union requirements are set out in the EIA Directive. In addition, the EBRD requires that the Public Information policy and Environmental policy of the Espoo Convention is followed for any project that may have transboundary impacts, regardless of whether the countries involved are party to the convention or are members of UNECE. This is in line with EU standards. The EBRD also concurs with the principles of the Aarhus Convention, which is specifically mentioned in the Public Information Policy.

A-level requirements

In the case of significant "greenfield", major expansion or transformation-conversion operations which have been classified as requiring an Environmental Impact Assessment, those potentially affected must have the opportunity to express their concerns and views about issues such as operation design, including location, technological choice and timing, before a decision on EBRD financing is made. At a minimum, sponsors must ensure that national requirements for public consultation are met and that EBRD's own public consultation procedures are met. The Bank's Board of Directors will take into account the comments and opinions expressed by consultees, and the way these issues are being addressed by sponsors, when considering whether to approve an operation.

Scoping

Both the EBRD Environmental Procedures and the Public Information Policy require a thorough scoping procedure for all "A" level operations, which will involve the Project Sponsor consulting with representatives of the locally affected public and with government agencies, as well as with other organisations.

Disclosure of EIA Documentation

Following the completion of environmental investigations, EBRD requires that the public is provided with adequate information on the environmental aspects of the operation to enable them to provide the Project Sponsor with comments on the proposals. To facilitate this, the Project Sponsor must make the EIA and an Executive Summary publicly available, in accordance with relevant national legislation, and allow sufficient time for public comment prior to the Bank's Final Review of an operation and its consideration by the Board. For private sector operations there will be a minimum of 60 days between the release of the EIA and the date of Board consideration.

The EBRD strongly encourages project sponsors to place EIAs on their websites to improve public accessibility to the documents, and to otherwise release information in electronic, as well as written format. Where an EIA has been released on a website, the EBRD's website will provide a direct link to the project sponsor's website.

The EBRD encourages project sponsors to leave EIAs in the public domain indefinitely, and at least for the life of the Bank's involvement with the project. In no case should the EIA be removed prior from the public domain prior to Project Completion, and will in any event, remain permanently in the public domain through the EBRD offices in London and the country in which the project is located.

Project Summary Documents

A Project Summary Document (PSD) will be prepared for each project, and will be released on the Bank's website with an Environmental Annex which summarises the results of environmental due diligence and the environmental action plan, at least 30 days prior to consideration by the Board of Directors.

On-going Consultation and Disclosure

For projects that have raised significant environmental or health and safety issues, or which have aroused the particular interest of the public or NGOs, the EBRD encourages the commitment to on-going information and communication programmes. For example, the Bank may require the results of ongoing environmental monitoring to be made available to the public.

International Conventions and Treaties

The EBRD, within the framework of its mandate, supports the Espoo Convention on EIA in a Transboundary Context. In this context, the Environmental Policy and the Public Information Policy state that the requirements outlined in the Convention on Environmental Impact Assessment in a Transboundary Context (the Espoo Convention) must be followed regardless of whether the country affected has ratified the convention.

In addition, the EBRD takes into account the Aarhus Convention, along with other relevant international conventions, in the implementation of its Environmental Policy.

3.4.3 *EUROPEAN COMMISSION*

Although European Commission legislation does not apply to Azerbaijan, this is included here as best practice and because these standards have been adopted by EBRD. European requirements for stakeholder involvement in the EIA process are specified in the 1985 Directive (85/337/EEC) on Environmental Assessment, as amended by Directive 97/11/EEC. The review of the implementation of the Directive 85/337/EEC is provided in Directive 85/337/EEC.

The 1985 Directive ensures that the Member States make information on proposed activities available to the public. The public concerned is given the opportunity to express an opinion before the project is initiated. The Directive requires that the Member States determine detailed arrangements for such information and consultation including identification of the public concerned, places where the information can be consulted, ways in which the public can be informed and consulted, and timeframe during which the consultation should be conducted.

The 1997 Directive supports the requirements put forward in the 1985 Directive, and adds a requirement to conduct public consultation for projects that are likely to have significant transboundary environmental effects. The Directive specifies that it is the responsibility of both a Member State in whose territory the project is intended to be carried out, and a Member State likely to be affected by the proposed project, to inform the public of the Member State likely to be affected by the proposed project.

3.5 *INTERNATIONAL CONVENTIONS ON PUBLIC PARTICIPATION*

3.5.1 *AARHUS CONVENTION: ON ACCESS TO INFORMATION, PUBLIC PARTICIPATION IN DECISION MAKING AND ACCESS TO JUSTICE IN ENVIRONMENTAL MATTERS*

The Convention was signed in Aarhus, Denmark in 1998 by the European Commission and governments of 36 countries, including Azerbaijan. The Convention was ratified in Azerbaijan in 1999. The objective of the Convention is to guarantee the rights of access to information, public participation in decision-making, and access to justice in environmental matters, in order to protect people’s rights to a healthy environment.

The Convention obliges public authorities to make sure that environmental information is available to the public upon request without discrimination and without having to state an interest. Although provisions are made for limitation of access to certain types of environmental information, this limitation is not strict and should take into account the public interest served by the disclosure. The Convention encourages public authorities to collect environmental information regularly and disseminate it in the form of a computerised and publicly accessible database.

The Convention entitles the public to participate in environmental decision-making concerning a wide range of economic activities, not only those covered by environmental impact assessment procedures. Public authorities ensure that the public is involved at as early a stage of the project planning as possible and that various project options are open for discussion. Any activities that may lead to environmental deterioration are to be subject to consideration in public and to the public’s consent. Public participation also takes place in the preparation of environmental plans and programmes and, with a lesser degree of commitment, in the preparation of policies.

Under the Convention the government ensures that anyone who considers that his or her request for information has been inadequately dealt with has access to court for a review procedure.

3.5.2 *ESPOO CONVENTION “ON ENVIRONMENTAL IMPACT ASSESSMENT IN A TRANSBOUNDARY CONTEXT”*

The Convention was signed in Espoo, Finland in 1991 by governments of European Countries, the United States, and European Community. Azerbaijan joined the Convention in 1999. The main objective of the Convention is to promote environmentally sound and sustainable economic development through the application of environmental impact assessment, especially as a preventive measure against transboundary environmental degradation. Under the terms of this Convention, Azerbaijan is required to notify other states if there is a potential impact upon their environment resulting from a development on the territory of Azerbaijan including its waters.

Although the Convention does not specifically deal with public participation in environmental decision-making, it provides the requirement for a country conducting a proposed activity to provide an opportunity to the public of a country(ies) likely to be affected to participate in the process of environmental impact assessment regarding the proposed activity.

The Espoo Convention is only applicable if both the party conducting a proposed project and the affected party have ratified the Convention. Currently Armenia is the only Caucasus state that borders with Azerbaijan by land, and Kazakhstan is the only Caspian state that borders with Azerbaijan by water that have ratified the Espoo Convention. As per the Convention, Azerbaijan should notify Kazakhstan and Armenia about the proposed project as soon as possible and no later than informing its own public. This notification should include information about the proposed project. Armenia and Kazakhstan will be expected to respond to this notification indicating whether they wish to participate in the environmental impact assessment process. Should these countries wish to participate, Azerbaijan will ensure that the public of these countries be provided with the opportunity to participate in the EIA process equivalent to that provided to the public of Azerbaijan.

3.5.3 *CONVENTION ON THE PROTECTION AND USE OF TRANSBOUNDARY WATERCOURSES AND INTERNATIONAL LAKES*

The main objective of this Convention is to prevent, control or reduce any transboundary impact resulting from the pollution of transboundary waters caused by human activity. Article 16 of the Convention contains requirements for public information. Under these requirements, the Parties have to ensure that information on the conditions of transboundary waters, measures taken to control, reduce and mitigate transboundary water pollution, and effectiveness of these measures are made available to the public. The information that has to be made available to the public includes:

- Water quality objectives (see Guidelines for Developing Water Quality Objectives and Criteria in Annex III of the Convention)
- Permits issued and the conditions required to be met
- Results of analysis of water sampling carried out for monitoring and assessment, and results of checking compliance with water quality objectives

The Parties have to ensure that the information is made immediately available to the public of their States, and is free of charge. Copies of the information will be provided to the riparian Parties for reasonable payment.

Table 3.1 International Standards on Public Consultation

	World Bank Group (including the IFC)	European Bank for Reconstruction and Development (EBRD)	European Commission
Policy Requiring Public Consultation	Operational Directive 4.01 Environmental Assessment and its successor documents. Operational Directive 4.30 Involuntary Resettlement	Public Information Policy, Environment Policy, and Environmental Procedures.	Directive 85/337/EEC on Environmental Assessment, as amended by Directive 97/11/EEC and Directive 90/313/EEC on Freedom of Access to Information on the Environment
Requirements			
Who should be consulted?	Directly and indirectly affected stakeholders, and those with an interest who feel they may be affected.	The public should be informed of ongoing project developments supported by EBRD	Directly and indirectly affected stakeholders, or representatives of affected groups.
Why involve the public?	Minimises conflict and delays; increases transparency; empowers people ensuring that their views are taken into account during project design and development of environmental and social management plans;	Minimises conflict and delays; increases transparency; empowers people ensuring that their views are taken into account during project design and development of environmental and social management plans;	Improves the quality and effectiveness of EIAs and project design and operation.
When should stakeholders be involved?	At a minimum, during scoping and screening phases, before the ToR for the ESIAs are finalised and on the draft ESIA. For complex projects where the environmental impacts and risks are high consultation during project execution is also required.	A project summary document (PSD) must be prepared for each private sector project and released at least 30 days prior to the consideration by the Board of Directors; An Environmental Impact Statement (EIA) must be prepared for Category 'A' projects (includes offshore gas and oil production) and released at least 60 days prior to consideration by the Board of Directors.	As early as possible in the EIA/project process and throughout the EIA/project cycle.

	World Bank Group (including the IFC)	European Bank for Reconstruction and Development (EBRD)	European Commission
What areas require consultation?	Alternative project design; assessment of project impacts; resettlement strategies; compensation rates and eligibility for entitlement; choice of resettlement sites and timing of relocation; development opportunities and initiatives; grievance redress procedures and dispute resolution; methods and mechanisms for monitoring, evaluation and implementing corrective actions.	Operation design, including location, technological choice and timing.	Transboundary environmental effects.
Responsibilities for Public Consultation	Responsibilities should be allocated clearly and early on. Project sponsor should ensure that: • All stakeholders have access to project information; • The information provided can be understood; • The locations for consultation are accessible to all who want to attend; • Vulnerable or minority groups are consulted.	It must be ensured that: • The EIA Executive Summary is made available in the local language; • The EIA and EIA Summary are made available in the EBRD's business Information Centre (BIC) in London (notice of this should be posted on the EBRD website; • Clients are recommended to place EIAs on their own websites.	The Member carrying out the project and the Member State(s) likely to be affected by the project must inform the affected public. It must be ensured that detailed arrangements within the Member States is made for: • Identifying the public concerned; • Providing places where information can be consulted; • Providing suitable methods for informing and consulting the public; • A suitable timeframe for consultation is developed
Other World Bank Group policies	• Operational Policy 14.70: Involving Non-Governmental Organisations in Bank-Supported Activities • Operational Policy 4.04: Natural Habitats • Operational Policy 4.11: Safeguarding Cultural Property		

	World Bank Group (including the IFC)	European Bank for Reconstruction and Development (EBRD)	European Commission
Requirements of these OPs	Early consultation with affected people and NGOs; early disclosure of information; providing accessible information.		
Comments	Specific requirements for disclosure of documents relating to the ESIAs on projects seeking international funding include: • Preparation and publication of a Public Consultation and Disclosure Plan (PCDP) for consultation; • Disclosure of draft ESIA (at least 60 days before IFC board date) including a non-technical summary in public places (in-country and are WB infoshop); • Preparation of an Environmental Action Plan containing social and environmental measures to manage, mitigate and monitor the impacts identified in the ESIA.		The European legislation does not apply to Azerbaijan. It is included as an example of best practice.

Table 3.2 International Conventions for Public Participation

	Aarhus Convention: ***On Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters***	**UNECE (Espoo Convention):** ***On Environmental Impact Assessment in a Transboundary Context***	**Convention on the Protection and Use of Transboundary Watercourses and International Lakes**
Policy Requiring Public Participation	No explicit policy Convention signed in Aarhus, Denmark in 1998 by the European Commission and governments of 36 countries	Parties to the Convention should take measures to facilitate Public Participation in decision-making. Convention signed in Espoo, Finland in 1991 by governments of European Countries, the United States and European Community. Azerbaijan ratified the Convention on 25.03.99.	No explicit policy
Objective	To guarantee the rights of access to information, public participation in decision-making and access to justice in environmental matters.	To promote environmentally sound and sustainable economic development through the application of EIA, especially as a preventative measure against transboundary environmental degradation.	To prevent, control or reduce any transboundary impacts resulting from the pollution of transboundary waters caused by human activity.
Requirements			
Who should be consulted?	The public. This means individuals or groups that request information. They do not have to state an interest.	The public. This means individuals or groups, without discriminating on the grounds of citizenship, nationality or domicile.	The public.
When should the public be informed?	As early in the project planning as possible; in the preparation of environmental plans and programmes (and to a lesser extent policies).	The responsible authority should inform affected parties in its own country and abroad as early as possible.	Information should be made immediately available to the public. It must be free of charge.

	Aarhus Convention: ***On Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters***	**UNECE (Espoo Convention):** ***On Environmental Impact Assessment in a Transboundary Context***	**Convention on the Protection and Use of Transboundary Watercourses and International Lakes**
What areas require participation/provision of information?	The public are entitled to participate in environmental decision-making, including economic activities.	The EIA process regarding the proposed activity.	Information that must be made available to the public includes: Water quality objectives; Permits issued and their conditions; Results of water analysis carried out for monitoring and assessment.
Responsibilities for Public Participation	Public Authorities are encouraged to collect environmental information regularly and to disseminate it in the form of a computerised and publicly accessible database	Parties to the Convention (i.e. government). The public also has a responsibility to take participation seriously and to organise itself for this process. Countries must provide an opportunity for the public to participate in the EIA process.	Parties subject to the Convention must ensure that information on the conditions of transboundary waters, measures taken to control, reduce and mitigate transboundary water pollution and effectiveness of these measures are made available to the public.
Comments		Only applicable if both the party conducting a proposed project and the affected party have ratified the Convention. (In this context, currently Armenia and Azerbaijan in the Caucasus)	

4 CONSULTATION DURING ESIA AND PRE-CONSTRUCTION PHASE

4.1 INTRODUCTION

This section outlines the main phases in the ESIA public consultation process prior to construction. Consultation during this period is focused on the development and publication of the ESIAs. However, many other areas of the project are also engaged in what could be classed as consultation activities, including the engineering team discussing project design issues with State Authorities, and the land team who are actively consulting with land owners and users on possible acquisition and compensation. The consultation process is designed to enable communities and other stakeholders to make a meaningful contribution towards the ESIA and hence toward the pipeline project, in particular through the development of potential mitigation measures.

Box 4.1 Objectives of the Consultation Process [1]

1. All stakeholders have access to project information
2. The information provided can be understood
3. Locations for consultation are accessible to all who want to attend
4. Measures are put in place which ensure that vulnerable or minority groups are consulted
5. Establish a high level of awareness among communities and other stakeholders about the nature of the project, its likely impact and proposed mitigation measures
6. Secure input from stakeholders on proposed mitigation measures, in particular through consultation with a representative sample of communities along the pipeline route and in relation to specific types of project activities
7. Manage expectations among communities and other stakeholders

A range of materials used during different phases of community consultation are attached in *Appendix 1*.

4.2 OVERVIEW OF CONSULTATION PROCESS

The SCP ESIA was initiated through consultation and information disclosure at both national and community level in October 2000. The consultation process was formally expanded to cover the BTC pipeline in August 2001. While many of the issues are common to both projects and almost the same set of communities are affected, additional consultation was undertaken with each community to identify differences in attitudes related to the oil pipeline, and also to the construction of two pipelines, instead of just one.

(1) Objectives 1 - 4 are those identified by IFC in their guide 'Doing Better Business Through Effective Public Consultation and Disclosure: A Good Practice Manual.'

The key consultation milestones are as follows:

- ***Identification of Stakeholders: October 2000***

- ***SCP Consultations: October 2000 – April 2001***

  Phase 1: October 2000 – November 2000 - Meetings with key officials

  Phase 2: November 2000 to December 2000 – Introductory workshops and meetings with NGOs and other stakeholders. Scoping of environmental and social issues, including first round of community level consultation and baseline data collection.

  Phase 3: March 2001 to April 2001 - Second round of community level consultation and preliminary development of mitigation options

- ***Combined SCP and BTC Consultations: August 2001 – May 2002***

  Phase 4: August 2001 – Consultation and baseline data collection with communities in the vicinity of potential sites of construction camps and pipeyards, including meetings with village leaders, migratory herders and interviews with a sample of community members

  Phase I: October 2001 to November 2001 – Introductory workshops with NGOs and Interest Groups for BTC, combined with issues management workshops with national and international NGOs on BTC and SCP in Baku and Ganja

  Phase II: December 2001 – January 2002 – Consultation on proposed mitigation:

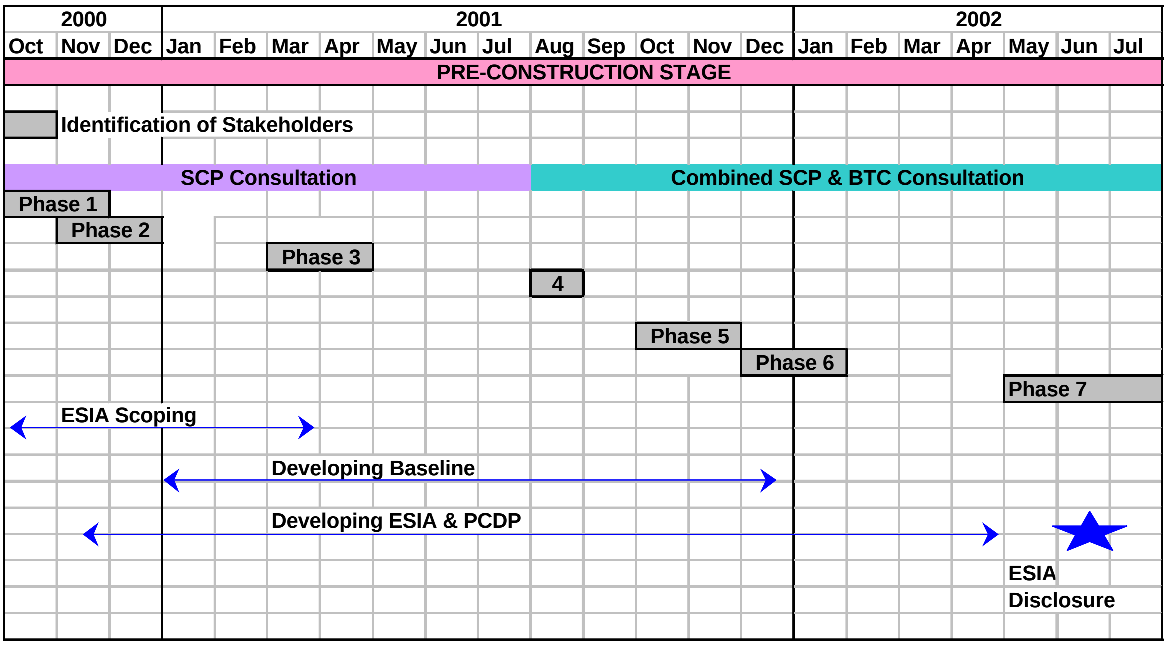
  - Community visits to raise awareness of the additional BTC pipeline, to carry out consultation, baseline data collection and testing of mitigation measures (December 2001)
  - Meetings with specialist organizations to canvas views on specific mitigation measures (January 2002)

  Phase III: April to May 2002 – Consultation on ESIA findings, after disclosure of the ESIA (during April 2002). This comprises two parts:

  - Meeting with national stakeholders, including international NGOs (April 2002)
  - One-day road shows at approximately ten communities along the pipeline route (May 2002)

The consultation schedule is illustrated in *Figure 4.1*

Figure 4.1 Consultation Schedule



4.3 IDENTIFICATION OF STAKEHOLDERS

The sponsor companies have worked with consultants to identify the key stakeholders who should be consulted with at various stages of the project:

- **Authorities** comprising national, regional and local government bodies, of primary political importance to the project and to the ESIA process
- **National and Local non-governmental organizations** which have a direct interest in the project, and which may have useful data or insight into the local and national challenges faced by the project
- **Interest Groups** including for example, media, academics, institutions, foundations and community groups
- **Residents** of communities adjacent to the pipeline corridor, landowners and land users (including migratory herders) of the towns and villages within a 4 km corridor around the pipeline who would be directly affected by the project
- **IFIs** including IFC and EBRD
- **BTC and SCP Partner Organisations**

A full list of the stakeholders identified is presented in *Appendix 2* of this PCDP.

The project has established a consultation tracking database that is being used to log all meetings with stakeholders at national, regional and local level. At the local level this is limited to discussions with village leaders during the ESIA process, but it will include meetings with individual landowners at later stages in the pre construction period. The database is held centrally by BP.

4.4 SCP CONSULTATION, OCTOBER 2000 TO APRIL 2001

Table 4.1 below summarises the consultation carried out for the SCP pipeline between October 2000 and April 2001. Phases 1 to 3 took place during the ESIA scoping phase. Phase 4 (discussed in *Section 4.5*) formed part of the baseline assessment.

Table 4.1 Summary of SCP Consultation

Phase	Date	Consultation Activity
Phase 1	Oct 2000	Introductory workshop and meetings with NGOs and other stakeholders
Phase 2	Nov – Dec 2000	Scoping of environmental and social issues and first round of community level consultation
Phase 3	Mar – Apr 2001	Second round of community level consultation and preliminary development of mitigation options

4.4.1 PHASE 1: MEETINGS WITH NGOS AND OTHER STAKEHOLDERS

October 2000
Introductory workshops and meetings with government authorities took place in October, led by the sponsor companies, and focussed on informing stakeholders of the status of the SCP project, explaining the ESIA activities and schedule. The views of these key organizations were sought regarding the proposed ESIA process with the aim to establish an effective and supportive working relationship throughout the project.

In addition, the sponsor companies led meetings with NGOs and Interest Groups, focusing on providing more detailed information on the project scope, ESIA activities and schedule. Feedback was solicited on topics of interest in relation to environmental and social impacts and the consultation process. The meetings also ascertained which organisations might wish to become actively involved in the process. Detailed minutes of the workshops were circulated to attendees, and are available on request.

4.4.2 PHASES 2 TO 3: COMMUNITY CONSULTATIONS

Prior to the start of any village-level consultation, the consultation team met with the Head of each Regional Administration to explain the proposed consultation process, and seek their support and assistance.

November to December 2000

In November 2000, ERM and its national sub-contractor, Synergetics, embarked on detailed community level consultation. 74 communities were visited within a 4 km corridor centred on the proposed route options (i.e. the refurbishment of the existing Azeri Gas line, or the building of a new pipeline along a slightly different route). The aim was to consult with community leaders and with a sample of individual householders who owned, used or had rights to land on the potential right of way (ROW) or in the construction zone. This formed part of the scoping process.

Quantitative Interviews were held with the 73 most senior government representatives, or the person who is commonly understood to be the community leader or key information source in each settlement or group of settlements. These community leaders were interviewed on a range of quantitative demographic questions, as well as qualitative questions designed to solicit their views and attitudes to pipeline construction, and to identify their key concerns.

814 semi-structured **Qualitative Interviews** were also held with a sample of the householders in every one of these 74 communities. The number of interviews in each community reflected the settlement size. The sample size was as follows:

- at least 5 people in small villages (below 1,000)
- at least 10 people in medium size villages (1,001 to 5,000)
- at least 20 people in large settlements (above 5,000)

Respondents were chosen using a combination of random and stratified selection. Groups of households were chosen to represent a range of living conditions. Households within these clusters were then selected by taking every third house on the left and then interviewing an equal number of men and women, old and young.

Village level stakeholders were provided with written information about the project in Latin and Cyrillic Azeri or Russian as appropriate.

Results of the interviews were used to populate a database, linked to a GIS, for subsequent analysis and presentation in the ESIA reports (see *Appendix 1*).

ERM has worked with Synergetics and others to determine that the methods of consultation proposed are culturally acceptable and socially appropriate, and to adapt the proposed approach to local circumstances (1) . ERM also ensured that the consultation team was fluent in local languages and included an appropriate mix of men and women in order to avoid appearing threatening upon arrival in the villages, and to ensure that the team was able to talk to a full cross-section of the population. *Table 4.2* lists all stakeholders contacted during the scoping phase.

Information obtained via consultation in Phases 1 to 3 was used to

(1) For example, before approaching individuals in villages we made sure that their "daily context" was normal, i.e. no big festivals, holidays, religious celebrations, or funerals.
When interviewing people we approached the " representative" of the household which in Azerbaijan means the senior male except in female headed households.
When interviewing groups, or in workshops, materials were presented in an appropriate language to ensure understanding of a level of technical information, or in two languages where necessary (Azeri, and Russian).
Village leaders were always informed of our presence and the aims of our interview prior to starting the interview process. Where the village leader was absent, other officials were consulted.
All comments and views expressed in specific villages were kept confidential along the route, despite frequent questions.
Individuals were always given the option to refuse an interview, or to refuse to answer questions if they felt that questions were too sensitive or difficult.
Local goods and services were purchased in communities where the team stayed during field work to assist in maintaining good relationships with the villagers.

- establish a route level baseline
- develop appropriate mitigation measures, which were then tested with communities and NGOs in following rounds of consultation
- define socio-economic clauses needed in the Construction Contractor Invitation to Tender

Table 4.2 Summary of Stakeholders Consulted During the Scoping Phase

Stakeholder Groups
Authorities – consulted through one-to-one meetings
SOCAR
Azerigas
AzETLGaz
Azerigaznagl
Minister of Internal Affairs
Key Members of Parliament
Authorities, NGOs and Interest Groups – consulted through meetings
Ministry of Culture
Geipromorneftegas
Former State Committee for Ecology
State Caspian Inspectorate
State Committee for Geology
Department of Nature Reserves
State Land Committee
Division for the Control of Land Utilisation
Caspian Environment Programme
Women and Development
Greens Movement
Great Silk Road Project
BP Research and Monitoring Group
Wide range of Academics from:
Institute of Archaeology and Ethnolography, Azerbaijan Academy of Sciences
Institute of Botany
Institute of Geography
Institute of Geology
Baku State University
ISAR
Ruzigar Society
Ecoenergy Academy
NGOs and Interest Groups - consulted through workshops
Greens Movement
Information analytical centre ECORES
TETA "HAZRI"
Environmental Juridical Centre ECOLEX
International Public Centre of Study of Local
Folk Lore and Ecological Tourism "Caucasus"
Azerbaijan Centre of Birds Protection
Scientific and Research Society "ECOIL"
For Clean Caspian Sea
ECOSCOP
Piligrim
Group of Rehabilitation of Nature
Hydrologist programme

Public Ecological Foundation
Voice of Azerbaijan
Centre "Human & Environment"
Hayajan
Azerbaijan Greens Movement
Ruzigar Society
Mammologists of Azerbaijan

Residents - consulted through survey
All local communities along ROW options

March to April 2001

Following the scoping phases and analysis of route options, a further round of community level consultation was required within the re-defined corridor. The aim was to identify all those communities that were no longer within 2kms of the ROW and to remove these results from the project specific baseline. The consultation also aimed to highlight where new communities were now affected, and to include these within the overall consultation framework.

4.4.3 *PHASE 4: COMMUNITY CONSULTATIONS ON PIPEYARDS AND CONSTRUCTION CAMP*

Additional consultations were also carried out in August 2001 to identify communities and households that may be in direct proximity to sites proposed for potential worker construction camps or storage yards for construction equipment and pipe. Villages within 2kms of potential locations for pipe yards and villages up to 5kms from a potential site for a major construction camp were consulted. The purpose was to capture any communities that may witness project activities although they fall outside the 4km corridor, and also to consult people on the specific issues that may be associated with living close to one of these developments. Consultations also identified households on access roads that may be affected by an increase in traffic flows between these sites and the spread. Households were selected for interview on the same basis as above (though from more specific target locations). These questionnaires were also designed to feed into the same database.

In addition, consultation was undertaken with migratory herders whose migratory routes cross or temporary camps are close to the ROW to ensure that relevant mitigation measures could be put in place to ensure minimum disruption to their lives and livelihoods.

4.5 *PHASE 5, OCTOBER TO NOVEMBER 2001*

The BTC ESIA was initiated through consultation and information disclosure at the national and community levels in August 2001 and October – November 2001.

Project leaflets were distributed to every location on a number of occasions, specifically informing the inhabitants about the pipeline projects or construction camp/yard developments or AGI developments, depending on the actual activities likely to be witnessed at the settlement.

4.5.1 *CONSULTATION AT THE NATIONAL LEVEL*

Introductory workshops for the BTC pipeline were held in Baku and Ganja in October/November 2001, combined with issues management workshops for both BTC and SCP. Participants in each workshop represented some 15 national and international NGOs, in addition to members of the local administration. The format included a first presentation of the BTC project, update on SCP, results of the consultation to date and subsequent roundtable discussions on the key issues of concern to project stakeholders and proposed mitigation. The outcomes of these discussions were fed back into the refinement of the proposed mitigation. The attendees at the two issues management workshops are listed below in *Tables 4.3* and *4.4.*

Table 4.3 Stakeholders Participating In Issues Management Workshop, (Baku, 30 October 2001)

Organisation	Activity
AREAT Research Centre	Conflict prevention and resolution
Azeri Sociological Association	Developing social science. Disseminating sociological research
Inam Centre for Pluralism	Freedom of speech and press, civil society
Azerbaijan Woman and Development Centre	Family planning
Ecolex – Azerbaijan	Rehabilitation services to vulnerable groups
Environmental Law Centre	Encouraging public participation in environmental decision making
Human and Environment Azerbaijan Public Association	Health and environmental problems
Azerbaijan AIDS Association	Overcoming denial of AIDS and preventing the spreads of HIV/AIDS
Women in the Oil Industry of Azerbaijan	Protecting the rights of women oil workers and their families
Ruzigar Ecological Social Union	Unifying ecologists, economists, sociologists, lawyers, journalists
Himayadar Humanitarian Organization	Human rights
Legal Education Society	Legal services to vulnerable groups
Caspian Environment Programme (international)	Marine Environment (Public Participation Advisor)
ISAR (international)	Co-ordination and capacity building of national NGO groups
CHF (international)	Community Development
Save the Children (international)	Health and education, Community Development
OXFAM (international)	Working to reintegrate IDPs
ACDI-VOCA	Farmer to Farmer program - US volunteers

Organisation	Activity
(international)	

Table 4.4 Stakeholders Participating In Issues Management Workshop (Ganja, 1 November 2001)

Organisation	Activity
Ana Kur International	Ecology of the Kura River
Ganja Agrobusiness	Agriculture and environment, providing assistance to
The Centre of Young	Education, protection of youth rights.
Tomris Mother Society	Women's rights, gender, social protection, democratic
Debate in Civil Society	Education, building civil society
Bridge to the future	Organizing leisure activities for children.
Helsinki Citizen's	Encouraging accordance with the main tenets of the Helsinki
Odjag Humanitarian	Providing humanitarian assistance to refugees and IDPs
City Hall (Mayor's Office),	Ganja city administrative authority
AIDS organization in	Raising AIDS awareness
Technological University	One of Ganja's respected higher learning institutions.
"Avicenna" medical NGO,	Health Education.
Municipality, chairman	Ganja's municipal authority
Helsinki Assembly on	Human rights
ACDI-VOCA	Farmer to Farmer program - US volunteers
ISAR (international)	Co-ordination and capacity building of national NGO groups

4.6 PHASE 6 BTC AND SCP COMBINED CONSULTATION (MITIGATION) NOVEMBER 2001 TO JANUARY 2002

The BTC ESIA process was initiated at community level through a visit to each of the communities potentially affected by the BTC pipeline in November/December 2001. These visits served several purposes: to test whether the earlier SCP data was valid for both projects; to assess changes in perceptions or cumulative perceptions as a result of the construction of an oil, as opposed to a gas, pipeline first as well as the construction of two pipelines rather than just one; to raise awareness of the BTC project; to collect baseline data and carry out consultation specifically in relation to BTC. Interviews were conducted in one settlement from each of the ten regions along the route, using a slightly modified version of the questionnaire previously used for SCP. The sample size was 10% of the original number of interviews done for SCP. The whole process built on the community consultation carried out in relation to SCP during the previous year. Informal users of any potentially affected lands, i.e. migratory herders, were also consulted during this process.

In addition to the above, the following community level activities were undertaken:

- Targeted consultation with a sample of individual householders/land users in each community close to (or close to access roads for) any other AGIs associated with the project (i.e. pump and pigging stations)
- Provision of project information through a 1 - 2 hour visit to every community in the corridor and discussions with community members on proposed mitigation measures, in

addition to the further identification of potential opportunities for community investment [(1)]. These meetings began with an introduction to the projects (summarising general information) followed by a question and answer session to outline proposed mitigation on any of the project issues (including employment, land-use during construction, and safety) that most interested community members. General project leaflets were also distributed during these meetings.

4.6.1 *MEETINGS WITH SPECIALIST ORGANISATIONS (NATIONAL AND INTERNATIONAL)*

The sponsor companies will meet with specialist organizations to canvas views on mitigation measures for particular issues, both environmental and social. *Table 4.5* identifies organizations having specialist knowledge of benefit to the project. Many of those meetings have already taken place.

Table 4.5 Specialist Organisations

Environmental Consultees	Social Consultees
Former State Committee for Ecology	Health Ministry
State Committee for Geology	Labour and Social Welfare Ministry
Department of Nature Reserves	UNICEF
Caspian Environment Programme	Oxfam
Research and Monitoring Group	Save the Children Fund
Institute of Botany	International Red Cross
Institute of Geography	International Alert
Institute of Geology	Ministry of Culture
Ecoenergy Academy	Women and Development
Greens Movement	Azerbaijanian Sociological Association
Environmental Juridical Centre	Azerbaijan Woman and Development Centre
ECOLEX	CHF
Folklore and Ecological Tourism 'Caucasus'	Human and Environment Azerbaijan Public Association
Azerbaijan Centre for Birds Protection	Women in the Oil Industry of Azerbaijan
Scientific and Research Society "ECOIL"	
For Clean Caspian Sea	
ECOSCOP	
Group of Rehabilitation of Nature	
Public Ecological Foundation	
Centre "Human & Environment"	
Mammologists of Azerbaijan	
Ruzigar Ecological Social Union	

(1) During the social survey work for SCP and BTC the survey teams have also worked to understand some of the key needs of each community beyond project mitigation. This information is being fed into a separate programme addressing opportunities for Community Investment.

Environmental Consultees	Social Consultees
Flora Fauna International Birdlife International WWF (international) Conservation International; IUCN; Wetlands International	

4.7 PHASE 7 BTC AND SCP COMBINED CONSULTATION (DISCLOSURE OF DRAFT), MAY TO JULY 2002

The draft ESIAs will be publicly disclosed in May 2002 and will be available for comment until July 2002. The document will be made available in Baku, Ganja and other centres along the route in the following types of locations:

- Government offices
- Public libraries
- Community centres
- Selected NGO headquarters
- BP offices
- The worldwideweb

Precise locations will be advertised in advance.

The non-technical summary will be disclosed and discussed with interested stakeholders and communities at national, regional and local level, in order to raise awareness of the project and obtain feedback on mitigation measures. This consultation process will include discussion on both environmental and social issues.

4.7.1 *INVOLVEMENT OF NATIONAL STAKEHOLDERS*

The sponsor companies will hold at least three formal public meetings along the route plus meetings for NGOs and academics in Baku to discuss the findings of the draft ESIA. These will be publicised through national media, both radio and printed media. These meetings will also be publicised directly to potentially interested stakeholders, including organisations invited to workshops at earlier stages of the ESIA process. The public meetings meetings will take place in June 2002 in Yevlakh, Ganja and Akstafa.

4.7.2 *COMMUNITY LEVEL*

The project will conduct a "road show" to highlight and discuss the findings of the draft ESIAs at ten locations along the route in June 2002. These will be chosen in co-operation with Synergetics and will be based on identifying appropriate locations along the route that ensure accessibility for all affected communities, as well as any cultural sensitivity factors. The primary objective of this phase of the consultation will be to enable representatives of all communities affected by the project to participate. The aim will be to get generalized agreement with stakeholders that the most important issues have been identified and properly analysed, and that the proposed mitigation and/or compensation measures are appropriate. The road show will spend half a day in each location and will include a presentation and display with information on the project. Leaflets and exhibition panels will be prepared in Azeri and English.

An advance team will visit all communities to raise awareness of the date and nearest venue for the forthcoming road show and to distribute information leaflets. Dates and locations of meetings will be advertised via posters placed in each community. The advance team will also ensure that public meetings during disclosure are accessible to all potentially affected parties. Should this prove problematic, the project will consider other options for enabling village representatives to attend these meetings wherever possible.

Additional Consultation

There may be consultation on specific issues that were not fully defined prior to the first phase of community consultation in December 2001. This will take place either prior to or during this phase of consultation. It could include the following:

- Construction of access roads
- Traffic management practices
- Sourcing of construction materials

4.7.3 DOCUMENTATION OF DISCLOSURE

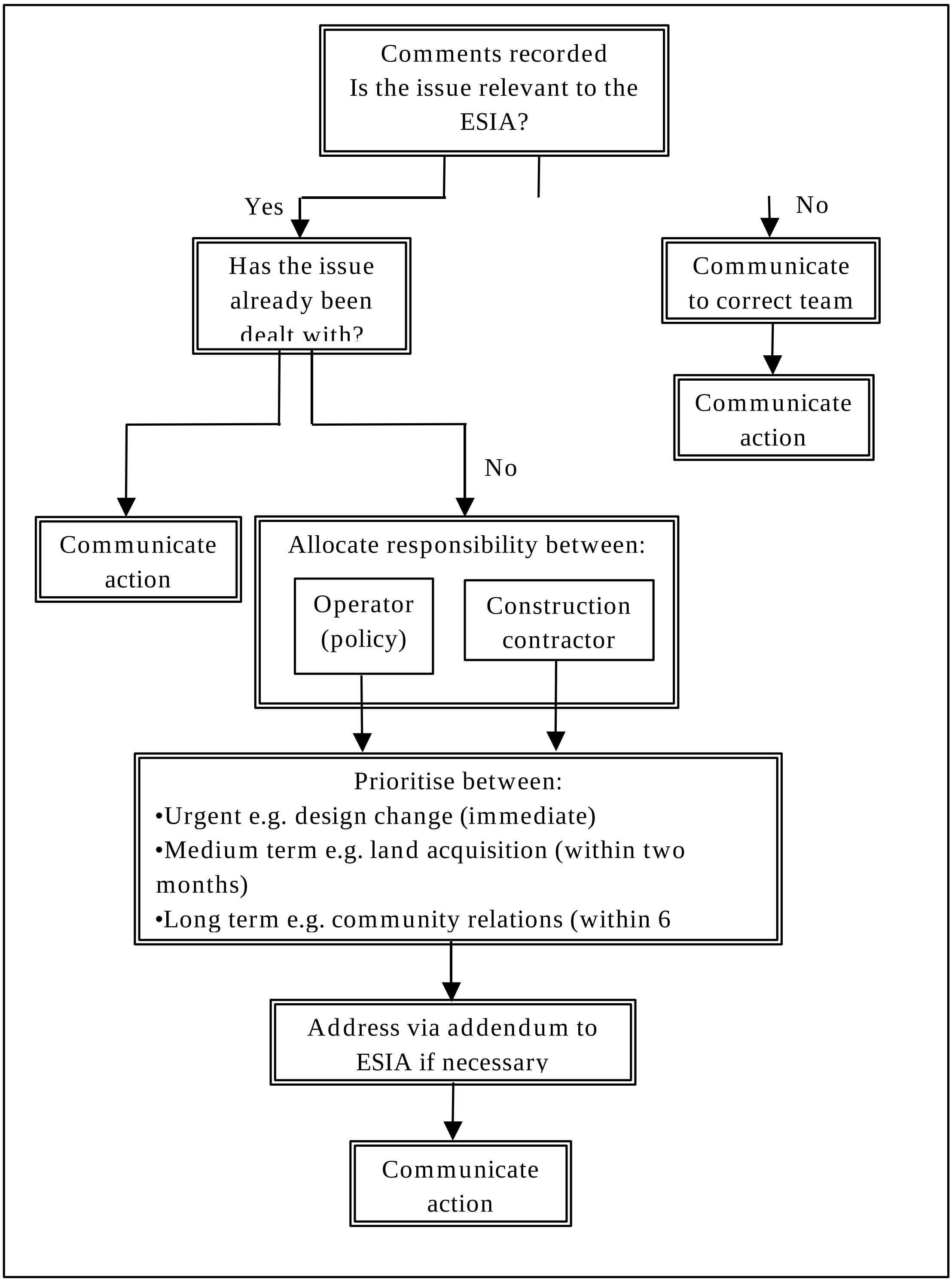
All comments on the ESIA during disclosure, whether written or oral, through meetings or Road Show events, will be dealt with according to the procedure below. Comments during meetings will be systematically recorded by the team (i.e. ERM, Synergetics, the sponsor companies) leading the meeting.

These comments will be assessed on whether they fall within the scope of the project. If comments don’t fall within the scope of the project but concern other related issues such as community investment, they will be passed on to relevant teams. Explanation will be provided to respondents whose comments are not relevant to either the ESIA or related activities.

Where project relevant comments are raised they will be checked to ascertain whether they have already been dealt with. If not, they will be included in the consultation tracker and responsibility for them will be allocated between the ESIA team, operator or the construction contractor. Where the responsibility lies with the ESIA team comments will be addressed during the revision of the ESIA. Where comments are not addressed reasons for this will be recorded within the consultation tracker.

For comments that are the responsibility of the project sponsors or the construction contractor, issues will be prioritised for required actions in the immediate, medium term or long term.

Summary of Documentation of Disclosure Process



4.7.4 *REVISION OF ESIA*

The sponsor companies and their consultant will revise draft ESIAs in July –August 2002, on the basis of comments received at national, regional and local level. The final ESIA reports will summarise the results of the consultation and how comments were addressed. This report will then by submitted to the Government of Azerbaijan, for review and approval.

4.8 *CONSULTATION WITH INTERNATIONAL ORGANISATIONS AND NGOS*

The involvement of international organisations and NGOs is an essential component of the ESIA. Consultation with specialist organizations (including international organizations and NGOs) took place during the initial development stages of the ESIA and will take place during the disclosure phases of the ESIA. These consultations have been described in the preceding Sections.

In addition to these consultations, there will be consultation with international NGOs on macro issues related to the project. This will take place through an independent regional review.

5 ONGOING CONSULTATION & COMMUNITY RELATIONS

5.1 COMMUNITY RELATIONS IN CONSTRUCTION PHASE

This section set outs the proposed mechanisms for liaison with communities affected by the project during the construction phase and operational phase. It identifies the approach to, and frequency of, consultation with affected communities.

The pipeline operator will be ultimately accountable for relations with the pipeline affected communities and the primary responsibility for daily liaison with communities will be borne by the construction contractor. The operator will therefore require the contractor to develop its own plan and more detailed proposals for community liaison. This will build on the approach outlined by the operator and discussed in this section. All potential contractors are required to draw up this plan as part of the tender process and the review of the plan by the sponsor companies will form part of the bid evaluation process.

5.1.1 OBJECTIVES AND DIVISION OF RESPONSIBILITY

The objectives of the community relations programme will be to:

- Provide communities affected by the project with regular information on the progress of work and implications for these communities
- Inform the pipeline operator of any community related issues that may impact on construction
- Monitor implementation of mitigation measures and the impact of construction via direct monitoring and feedback from communities
- Identify any significant new issues that may arise during the construction period
- Manage any complaints against the operator / contractors and communities

Table 5.1 below sets out the number and role of community liaison staff that will be employed in Azerbaijan.

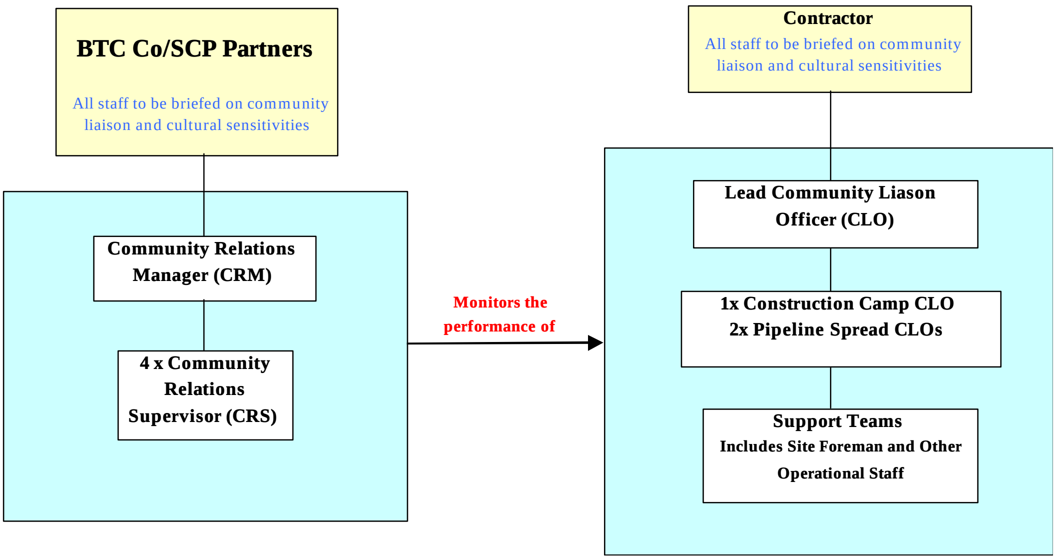
Table 5.1 Community Liaison Teams

Company	Management	Spread 1	Spread 2 (1)	Construction Camps	Total
Construction contractor		1	1	2	4
Operator	1	0	0	2	3

(1) If only one spread is used, only 1 pipeline spread CLO will be necessary.

The construction contractor will be the first point of contact with affected communities. He will appoint a team of three/four dedicated Community Liaison Officers (CLOs), supported by operational staff with specific responsibilities in relation to Community Liaison. This team will comprise 2 Construction Camp CLOs (one of whom will be the lead CLO) and 2 Pipeline spread CLOs.

The operator will establish a project management team on behalf of the project sponsors (for each project) that will monitor the contractor's performance. This team will employ a Community Relations Manager (CRM) with overall responsibility for liaison with affected communities *(see Section 5.1.3 below)*, and two Community Relations Supervisors (CRSs).



5.1.2 *RECRUITMENT AND TRAINING*

The Community Liaison team will be predominantly made up of country nationals. The position of CRM and the lead CLO will be open to both national and international applicants.

The CRM will be appointed when preparatory work with a significant potential construction impact begins. The CLOs will be appointed once the construction contract is in place.

All other members of the Community Liaison team will be in post at least two months prior to the commencement of construction. This will be necessary in order to enable them to be fully briefed, integrated into the project team, given adequate training and be in a position to provide training for other staff with community liaison responsibilities.

The operator and the construction contractor will brief all staff on community liaison and cultural sensitivities as part of the overall project induction training.

5.1.3 *THE OPERATOR'S ROLE IN COMMUNITY LIAISON*

The CRM will have overall responsibility for community liaison during the construction period, ensure that the contractor carries out their responsibilities in relation to the social impact of the project, and that smooth relations with communities are maintained. As part of this role the CRM's responsibilities will include:

- collecting and analysing the reports submitted by the CLOs and dealing with issues arising, alerting the operator as appropriate
- tracking the overall levels of complaints reported and ensuring that the processes for dealing with those complaints and other related disputes are prompt and effective
- organising pipeline attitude surveys (as required by the management and monitoring plan) and ensuring that the results are analysed and appropriate management responses implemented
- ensuring that there is an appropriate balance in community liaison between the pipeline spread itself and the construction camps and pipeyards, encouraging the reallocation of resources by the contractor as appropriate

The role of the two Community Relations Supervisors (CRSs), based at two of the construction camps will be as follows:

- Provide regular information to the project team for communication to external audiences on the social impact of the project and community liaison activities
- Monitor implementation of the management plans for community relations, construction camps, and traffic, through liaison with the contractor and meetings with communities
- Identify breaches of management plans, and recommend corrective action
- Represent the operator at community meetings on occasion, as requested by the construction contractor
- Provide support to the contractor in the development of their CL teams, in particular prior to construction
- Agree a dispute resolution process between the operator, the contractor and communities, based on the grievance procedure attached
- Develop community relations procedures consistent with the operators and project social and security policies, and ensure that CLO training is consistent with this approach

5.1.4 CONSTRUCTION CONTRACTOR ROLE IN COMMUNITY LIAISON

This section sets out the requirements that are currently envisaged by the operators. The construction contractor will be required to produce a Community Relations Plan that sets out in detail their community relations strategy. This will be reviewed and finalised by the operator.

Successful community liaison will be achieved through sharing this responsibility throughout the construction team. Each work team will allocate primary responsibility for community liaison to an individual. These individuals will liaise with the team of four dedicated CLOs, and involve them as necessary.

Lead CLO

The lead CLO will have overall responsibility for the following:

- Implementation of the management plans for community relations, construction camps, and traffic
- Training of all contractor staff with community liaison responsibilities
- Communication with communities affected by the project
- Provision of reports to the operator
- Management of contractor CLOs to carry out roles listed below

Construction Camp CLOs

The project currently anticipates that there will be up to four construction camps in Azerbaijan. This will be finalised following the appointment of the construction contractor. There will be one CLO attached to two of these construction camps. Their role will be to:

- Hold regular meetings with communities throughout the lifetime of their host camp, and a second camp closest to their host camp
- Support implementation of the construction camp management plan
- Advise the lead CLO and construction camp management, on changes required to the camp management plan
- Meet with communities close to smaller camps and AGIs on a monthly basis, and advise contractor management and the lead CLO on issues arising from these meetings
- Produce fortnightly reports on implementation of the camp management plan, specific incidents, and action taken to address community concerns

Movement around the pipeyards will be the major focus of traffic associated with the project, since line pipe and other project materials will be stored at the pipeyards and transported to the point of use. The project currently envisages that there will be approximately five pipe yards in Azerbaijan, and that three yards may be operational at any one time. These locations will be finalised following appointment of the construction contractor.

The construction camp CLO will therefore be responsible for:

- Monitoring implementation of the traffic management plan, through liaison with other contractor staff
- Implementing the dispute resolution and grievance procedures where required
- Holding meetings, on a monthly basis, with communities identified in the traffic management plan as most affected
- Producing a quarterly report on implementation of the traffic management plan
- Raising issues of concern in relation to the implementation of the traffic management plan on a fortnightly basis

Pipeline Spread CLOs

The construction teams in each spread will be working approximately along a 50-kilometre length at any one time. One CLO will therefore be required on each spread to liaise with communities along the pipeline route. Their role will be to:

- Meet village leaders and speak at village meetings prior to arrival of construction teams in a given locality, to inform them of the nature and length of activities in their area

- Hold fortnightly meetings with village leaders and communities while construction teams are present in their area
- Liaise with contractor staff with primary responsibility for community liaison in each work team
- Provide a focus for negotiation and resolution of specific complaints from communities if / when they arise, using the dispute resolution or grievance procedure
- Provide short weekly updates to the Community Relations Manager
- Liaise with the management of the spread team on major issues arising, and provide feedback to communities on responses to these issues

5.2 COMMUNITY RELATIONS IN OPERATIONAL PHASE

The objective of the community relations programme in this phase will be to:

- Maintain constructive relationships between communities and the pipeline operators, to assist in the operation of the pipeline
- Maintain awareness of safety issues among communities along the pipeline route
- Ensure compliance with land use constraints among land owners along the pipeline route
- Monitor community attitudes to the pipeline and operating company

There will be a telephone “hotline” that anyone with concerns about the pipeline can call. There will also be an email address and a postal address to which written comments or complaints can be sent. Clearly, however, the telephone, email and postal contacts will be of limited use to residents outside Baku and larger settlements. The Community Liaison Officer will therefore be an important link for individuals at the village level, both for registering opinions and comments and for keeping communities informed of developments, up-coming meetings and consultations.

The operator will maintain a Community Liaison team during the operational phase. The precise nature of this team has not yet been finalised. It is currently envisaged that the team will be managed by an operator staff member based in Baku, and that field members of the team will be recruited from villages along the pipeline route to perform a dedicated Community Liaison role. Members of this team during the operational phase will be required to:

- Hold quarterly meetings with communities along the pipeline route, reducing to six monthly or annual as appropriate
- Patrol the pipeline route, to ensure compliance with land use constraints
- Provide monthly reports to the pipeline operating company on issues arising from liaison with communities
- Inform the operating company immediately of major breaches of safety or land use constraints, or serious complaints from communities along the pipeline route
- In the event of decommissioning of the pipeline, liaise with communities in the 3 – 5 years prior to de-commissioning. This role would complement work carried out by the operating company and community investment team to reduce the negative impact of pipeline de-commissioning

6 SUMMARY TABLE: CONSULTATION AND DISCLOSURE TIMETABLE

Table 6.1 below summarises the consultation and disclosure activities that will be carried out until the end of Disclosure of the draft ESIA in mid July 2002. These are broken down for each stakeholder group. Consultation activity includes both the BTC and SCP pipelines, unless otherwise mentioned.

Table 6.1. Summary Table of Consultation and Disclosure Activities

Stakeholder Type	Environmental	Social
Authorities	• Preliminary (pre-scoping) consultation through meetings October 2000. • Written feedback on ESIA after disclosure, May 2002	• Preliminary (pre-scoping) consultation through meetings. Written feedback on ESIA after disclosure, May 2002
Authorities, Academics, National and Local non-governmental organisations	• November and December 2000 • Participation in SCP scoping workshops. • Consultations on mitigation measures with specialist organisations, January 2002 • Written feedback on ESIA after disclosure, May 2002	• November and December 2000 - Participation in SCP scoping workshops. • October and November 2001 - • Issues Management Workshops in Baku and Ganja • Consultations on mitigation measures with specialist organisations, January 2002 • Written feedback on ESIA after disclosure, May 2002

Stakeholder Type	Environmental	Social
Other Interest Groups	• One to one meetings with key academics and NGOs (intermittent) • Presentation to environmental NGOs, December 2001 • Written feedback on ESIA after disclosure, May 2002	• One to one meetings with key academics and NGOs (intermittent) • Written feedback on ESIA after disclosure, May 2002
Residents	• General environmental questions included within baseline consultations • Environmental issues addressed in "Road Show" to ten locations on the pipeline route to discuss findings and proposals in draft ESIAs	• Meetings with community leaders and representatives of every community within 4km of the proposed pipeline routes, November to December 2000 • Once the project corridor was defined, new communities that would be affected were also consulted (March and April 2001) • Consultation targeting communities in direct proximity to potential construction camps and pipe yards (August 2001) • Consultation to raise awareness of BTC and discuss proposed mitigation measures and to consult with householders/land users adjacent to AGIs (December 2001) • Consultation with communities located down stream of a proposed BTC river crossing (February 2002) • "Road shows" at 10 communities along the pipeline route to present findings from ESIA, May 2002

7 RESOURCE ISSUES: STAFF TIME AND COSTS ASSOCIATED WITH CONSULTATION

This section sets out the estimated resource implications of the proposals set out in this PCDP. It includes both staffing levels and costs associated with consultation, and has been divided into the period prior to and during construction and the post construction phases.

7.1 PRE CONSTRUCTION

The focus of consultation prior to this period is the development of the ESIA. *Section 4* outlined the specific consultation activities that have been or are planned to be carried out as part of this process.

7.1.1 STAFF TIME

The sponsor companies employ a dedicated staff of four during the pre construction phase to oversee the ESIA process and related project activity and decisions. This staff comprises 75%Azeri nationals. This team devotes a significant proportion of its time to involvement in, and support for, the public consultation process. The team is committed to participating directly in all consultation at the national level, and to participating as team members in consultation activity at local level.

The sponsor companies also employ a team of approximately 18 land staff. This team, which is 100% Azeri national, will take the lead in liaising and negotiating with individual landowners in the period immediately prior to construction. The team has been recruited at this early stage to carry out preparatory work and to enable them to familiarise themselves with affected communities. This team currently undertakes consultation activities with landowners and occupiers.

7.1.2 RESOURCE IMPLICATIONS

The SIA consultants (national and international) are responsible for public consultation at local level and also for consultation on social issues at national level. Over a period of 18 months during which the consultation has taken place, the size of the team will have varied from one permanent person to 12 people working full time at peak periods of consultation and data collection.

7.2 CONSTRUCTION AND OPERATIONAL PHASES

Section 5 outlined the consultation and public information activities that have been identified to date for the construction and operational phases. The approximate resource implications of this activity are summarised below.

7.2.1 STAFF TIME

Liaison with affected communities during the construction phase will require a team of at least seven Community Liaison Officers, employed by the Construction Contractor and the operator as discussed in *Section 5*. It is estimated that one of these will be an expatriate and that the remainder will be Azeri nationals.

The precise staff implications for the operational phase have not yet been defined. The sponsor companies are committed to maintaining a presence along the pipeline route through a smaller Community Liaison team. The current analysis is that this team will employ approximately ten staff, of whom one will be an expatriate and the remainder will be Azeri nationals, recruited from communities on the pipeline route. This level of local recruitment is consistent with both the approach and staffing levels on the Western Route.

7.2.2 RESOURCE IMPLICATIONS

The team of Community Liaison Officers will be provided by the sponsor companies.

8 GRIEVANCE MECHANISM

8.1 LOCAL COMMUNITIES COMPLAINTS PROCEDURE

8.1.1 PURPOSE & SCOPE

To ensure all complaints from local communities are dealt with appropriately, with corrective actions being implemented and the complainant being informed of the outcome. It will be applicable to all complaints received from any pipeline-affected communities.

8.1.2 RESPONSIBILITIES

The Community Liaison Officers will be responsible for collating written complaints and co-coordinating responses to all complaints.

8.1.3 PROCEDURE

General Complaints

All complaints shall be handled in accordance with the flowchart below. Both verbal and written complaints are to be entered on the Complaints Log and the Complaints Action Form (see below).

Upon receiving a complaint, all employees shall refer the complainant to the Community Liaison Officer or the HSE department. Any members of the HSE department receiving a complaint shall ensure that a Complaint Action Form is completed. The form shall then be forwarded to the Community Liaison Officer who will assign it a number. The Community Liaison Officer shall ensure that all actions are completed to close out the complaint.

If the CLO is not able to respond to or deal with a complaint directly, he/she will refer the complaint to the appropriate manager, through the CRM, or to the Construction Contractor, via the lead CLO. However, the CLO remains responsible for tracking the complaint and ensuring that it is dealt with.

Complaints Log

Ensures that each complaint has an individual number and that tracking and recording actions are carried out. It also contains a record of who is responsible for an individual complaint and records dates for the following actions:

- Date the complaint was reported
- Information on proposed corrective action sent to complainant (if appropriate)
- The date the complaint was closed out
- Date response sent to complainant

Complaints Action Form

This specifies the information required to ensure the complaint is dealt with. The form is split into four parts:

> **Part A** Information about the complainant, the number of the complaint (taken from the Complaints Log)
> **Part B** The complaint section, where all the details relevant to the complaint are recorded
> **Part C** For recording the immediate action required and identifies any long term corrective action required
> **Part D** Details how the corrective action shall be verified and signed off

8.2 RESPONDING TO A COMPLAINT

All complaints shall be responded to in writing, though a verbal response will be provided as well, if this is more appropriate under the circumstances (e.g. where the complainant can not read)

All complaints must be responded to within two weeks of being received, even if the response is just a summary of what is planned and when it is likely to be implemented. Further correspondence should be given once the complaint is closed out.

8.3 MONITORING COMPLAINTS

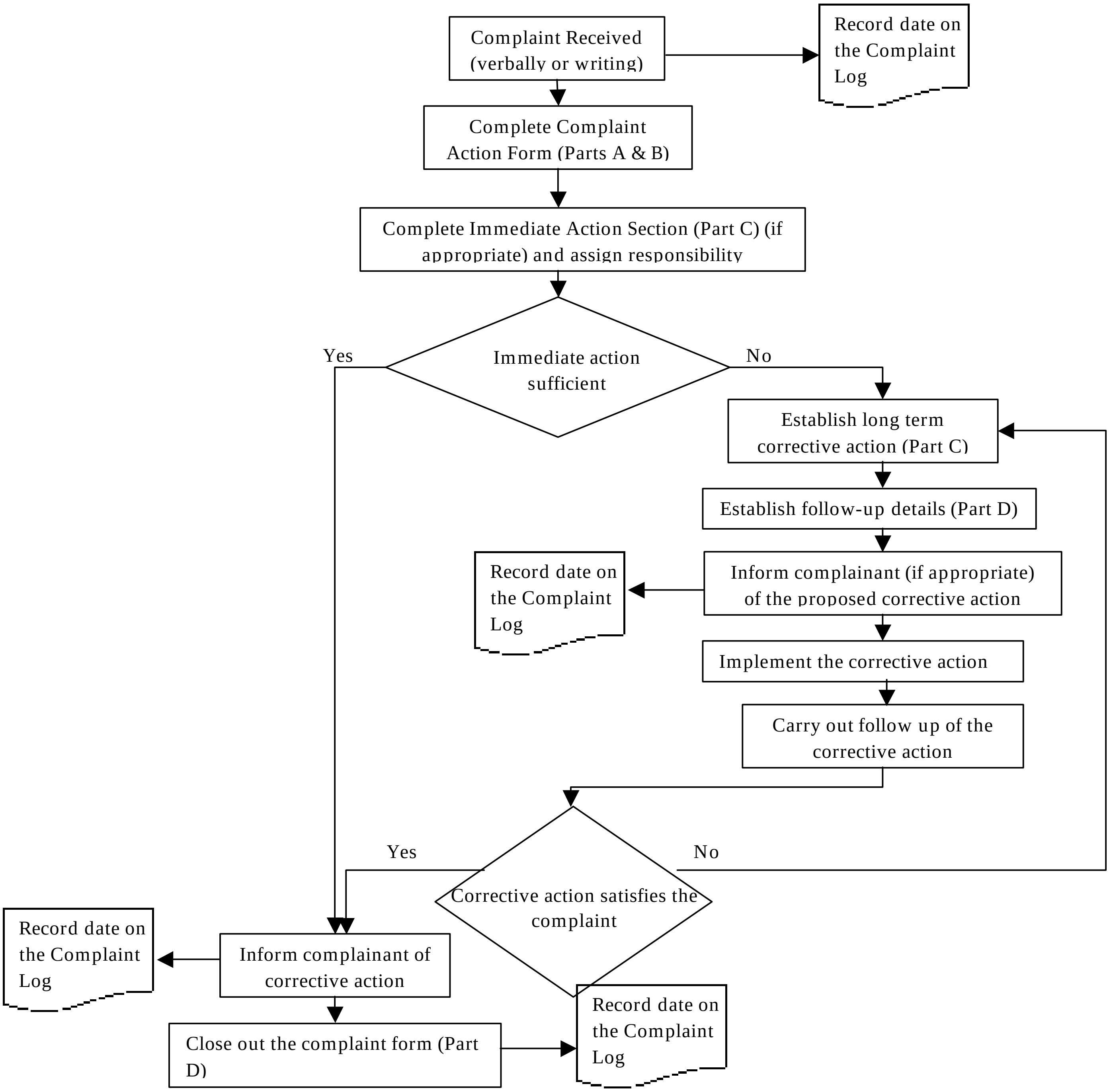
The lead CLO will be responsible for providing the sponsor companies with a weekly report detailing the number and status of complaints and any outstanding issues to be addressed and monthly reports, including analysis of the type of complaints, levels of complaints and action taken to reduce complaints.

8.4 *RECORDS*

The Community Liaison Officer shall file all documentation related to complaints in a file in his office. All complaint documentation shall be kept on file for two years and then archived.

Levels and types of complaints will be monitored through the Social Management and Monitoring Plan, as well as the speed which complaints are dealt with.

Figure 8.1 Complaints Procedure Flowchart



ANNEX 1

Public Consultation Materials

Questionnaire for Village Level Data (1)

This questionnaire is designed for use with community leaders as a tool for rapid acquisition of community profile data. It is estimated that completing this pro-forma will take one to two hours in meetings and village walks with village leader(s). The pro-forma should be introduced after the pipeline project and the ESIA and consultation have been introduced.

The information collected using this questionnaire will be entered onto a database and subsequently be part of the GIS system used for pipeline design and management.

1. Basic Data

1. Name of respondent(s)

2. Name of settlement (‘*naselyonnogo punkta*’)

3. Name of district (‘*rayon*’)

4. Distance from administrative (district - ‘*rayon*’) centre

5. Nearest town (if different to this settlement)

6. GIS reference (precise geographic coordinates of the settlement)

7. Are there any separate houses in the vicinity of your village?

8. Approximate distance from the pipeline to
(a) nearest land plot of your settlement
(b) nearest house in your settlement

9. Number of houses in this settlement:
(a) with permanent residents
(b) with temporary residents
(c) with no residents

10. Population (including children):
(a) permanent resident
(b) temporary resident
(c) Internally Displaced Person/refugee

11. Population Analysis (residents)

	Male	*Female*	
Total			data[(1)] / estimate
Under 5			data[(1)] / estimate
5-18			data[(1)] / estimate
19-59			data[(1)] / estimate
60+			data[(1)] / estimate

[(1)]*Please provide reference*

12. Has the population of the village changed over the last 5 years or so?

	Code	*Reason*
Grown	1	
No changes	2	
Decreased	3	

2. Ethnic structure (by individual)

Ethnic Groups	*Yes*	*No*		*Number (estimate)*
Azeri	1	2		
Russian	1	2		
Other (specify)				

3. Religious structure (by individual)

Religious Affiliations	*Yes*	*No*		*Number (estimate)*
Muslim	1	2		
Christian	1	2		
Other (specify)				

4. How do people in this settlement secure their livelihood (*multiple responses possible*)?

	Most households	*Some households*	*No households*
Crops	1	2	3
Animal husbandry	1	2	3
Hunting, fishing, gathering	1	2	3
Industry	1	2	3
Trade	1	2	3
Salaries paid from sate budget	1	2	3
Material aid provided by family members living outside the village	1	2	3
Social benefits (excluding Humanitarian aid)	1	2	3
Humanitarian aid	1	2	3
No permanent source of livelihood	1	2	3

5. What is the form of land ownership in the settlement (for villages only)?

	Most land	*Some land*	*None*
State owned	1	2	3
Municipally owned	1	2	3
Privately owned (farming, etc.)	1	2	3

6. Agriculture/fishing : Scale of settlement production

1. Please list the main agricultural products produced in the village.

2. Is agricultural produce mostly used in the village or sold outside?

3. Does the village use temporary/seasonal irrigation? If so, are irrigation canals dug in the same places every year?

7. Industry/ Commerce in the settlement

1. Please list the industry/commerce/crafts in the village (e.g. workshop, restaurants, taxis, hairdressers etc.)

8. Labour force

1. In your opinion, are there people in the settlement who take on temporary work or could take on temporary work?

2. If villagers were offered a temporary job, would they take it?

3. Are there people in this settlement qualified/experienced in pipeline construction?

4. What kind of skills do people have that could be useful to pipeline construction?

5. Are there people who belong to this settlement who have gone away for work? Approximately how many?

9. Education

1. How many students from your settlement enrolled in universities/higher education institutes this year?

2. How many schools are there in the settlement, and what are their names?

3. Where are the schools located in relation to the pipeline route?

4. Do children from the settlement go to schools outside the village? If so, where?

5. Are there any educational issues in the community, e.g. condition of schools; need for children to travel long distances to school?

10. Heath

1. What are the health services in this settlement?

	Yes	*No*
Polyclinic	1	2
Medical Post	1	2
Private Doctor(s)	1	2
Pharmacy	1	2
Traditional medicine (‘*znachar*’)	1	2
Other (please specify)		

2. How far is the nearest hospital?

3. Are there any problems with health services/care in your settlement?

4. In your opinion, how has the health of the local population changed during the past five years?

Worsened	1
Improved	2
Remained the same	3

5. If health has deteriorated, what do you think could be the causes of this? (*Multiple responses possible)*

Insufficient food	1
Poor quality of food products	2
Poor quality drinking water	3
Inadequate sanitation	4
Ageing	5
Reduced quality in health care	6
Psychological stress	7
Worsening economic conditions	8
Other (specify)	
Don't know	9

11. Community services

1. Is electric energy provided to your settlement?

Permanently	1
Provided, but with interruptions	2
Depending on season	3
Not at all	4

2. Is there a gas line to this settlement? If yes, how regular is your supply?

Permanent	1
Provided, but with interruptions	2
No supply	3

3. Do villagers purchase gas canisters? If not, why?

Yes	1
No, we have supplies from the gas line	2
No, not available locally	3
No, too expensive	4
No, we do not use gas at all	5
Other (specify)	

4. Does your village receive water from communal supply (*vodoprovod*)?
If yes, how regular is the supply?

Yes, we always receive water	1
Yes, but with interruptions	2
No, we do not receive water from communal supply	3

5. If your settlement does not regularly receive water from communal supply (*vodoprovod*),
where do you get water from ?

Household well	1
Neighbourhood / community well	2
Stored water supply	3
Spring	4
Other (specify)	

6. Is there a communal sewerage line in this village?

Yes	1
No	2

7. Is your settlement connected to a telephone line?

Yes, most households have a telephone connection	1
Yes, but it is available only at communal points (e.g. post office, local government office, school)	2
No	3

8. How reliable are the telephone lines?

Reliable	1
Not reliable	2

9. What is the percentage of people in the settlement who use mobile phones?

10. How do the residents of this settlement dispose of their garbage?

11. Please list and describe services and infrastructures in your area:

	Yes, working	*Yes, not working*	*No*	*DK*
Police	1	2	3	9
Fire department	1	2	3	9
Health clinic/hospital/ emergency healthcare services (ambulances, etc.)	1	2	3	9
Schools	1	2	3	9
Child care services (kindergarten)	1	2	3	9
Post Office	1	2	3	9
Community Centre/Club	1	2	3	9
Banks /(*sberkassa*)	1	2	3	9
Shop/market	1	2	3	9
Public bath	1	2	3	9
Telecommunications	1	2	3	9
Sanitation (sewerage, garbage services, etc.)	1	2	3	9
Local government office	1	2	3	9

12 Problem solving

1. How are the decisions affecting the whole settlement taken (e.g. local meeting)?

13 Information sources

1. How do people in the settlement normally receive information about local and national issues and events? *(multiple choices possible)*

Television	1
Radio	2
Newspaper	3
Family and/or friends, neighbours	4
Other sources (specify)	

14. Local development

1. What are the plans for use of the land adjacent to the area for the next three years?

15. For settlements close to existing pipeline routes, worker camps, pipe yards only (less than 2 km)

	No	*Yes*	*If yes, please describe*
1. Has safety/emergency response information been provided?	1	2	
2. Have there been any incidents?	1	2	
3. Are markers all in place?	1	2	
4. Are there any issues/concerns related to the site	1	2	

5. What sort of contact do you have with the pipeline company?

16. For all settlements

1. What information do you have about the pipeline project near here?

No information before this meeting	1
Had heard rumours	2
Had heard from other sources (please specify)	3

2. What benefits, if any, do you think the construction of a new pipeline would bring to this settlement?

3. What problems, if any, do you think the construction of a new pipeline would bring to this settlement?

4. What information does this community need if a new pipeline is to be built nearby?

5. If an oil pipeline construction goes ahead, there will be a few construction personnel camps and workers may be located in the vicinity. What benefits would the village derive from construction personnel living nearby?

Money	1

Employment opportunities	2
Other (specify)	

6. What do you think would be the main problems from their stay? *(Please ask first without prompts, then provide examples)*

Noise	1
Increased traffic	2
Increased crime	3
Take jobs away from locals	4
Take land	5
Other (specify)	

7. If an oil pipeline is to be constructed near here, what do you think the main involvement of this settlement could be? *(Please ask first without prompts, then provide examples)*

Provide skilled labour	1
Provide unskilled labour	2
Provide food/services to workers	3
Rent house/room to workers	4
Offer specialist contribution (advice, expertise, etc.)	5
Other (specify)	

17. Summing up

1. What, in your opinion, are your settlement's **three most important problems**? *(Please ask without prompts, then show card)*

Problem	
Poor roads - inadequate access	1
Inadequate health care	2
Inadequate schools	3
Inadequate housing	4
Inadequate child care services	5
Poor drinking water supply	6
Unsafe sanitation	7
Poor drainage	8
Inadequate irrigation	9
Inadequate telecommunications	10
Crime	11
Political problems	12
Ethnic conflicts	13
Land conflicts	14
Lack of employment opportunities	15
Lack of money	16
Other (specify)	

2. What are the **three best things** about (settlement name)?

Thank you very much for your co-operation and for spending your time answering our questions.

Individual Qualitative Interview

Oil Vs Gas Pipeline
Guide and Questionnaire (5)
Azerbaijan-November/December 2001

Introduction

The Government of Azerbaijan and BP (international petroleum and petrochemicals group) are discussing the possibility of constructing two pipelines (one oil and one gas) from terminals near the Caspian Sea, through Azerbaijan, and subsequently to Georgia and Turkey. The pipelines will be located side by side, largely along a route common to the existing Western Route Export Pipeline (WREP).

Before any decisions can be made it is important for all involved to learn more about life in your and others' towns/settlements, both near to the suitable sites and close to any adjoining roads.

This interview is part of a major study being done in Azerbaijan that looks at both environmental and social issues and concerns for the entire pipeline project. In addition to interviews like these, we are also collecting data through meetings with community leaders, and we have also interviewed people in all the settlements close to the actual route of the pipelines.

So, although a number of the pipeline route questions may not be applicable to you, we would be interested in your views concerning both the oil and gas pipelines. Your input will be very valuable to the decision-making process, and because any information you provide will be kept anonymous, all of your answers will be strictly confidential.

General Information

First, I'd like to ask you a few questions about yourself, your household, and your town.

1. How long have you been living in this settlement? In this house? *(If respondent was born in the settlement, also ask how long their family has lived there.)*

Ask people who have been living in the settlement for over 5 years

2. Have there been any big changes in this settlement over the last five years? For example did certain groups of people leave the settlement? Are there people who have moved to the area from other areas?

Unless otherwise mentioned: Do you think population in this town has increased or decreased over the last five years or so?

Ask every interviewee

3. How do you assess your families' standard of living? Do you think the standard of living of your family is better, same or worse than that of the majority of families in this area?

4. What provides the main income to your family?

5. What are the main items of expenditure for your family?

6. Do you think that there are possibilities for economic development in this town? What are they?

7. Do you or any members of your household take work outside this town? If so, what types of work? Where? Would you or other members of your settlement like to work outside your settlement?

8. Does any member of your family live or work permanently outside of this settlement? Where - elsewhere in Azerbaijan or outside the country?

9. What do you consider as the best thing about living here? Why?

10. Are there any cultural or historical monuments here or are there any important environmental sites?

11. Do people get on well together in this region? How do disputes get resolved?

12. What do you think are the biggest problems in this town and why do you think so? How do you think they might be solved?

13. What do you consider to be the best sources of information about local and national issues here? What kind of information seems most reliable to you?

14. How do people here usually communicate with each other? Do they have any permanent gathering places?

15. How do people usually communicate with members of the local government?

Infrastructure

Now I'd like to ask you about your opinions on local services and infrastructure.

16. Do you have regular access to electricity? If so, what do you use it for? If not, do you consider the lack of electricity a big problem for your household?

17. Do you use gas? Piped or from canisters? If you use gas, what do you use it for (e.g. cooking, lighting)? If you do not use gas, is this a problem for you?

18. How do you get water? How would you describe your water situation: do you have enough for household purposes? How about for agricultural purposes?

19. How would you describe the conditions of roads in and around your town? Are roads, or the lack of them, a problem for your household? Why?

20. Do members of your household usually receive medical care locally? If so, from where (e.g. polyclinic, traditional doctors)? If not, where and how do you receive medical care? How would you describe local healthcare services? What is most problematic about medical treatment here? What is best about healthcare here?

21. Are fires a problem in your area? If yes, how do you deal with them? Are you capable of extinguishing fires? If yes, how: through family, fire brigade or neighbours?

22. Do you have schools in your settlement? What kind of problems does your settlement have with education? Are the schools in this area getting better, worse or remaining the same?

23. What kinds of industrial facilities are there in your area? Are these facilities still operational?

24. Is there a sewerage system in your area of residence? If not how do you dispose of waste water? Is this a problem?

25. Where do you dispose of garbage/ waste? Is this a problem?

26. What would you say the biggest infrastructure problems (including schools, medical care) are here? What are the things that work best?

Land Issues

Let's talk about land - I'd like to ask you about how your and other households here use land.

27. Does your household own land here? How do you use this land? For example, do you grow any kinds of crops or raise animals on it? What is your land ownership form?

28. Do you or any members of your family hunt or fish? Are hunting and fishing important sources of food for your household? What time of year is most profitable for these activities?

29. Does most of your food come from your own farming and fishing or is it purchased?

30. Is there a forest in the vicinity of your settlement? How do you use the forest resources?

Oil pipeline first, then possible a gas pipeline second

As I mentioned earlier, it is possible that construction of an oil pipeline will begin in your area late next year, rather than a gas pipeline which had been proposed earlier. A second pipeline for gas may then be built immediately after the completion of the oil pipeline. This means that there could be construction in your area for up to three years. However, following construction, both the pipelines will be buried.

I would like to ask you about your opinions regarding the potential oil pipeline construction process and the idea of the two pipelines themselves.

31. Are there any pipelines in your area now?

32. Aside from what I've told you, have you heard anything about plans for building an oil pipeline in your area? What kinds of things have you heard? Where have you heard them?

33. In general, would you support the presence of an oil pipeline in your area? Why or why not?

34. In general, would you support the presence of a natural gas pipeline in your area? Why or why not?

35. How do you think the presence of an oil pipeline could benefit you and your village?

36. What problems do you think a new oil pipeline could bring to this settlement or to you?

37. Understanding that a lot of work will be carried out to construct a pipeline and facilities here, what are your biggest concerns about the potential

construction process? For example, would you be worried about noise or other possible disruptions?

38. What do you think would be the main concerns in your settlement(s) in relation to the use of land during the construction phase?

39. If the pipeline is to be constructed in your settlement area, what do you think should be your involvement or the involvement of others?

Now I'd like to ask you about the possible construction of two pipelines.

40. What do you think the main impacts would be (positive and/or negative) if two pipelines are constructed?

41. What do you think the main impacts would be (positive and/or negative) if the use of land in the pipeline corridor for construction of the pipeline continues for up to three years?

42. How could the impact of the construction of two pipelines be improved?

43. How would you like to receive information in future about the possible pipelines and their construction?

44. Do you have any further comments about any of the things we've discussed today?

Thank you very much for your time.

AGT Project Leaflet: English

Some common concerns:

Will the pipelines be safe?

Yes. The pipelines will be built to the highest international standards, and will pose no threat to nearby residents.

Will the pipelines be visible after it has been built?

No. The pipelines will be buried and the land will be restored. There may also be several above ground facilities on the pipeline route, such as compression and valve stations. No trees or large shrubs will be allowed to grow on the pipeline route.

What will happen to the land following construction of the pipeline?

The land will be restored to minimise environmental impacts along the route, and an ongoing programme of monitoring and reporting will be implemented. Owners of adjacent land will be consulted and informed with respect to access to the pipeline route following construction.

Will local people benefit from the pipeline?

Yes. There may be employment opportunities during construction. In addition, local communities will benefit from indirect employment opportunities through the provision of

Contact BP:

For further information, please contact the following BP representative.

Namig Abbasov
Project Development Manager, AGT Pipelines Project

BP Group
ADDRESS to COME

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Azerbaijan

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services to construction teams.

Project description:

The Azerbaijan-Georgia-Turkey (AGT) Pipeline Project comprises two pipelines (one oil and one gas) from the Caspian Sea, through to Turkey. Within Azerbaijan, the pipelines will be located side by side, largely along a route common to the existing Western Route Export Pipeline (WREP - see map). The construction of the two pipelines will take approximately 3 years assuming the construction of the gas pipeline follows on immediately from the oil pipeline construction.

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Áèð íå÷ÿ öìóìè ñóàë:

Áó ëàéèhÿ òÿhëöêÿñèç îëàæàãäûðìû?

Áÿëè. Áîðó êÿìÿðëÿðè âÿ îíëàðûí áöòöí àâàíäûãëàðû ÿí éöêñÿê áåéíÿëõàëã ñòàíäàðòëàðà óéüóí îëàðàã ÷ÿêèëÿæÿê âÿ éàõûíëûãäà éàøàéàí ñàêèíëÿðÿ he÷ áèð òÿhëöêÿ òþðÿòìÿéÿæÿêäèð.

Áîðó êÿìÿðëÿðèí òèêèëìÿñèíäÿí ñîíðà, êÿìÿðëÿð ýþçÿ ýþðóíÿí îëàæàãëàð?

Õåéð. Áîðó êÿìÿðëÿðè éåðèí àëòûíà áàñòûðûëàæàãëàð âÿ òîðïàãëàð ñîíðà áÿðïà îëóíàæàã. Áîðó ùÿòèííèí äÿùëèçèíÿ íàñîñ âÿ êëàïàí ñòàíñèéàëàð êèìè éåð öñòö ãóðüóëàð äà òèêèëÿ áèëÿð. Áîðó êÿìÿðèí ìàðøðóòóíäà ùåæ áèð àüàæëàðûí âÿ èðè êîëëóãëàðûí ÿêèëìÿñèíÿ èæàçÿ âåðèëìÿéÿæÿã.

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ßòðàô ìöùèòÿ òÿñèðëÿðèíèí àçàëòìàñû ìÿãñÿäè èëÿ äÿùëèç áîéö òîðïàãëàð áÿðïà îëóíàæàãëàð, âÿ äàèìè ìîíèòîðèíã âÿ ùåñàáàòëàøìà ïðîãðàìû òÿòáèã îëóíàæàã. Áîðó êÿìÿðèíèí òèêèëìÿñèíäÿí ñîíðà îíóí éàõûíëûãûíäà éåðëÿøÿí òîðïàãëàðûí èñòèôàäÿñè ùàããûíäà, áó òîðïàãëàðûí ñàùèáëÿðè èëÿ ìÿñëÿùÿòëÿøìÿëÿð àïàðûëàæàã.

ÁèÏè èëÿ ÿëàãÿ:

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Íàìèý Àááàñîâ Ëàéèùÿíèí Èíêèøàô öçðÿ Ìåíåæåð, ÀÝÒ Áîðó Êÿìÿðëÿðèí Ëàéèùÿñè

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Èçìèð Êöæÿñè 1033
Áàêû, Àçÿðáàéæàí**

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Áó êèòàá÷à ÁèÏè øèðêÿòèíèí Àçÿðáàéæàíäà ÿhàëèéÿ ìÿëóìàòëàðûí ÷àòäûðûëìàñû âÿ îíëàðëà ìÿñëÿhÿòëÿøìÿ àïàðûëìàñû öçðÿ ïðîãðàìûíûí òÿðêèá hèññÿñèíè òÿøêèë åäèð. Áó ìÿñëÿhÿòëÿøìÿ ëàéèùÿäÿ åêîëîæè âÿ ñîñèàë òÿñèðëÿðèí ãèéìÿòëÿíäèðèëìÿñè èëÿ ÿëàãÿäàð öìóìè ïðîãðàìûí áèð hèññÿñè êèìè hÿéàòà êå÷èðèëèð.

Áàøãà ãåéäëÿðèâèçè òÿêëèô åòìÿê ö÷öí ÿëàâÿ å'ëàí åäèëìèø ìÿñëÿùÿòëÿøìÿëÿðäÿ èìêàíëàðûâûç îëàæàã.

Éåðëè ÿùàëè áîðó êÿìÿðèí òèêèëìÿñèíäÿí ôàéäàëàíàœàãìû?

Áÿëè. Òèêèíòè çàìàíû áÿçè èø èìêàíëàðû îëà áèëÿð. Áóíäàí ÿëàâÿ, éåðëè ÿùàëè èø áðèãàäàëàðà õèäìÿòëÿð ýþñòÿðìÿê èëÿ áèð áàøà îëìàéàí èø èìêàíëàðäàí ôàéäàëàíà áèëÿð.

Ëàéèhÿíèí òÿñâèðè:

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Íåôò áîðó êÿìÿðèíèí 2003-æö èëèí áàùàðûíäà òèêèëìÿñèíèí ïëàíëàøäûðûëìàãà áàõìàéàðàã, áÿçè êåæèä éîëëàðûí âÿ èøæè äóøÿðãÿëÿðèí ìöùÿíäèñëèê èøëÿðè 2002 èëèí êåéíæè ùèññÿñèíäÿ áàøëàéàæàã.

ÁèÏè øèðêÿòè hàããûíäà:

ÁèÏè øèðêÿòè Àâðîïà, Øèìàëè âÿ Æÿíóáè Àìåðèêà, Àñèéà, Àâñòðàëèéà âÿ Àôðèêàíûí 100 þëêÿñèíäÿ áþéöê ÿìÿëèééàòëàð hÿéàòà êå÷èðÿí äöíéàíûí ÿí áþéöê íåôò-ãàç âÿ íåôò-êèìéà ãðóïëàðûíäàí áèðèäèð.

Áèçèì ÿñàñ èøëÿðèìèç õàì íåôò âÿ ãàçûí êÿøôèééàòû âÿ hàñèëàòû, åìàëû, ìàðêåòèíãè, òÿúhèçàòû âÿ íÿãë åäèëìÿñè âÿ íåôò êèìéà ìÿhñóëëàðûíûí èñòåhñàëû âÿ áàçàðà ÷ûõàðûëìàñûíäàí èáàðÿòäèð. Ãàç hàñèëàòû âÿ ýöíÿø åíåðæèñè äÿ äàõèë îëìàãëà åíåðæè èñòåhñàëû ñàhÿñèíäÿ èøëÿðèìèçè ýåíèøëÿíäèðèðèê.

ÁèÏè êîðïîðàòèâ øÿðèêëÿðè àäûíäàí, ÀÝÒ áîðó êÿìÿðëÿðè (íåôò âÿ ãàç) ëàéèùÿñèíèí ìöùÿíäèñëèê èøëÿðèíÿ ðÿùáÿðëèê åäèð.

ÁèÏè øèðêÿòèíèí ñîñèàë âÿ åêîëîæè ìöäàôèÿ ñèéàñÿòè:

ÁèÏè øèðêÿòè áèçèì èøëÿäèéèìèç ìöõòÿëèô þëêÿëÿðäÿ ìÿäÿíèééÿòëÿðÿ âÿ ôÿðäëÿðèí höãóãëàðûíà hþðìÿò åäÿðÿê ñîñèàë âÿ åêîëîæè ìÿñóëèééÿòëÿ éàíàøìàã ÿñàñûíäà èø ýþðìÿéè ãàðøûñûíà ìÿãñÿä ãîéóð.

Áèç èøëÿðèìèçÿ ìàðàã ýþñòÿðÿí éåðëè ÿhàëè, ãåéðè-hþêóìÿò òÿøêèëàòëàðû âÿ åëÿæÿ äÿ ôÿðäëÿð èëÿ ãàðøûëûãëû àíëàøìà éàðàòìàüà, îíëàðëà êîíñòðóêòèâ ÿëàãÿëÿð ãóðìàüà âÿ ÿòðàô ìöhèòÿ çÿðÿð âóðìàìàüà ÷àëûøûðûã.

Åéíè çàìàíäà ÁèÏè øèðêÿòè æÿìèééÿòèí èíêèøàôû, òÿhñèë âÿ ÿòðàô ìöhèòÿ áàüëû ëàéèhÿëÿð äÿ äàõèë îëìàãëà áöòöí äöíéàäà ñîñèàë èíêèøàôû òÿøÿááöñëÿðèíÿ ìàääè éàðäûì åäèð.

ANNEX 2

Stakeholder Listing

Stakeholder Organisations
SOCAR
Azerigas
AzETLGaz
Azerigaznagl
Minister of Internal Affairs
Key Members of Parliament
Ministry of Culture
Geipromorneftegas
Former State Committee for Ecology
State Caspian Inspectorate
State Committee for Geology
Department of Nature Reserves
State Land Committee
Division for the Control of Land Utilisation
Caspian Environment Programme
Research and Monitoring Group
Institute of Archaeology and ethnolography, Azerbaijan Academy of Sciences
Institute of Botany
Institute of Geography
Institute of Geology
Baku State University
ISAR
Ruzigar Society
Ecoenergy Academy
Women and Development
Greens Movement
Great Silk Road Project
Greens Movement
Information analytical centre ECORES
TETA "HAZRI"
Environmental Juridical Centre ECOLEX
International Public Centre of Study of Local
Folk Lore and Ecological Tourism "Caucasus"
Azerbaijan Centre of Birds Protection
Scientific and Research Society "ECOIL"
For Clean Caspian Sea
ECOSCOP
Piligrim
Group of Rehabilitation of Nature
Azerbaijan National Committee on International
Hydrologist programme
Public Ecological Foundation
Voice of Azerbaijan

Stakeholder Organisations
Centre "Human & Environment"
Hayajan
Azerbaijan Greens Movement
Ruzigar Society
Mammologists of Azerbaijan
AREAT Research Center
Azerbaijanian Sociological Association
Inam Center for Pluralism
Azerbaijan Woman and Development Center
Ecolex – Azerbaijan Environmental Law Center
Human and Environment Azerbaijan Public Association
Azerbaijan AIDS Association
Women in the Oil Industry of Azerbaijan
Ruzigar Ecological Social Union
Himayadar Humanitarian Organization
Legal Education Society
Caspian Environment Programme (international)
ISAR (international)
CHF (international)
Save the Children (international)
OXFAM (international)
ACDI-VOCA (international)
Ana Kur International Ecological Society
Ganja Agrobusiness Association
The Center of Young Leaders
Tomris Mother Society
Debate in Civil Society Resource Center
Bridge to the future Youth Union
Helsinki Citizen's Assembly
Odjag Humanitarian Union
City Hall (Mayor's Office), deputy mayor for social and economic affairs
AIDS organization in Sanitary and Epidemic Station of Ganja, doctor-in-chief
Technological University
"Avicenna" medical NGO, head
Municipality, chairman
Helsinki Assembly on Women Rights, head
ACDI-VOCA (international)
ISAR (international)

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Baku – Tbilisi – Ceyhan Oil Pipeline Azerbaijan

Technical and Baseline Appendices

Prepared for BP

By AETC Ltd / ERM

May 2002

GENERAL NOTES

Project No: P8107

Title: Environmental and Social Impact Assessment
Baku – Tbilisi – Ceyhan Oil Pipeline Azerbaijan

Technical and Baseline Appendices

Client: BP

Issue Date: May 2002

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Authorised by: ______________ **Project Manager** **Date:** __________

Authorised by: ______________ **Project QA Rep** **Date:** __________

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Hydro Scientific Limited
M & M Impact
Synergetics
UTT
WSP

Academic and scientific experts and their organisations

Baku State University (Zoology)
Institute of Archaeology and Ethnography
Institute of Botany
Institute of Erosion and Irrigation
Institute of Geography
Institute of Zoology
Ministry of Environment and Natural Resources
Ministry of Culture
BP Research and Monitoring Group

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ECOLOGICAL BASELINE REPORT

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1 ECOLOGY

1.1 INTRODUCTION

This appendix report presents the findings, in terms of ecology and nature conservation interest of habitats and species present along the pipeline route, of a desk-top study and field surveys undertaken for the proposed BTC pipeline. Natural habitats and the species of plants and animals within them are of vital importance to the protection, maintenance and continuing functionality of the world's ecosystems. The conservation of these natural habitats and their biodiversity, not only of species but also of genes and populations, is therefore essential for long-term sustainable development.

The aims of the study and surveys were to describe the extent of the different floral and faunal assemblages found within the various habitats along the proposed BTC pipeline. Any sites or species of nature conservation importance, which may be affected by construction of the pipeline, have been identified. These findings have been used to help identify areas where further survey work is required and to develop mitigation measures to reduce the impacts of the proposed BTC pipeline development.

During the pipeline routing process emphasis was placed on avoiding designated protected areas and habitats or species sensitive to disturbance. As a consequence, the route now only crosses one area proposed for nature conservation, and the majority of land crossed is agricultural (62.2%).

1.2 METHODOLOGY

The proposed BTC pipeline follows the Western Route Export Pipeline (WREP) for the majority of its length. The literature reviews undertaken by the Institute of Botany, Institute of Zoology and Institute of Fisheries during the planning phase of the WREP were therefore re-examined and supplemented with additional information provided by local experts. Survey data obtained for the WREP also reviewed for relevance to the proposed BTC route.

A baseline field survey of the BTC pipeline/SCP route was undertaken in August-September 2000 by ERM and local experts (ERM, 2000), with a further baseline survey of reroutes undertaken in January 2001 by AETC and local experts (AETC, 2001). A river corridor survey of the main river crossings was undertaken in November 2001 by AETC (Part 5 of Baseline Reports in the Appendices). In order to improve the seasonal coverage of the surveys, experts from the Institute of Botany undertook a survey for spring flowering species in the Gobustan area during April 2002. A further survey of birds, mammals and herpetofauna along the whole route began during April 2002.

As a result of additional reroutes during the latter half of 2001 short sections of the proposed pipeline route fell outside of the area previously surveyed by ERM and AETC. Due to the late time of year it was decided that further field surveys were unsuitable and therefore baseline habitats along the rerouted sections were mapped with the aid of aerial photographs (taken in summer 2001 on behalf of BP).

It should be noted that only six broad habitat categories (desert, semi desert, agriculture, woodland and scrub, wetland and other) could be distinguished from the aerial photographs. Details of vegetation, faunal assemblages or protected species of flora or fauna could not be ascertained. For the purpose of this exercise, therefore, where rare / protected species of flora or fauna were identified during field surveys along the initial BTC pipeline route it has been assumed that these species will also be present along any parallel rerouted section of the pipeline.

In order to verify the baseline data in this report further surveys will be undertaken within the proposed pipeline corridor prior to construction.

The information contained within these above mentioned surveys has been used to write this baseline description along with additional information provided within the EIA of the WREP (AIOC 1997), which was based on extensive literature reviews and field surveys for the whole of the WREP undertaken in August – October 1996.

The local experts who have been involved in the various aspects of ecological work during these projects are listed in Table 1-1 below.

Table 1-1 Involvement of local experts

ACTIVITY	NAME	ORGANISATION	SPECIALISATION
Literature Review for WREP 1996	Academician Gadjiyev	Institute of Botany	Flora
	Academician Musayev	Institute of Zoology	Fauna
	Professor Z M Kuliyev	Institute of Fisheries	Freshwater fish stocks
Field survey for WREP, August - October1996	Eldar Shukurov	Institute of Botany	Flora
	Professor Shaig Ibrahimov	Institute of Zoology	Fauna
Field survey for SCP, August - September 2000	Maya Asker Nuriyeva	Institute of Botany	Flora and habitat
	Eldar Shukurov	BP	Assistance in flora and habitat
	Ilham Khayyam Alekperov	Institute of Zoology	Fauna and protected areas
Field survey for SCP reroutes January 2001	Salim Musayev	Institute of Botany	Flora
	Nijat Hasanov	Institute of Zoology	Fauna
	Shaig Ibraghimov	AETC	Fauna
Field survey for BTC pipeline/SCP – April 2002	Rafik Melikov Tofik Guliyev Vahid Gadjiyev	Institute of Botany	Flora
	Nijat Hansanov	Azer Consulting Services	Fauna

In addition to the information already contained within the WREP EIA (AIOC, 1997), the present baseline field surveys, carried out by ERM and ATEC, were undertaken, in order to provide:

- Detailed baseline information on the vegetation types and habitats to be crossed by the proposed pipeline route
- Detailed baseline information on the faunal assemblages encountered along the route of the proposed pipeline

- Information on the presence/ potential presence of species of flora or fauna which are internationally protected or are listed in the 'Red List' of the Azerbaijan Republic (1989)
- Information on any additional specialist surveys that are required
- Verification of WREP data
- Analysis of WREP corridor condition

The standard survey corridor was 100m either side of the pipeline centreline. During the surveys, the botanists and zoologists were required to complete proforma data sheets for each different habitat encountered, for different faunal assemblages in different habitats or for any unusual or rare species.

The proforma for flora comprises the identification of the habitat including a species list and general comments on the extent and nature of the habitat such as disturbance, anthropological uses and nature conservation significance. Habitats were identified in accordance with The Vegetation Map of Azerbaijan, 1996 and species were identified using Flora Azerbaijana (1950-1961).

The presence of faunal species was recorded by direct observation or observation of footprints, food remains, faecal remains, burrows, corpses and any other field signs. Additional information was also obtained from discussions with the local population and a review of available literature. The species are listed on the proforma for fauna, along with any additional information on rarity or conservation significance.

The ERM baseline was a rapid reconnaissance survey undertaken by driving along the right of way of the WREP. GPS readings were taken and proforma data sheets for flora and fauna were completed at regular stops along the pipeline route. Additional Proformas were completed as and when points of interest were seen.

The AETC reroute survey was undertaken predominantly on foot and in more detail than the ERM survey since no baseline data existed for these new routes. Where habitat areas and faunal assemblages required description or where rare/protected species of flora and fauna were seen, a GPS reading was taken and a proforma data sheet filled in. Due to the timing of this survey in January, it was not possible to record many species of flora and fauna. The majority of annual plants were absent or just beginning to emerge making identification difficult, while some faunal species were still in hibernation or dormant, eg amphibians, reptiles, invertebrates or wintering elsewhere (ie migratory). Therefore the survey concentrated on perennial plants, mammals and birds which are either resident or wintering in the region.

The original AIOC survey and the ERM survey were both undertaken during late summer and autumn. In these circumstances many of the annual plants will also not have been recorded since they would already have died off. However, a better coverage of fauna was achieved since species had not gone into hibernation. Some birds may already have migrated away from the region, but the surveys were undertaken during the migratory season and this would have added to bird species recorded. To overcome the weakness in the original botanical surveys, supplementary surveys were carried out by the Institute of Botany on behalf of BP during May 2001 and April 2002 in the Gobustan, Kazi-Magomed and Shamkir sections of the pipeline route.

A survey of birds, mammals and herpetofauna started in April 2002 to expand the zoological dataset, particularly for those areas that have been identified as important during previous surveys. Particular emphasis will be placed on breeding birds and spur-thighed tortoises (*Testudo gracea*). Simple methodologies will be used, to facilitate repeat surveys in other seasons and years. The dataset thus generated will form the basis for future monitoring programmes.

It is considered that the data on birds and mammals are of a good standard as regards completeness and accuracy. The data on other vertebrate groups are adequate, although more reliance has had to be placed on prediction based on known habitat requirements and distribution data. Invertebrate coverage is less extensive and it has been assumed that any rare species are likely to be associated with scarce habitats or plants and that measures to safeguard these will therefore embrace any important invertebrates.

1.2.1 Species status and occurrence

The conservation status of species has been assessed by reference to the Red Data Book for Azerbaijan (1989), information from local scientists on proposed additions to the Red Book, European Bird Populations: Estimates and Trends (Birdlife International/ European Bird Census Council, 2000)and the 2000 IUCN Red List of Threatened Species. The status categories used in tables in the following sections are described in Table 1-2. The definition or likelihood of occurrence of a species along the pipeline route is described by three different categories as outlined in Table 1-3.

Table 1-2 Threatened species status categories

STATUS CATEGORY	DESCRIPTION
Ie	Species of International Conservation Concern – endangered
Iv	Species of International Conservation Concern – vulnerable
Ilr	Species of International Conservation Concern – low risk
Ee	Bird of European Conservation Concern - endangered
Ev	Bird of European Conservation Concern - vulnerable
Er	Bird of European Conservation Concern – rare
Ed	Bird of European Conservation Concern - declining
RDB	Listed in Red Data Book of Azerbaijan Republic
PRDB	Proposed for inclusion in Red Data Book of Azerbaijan Republic

Table 1-3 Definitions of occurrence

OCCURRENCE	
Possible	Identified in literature review (AIOC, 1997), but unknown if suitable conditions exist along pipeline route or downstream of it.
Probable	Identified in literature review (AIOC, 1997) and suitable conditions are likely to be present along pipeline route according to field survey data
Confirmed	Observed (directly or indirectly) during field surveys.

1.3 OVERVIEW OF FLORA AND FAUNA IN AZERBAIJAN

The UNEP World Conservation Monitoring Centre has recently produced (2001) a Biodiversity Profile for Azerbaijan that provides information on the biodiversity resource within the country, conservation measures in place and the threats to biodiversity. The following information is taken from this report.

Azerbaijan lies at the convergence of at least three biogeographic provinces, where species typical of Europe (eg brown bear, lynx, chamois, red deer), Central Asia (eg wild goat, leopard), and Asia Minor (eg striped hyena, goitered gazelle) occur. This geographic position, combined with the country's varied climate, topography and geology, has resulted in high levels of biodiversity.

Azerbaijan is included within one of Conservation International's 25 'biodiversity hotspots'. These are biologically rich areas that are under the greatest threat of destruction and represent a variety of global ecosystems, identified on the basis of three criteria: the number of species present, the number of endemic species in an ecosystem and the degree of threat faced. Hotspot areas cover less than 2% of global terrestrial ecosystems, yet account for 44% of all vascular plant species and 38% of birds, mammals, reptiles and amphibian vertebrate groups. Azerbaijan is included within the 'Caucasus' hotspot. The area also includes Georgia, Russia (Dagestan) and Armenia and a small portion of north-east Turkey.

The key biodiversity ecosystems within Azerbaijan include marine and coastal biomes, forests (lowland and montane), subalpine and alpine meadows, dry and semi-desert areas, grassland/ steppes and wetlands.

The flora of Azerbaijan comprises of approximately 4,200 identified species, more than Georgia or Armenia, divided into 125 families and 920 genera. An estimated 270 species of plants (6.4%) are endemic to Azerbaijan, but a much greater proportion (of plants and animals) is unique to the Caucasus region.

The fauna of the country is represented by 99 species of mammals, 360 species of birds, 54 species of reptiles, 11 species of amphibians, 95 species of fish and 14,000 species of insects. Azerbaijan is particularly important for some animal groups especially birds and bats. The diverse large mammal fauna includes wild goat (*Capra aegagrus)*, mouflon (or urial) (*Ovis orientalis)*, red deer (*Cervus elaphus)*, roe deer (*Capreolus capreolus)*, and their predators, including wolf (*Canis lupus)*, lynx (*Lynx lynx)* and possibly leopard (*Panthera pardus)*.

In all, Azerbaijan has 77 animal species and 3 plant species that are considered threatened (IUCN, 2000). A summary of the global status of Azerbaijan's animal and plant populations is presented in Table 1-4 below.

Table 1-4 Threat status of Azerbaijan's plants and animals

	CR	EN	VU	LR/CD	LR/NT	DD	TOTAL
Flora	0	0	0	0	2	1	3
Fauna	2	7	28	3	21	16	77

Source: Hilton-Taylor, C. (Compiler). 2000, and IUCN Red List at http://www.redlist.org
Note: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LR/CD = Low Risk (Conservation dependent); LR/NT = Low risk (Near Threatened); DD = Data Deficient

Table 1-5 Summary of diversity and threat status of the flora and fauna of Azerbaijan

	NUMBER OF SPECIES	NUMBER OF ENDEMIC SPECIES	NUMBER OF GLOBALLY THREATENED SPECIES	NUMBER OF CRITICALLY ENDANGERED SPECIES
Mammals	99	0	11	
Birds (breeding)	360 (248)	0	8	
Reptiles	52	0		
Amphibians	8	0		
Fresh water Fish		0		
Plants	4,300	240	28	0*

Source: Hilton-Taylor 2000, WCMC 2000, Walter and Gillett 1998.

In 1977, the Government of Azerbaijan adopted a resolution to develop a Red Book of the nation's most threatened and valuable flora and fauna, which was first published in 1989. It lists 50 species of plant, 5 species of fish, 5 amphibians, 8 reptiles, 36 birds, and 14 species of mammal as threatened (no information is included on how the degree of threat is assessed). A further 16 species of plant have been proposed for inclusion by Azerbaijan botanists. Several fish species whose stocks have declined markedly in Azerbaijan's coastal waters in recent years, such as barbel (*Barbus mursa)* and Danubian bleak (*Chacalburnus chalcoides)*, are under threat and have also been suggested for inclusion in an updated Azerbaijan Red Book. A second edition is now being prepared.

The main threats to Azerbaijan's biodiversity have been identified as pollution, habitat destruction, over-exploitation of wildlife populations and other threats such as war and rise in Caspian Sea level.

1.4 PROTECTED AREAS

In Azerbaijan, sites or areas that are of particular importance for nature conservation are designated as protected areas covered by the *Law on the Protection of the Nature Environment and the Utilisation of Natural Resources* (Anon, 1992). There are several different levels of protection (Table 1-6) ranging from the Nature Reserve where public access is allowed through to Hunting Areas where licenced hunting is possible through to the protection of individual trees or palaeontological sites.

Table 1-6 Significance of designated conservation sites (in descending order of conservation importance)

DESIGNATION	SIGNIFICANCE	USAGE CONSTRAINTS
Nature Reserve	National	No public entry, some scientific research.
Forbidden Area	National	Permission for restricted human activities given by State Committee on Ecology.
National Park	National	Public access.
Hunting Area	National or Local	State licensed shooting area. Habitat managed for game.
Nature Monuments	National	Individual features of landscape eg trees, caves, palaeontological sites.

In addition, several of the protected areas in Azerbaijan have also been assigned a Management Category by IUCN (1994). The full list of IUCN categories is presented in Table 1-7. Only two categories, Category Ia and Category IV are represented in Azerbaijan, and only four of the 10 protected areas in the vicinity of the pipeline route have been assigned an IUCN category.

Table 1-7 IUCN protected area management categories

DESIGNATION	MANAGEMENT OBJECTIVE
Category Ia	Strict Nature reserve: protected area managed mainly for science
Category Ib	Wilderness Area: protected area managed mainly for wilderness protection
Category II	National Park: protected area managed mainly for ecosystem protection and recreation
Category III	Natural Monument: protected area managed mainly for conservation of specific natural features
Category IV	Habitat/ Species Management Area: protected area managed mainly for conservation through management intervention
Category V	Protected Landscape/ Seascape: protected area managed mainly for landscape/ seascape conservation and recreation

Table 1-7 IUCN protected area management categories

DESIGNATION	MANAGEMENT OBJECTIVE
Category VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems

As already mentioned 10 protected areas, of which four are proposed sites, are present within 10 km of the proposed pipeline route. Whereas the WREP crossed three designated and two proposed protected areas, the proposed BTC pipeline has specifically been routed to avoid crossing protected areas where at all possible. However, it has not been possible to avoid crossing the proposed Gobustan State National Park which comprises a range of desert and semi-desert habitats and encircles Sangachal. The Barda State Forbidden Area is 6km downstream of the proposed pipeline crossing. Table 1-8 gives an indication of the location and proximity of the protected areas to the pipeline, while the Environmental Route Maps (Volume 2) show the spatial extent of the areas.

In addition, Azerbaijan is in the process of becoming a Contracting Party to the Ramsar Convention, which is aimed at protecting the wildlife and habitats of internationally important wetlands, having recently submitted their instrument of accession to UNESCO.

Lake Jandari, which straddles the border between Azerbaijan and Georgia has been included in the book of potential Ramsar sites in Azerbaijan, but it is not known when or if this site will become designated. Never the less, under the Ramsar Convention proposed sites are afforded the same level of protection as designated sites and contracting parties have an obligation to maintain/protect any wetland within their territory.

Table 1-8 Protected areas in the vicinity of the proposed pipeline

PROTECTED AREA	IUCN CATEGORY	REASON FOR DESIGNATION	APPROX. LOCATION ALONG PIPELINE (KP POINTS)	APPROX. DISTANCE FROM PIPELINE (KM)
Gobustan State National Park (proposed)	-	Nationally important desert/semi-desert with an area of 178,700 hectares (ha) located west and south west of Baku.	KP 19.5-28.5	0
Basic Steppe State Nature Reserve (proposed)	-	Grassland steppe habitat with an area of 268,000 ha. Site now very degraded and future designation is unlikely	KP 120 – 122.5	1
Shilyan State Forbidden Area (proposed)	-	Wetland area which has been drained and degraded. Future designation very unlikely	KP 146 – 147.5	1.5
Barda State Forbidden Area	IV	Rare Tugay river forest area of 7,500 ha in the Barda/Agdas Regions.	KP 200-215	6
Varvara State Hunting Area (proposed Local Site)	-	Varvara Reserve and adjacent habitat comprising an area of 5,650 ha in the Yevlakh Region	KP 232 - 237	4.5
Korchay State Forbidden Area	-	Steppe/semi-desert area of 27,050 ha in the Samukh and Goranboy Regions.	KP 285-301	3
Samukh State Hunting Area (National Site)	-	Wetland area including part of Mingechaur Reservoir comprising 40,424 ha	KP 301-319	3.5
Shamkir State Forbidden Area	IV	Rare Tugay river forest area of 10,000 ha in the Shamkir Region.	KP 332-359	5
Karayazo-Akstafa State Forbidden Area	IV	Rare Tugay river forest area of 17,873 ha in the Kazakh Region	KP 410-434	0.5
Karayazi State Nature Reserve	Ia	Rare Tugay river forest area of 4,900 ha in the Kazakh Region	KP 434-442	4
Jandari Lake (proposed Ramsar site)	-	Large wetland area known for its large numbers of wintering wildfowl	KP 437-442	3

1.5 HABITATS AND VEGETATION

The results of the vegetation survey have been mapped at 1:50,000 scale and are presented in the Environmental Route Maps (Volume 2). The vegetation along the proposed pipeline route have been categorised into six broad habitat types. These are detailed in Table 1-9, which provides an analysis of the habitats crossed by the proposed pipeline.

Table 1-9 Extent of the main habitat types crossed by the proposed BTC pipeline

HABITAT TYPE	LENGTH IN KM	% OF TOTAL LENGTH
Desert	110.15	24.9
Semi-desert	35.5	8.0
Woodland and scrub	4.3	1.0
Wetland	16.25	3.7
Agricultural	275	62.2
Other (quarries, refugee camps etc.)	0.8	0.2
Total	442	100

Where vegetation data has been collected during field surveys, community types for each broad habitat type have been identified. These are detailed in Table 1-10. Their extent is shown on the Environmental Route Maps (Volume 2) of the ESIA and their structure and species composition described below.

Table 1-10 Vegetation communities with broad habitat categories

DESERT	
D1	*Artemisia fragrans*
D2	*Artemisia fragrans + Salsola nodulosa*
D3	*Artemisia fragrans + Salsola dendroides*
D4	*Artemisia fragrans + Suaeda dendroides*
D5	*Salsola nodulosa*
D6	*Salsola dendroides*
D7	*Suaeda dendroides*
D8	*Kalidium caspicum*
D9	*Halocnemum strobilaceum*
D10	*Capparis spinosa*
D11	Ephemeral desert
D12	Interzone
D13	*Salsola nodulosa + Artemisia fragrans*
D14	*Salsola ericoides*
SEMI-DESERT	
SD1	*Artemisia fragrans*
SD2	*Artemisia fragrans + Salsola nodulosa*
SD3	*Artemisia fragrans + Salsola dendroides*
SD4	*Salsola dendroides*
SD5	Interzone
AGRICULTURAL	
A1	Fields
A2	Old Fields
WOODLAND AND SCRUB	
WS1	Plantations

Table 1-10 Vegetation communities with broad habitat categories

WS2	Scrub
WETLAND	
W1	River
W2	Lake
W3	Canals (Major)
W4	Marsh
W5	Seasonal marsh / Chal meadow
OTHER	
Individually Named	

The predominant habitat type crossed by the proposed pipeline route is agricultural (62.2% in total). As such, the majority of the land, which the proposed pipeline will cross, is of little biodiversity or nature conservation interest with respect to plant species, although it is capable of supporting several species of fauna, which are of interest. A further 0.2% of the route is taken up by other land uses such as quarries.

The remaining 37.6% of habitats along the proposed pipeline route are of greater nature conservation importance since they have a greater structural and species diversity compared to agricultural land and are more semi-natural in character, even if some of these habitats have been subject to significant disturbance.

These semi-natural habitats also provide an important wildlife resource and refuge for many animals, which would otherwise not survive within the agricultural landscape sections of the pipeline route. Linear structures, such as bands of trees and watercourses, can also act as wildlife corridors, allowing the passage of animals and plants along them and linking larger areas of wildlife habitat so as to prevent their isolation.

A description of the main habitats types and their distribution along the proposed pipeline route is provided below.

1.5.1 Desert and semi-desert

The desert and semi-desert vegetation of the region has primarily been determined by the extreme climate, with its low rainfall and high summer temperatures, which creates a pronounced seasonal rhythm of growth and seed production typical of interior continental deserts. This is tempered to some extent in the Gobustan region by the proximity of the Caspian.

The complex geology, topography and soils of Azerbaijan are also involved in the smaller scale distribution of different plant communities and therefore desert or semi-desert vegetation types. These factors range from hill areas with lower salinity soils to areas with highly saline soils to depressions and valleys with a variety of soil types.

Desert and semi-desert vegetation in this region has two main components, perennial plants and, annual or ephemeral plants. Perennial plants include bushes such as mugwort species (*Artemisia fragrans*) and several species of saltwort (*Salsola species*) which are visible all year, beginning growth in early spring with the rains, slowing in mid-summer and then growing again with the autumn rains until colder temperatures stimulate leaf fall. Other perennial species include the xerophytic desert grass: bulbous meadow-grass (*Poa bulbosa*), which uses a different life strategy to mugwort species (*Artemisia* spp.) and saltwort species (*Salsola* spp.) It is an ephemeroid ie a long-lived perennial species, which flowers and sets seed early each spring within a 40-50 day period, then withers until the autumn rains stimulate new growth from underground root stocks. Annual or ephemeral species, such as bur-medick (*Medicago minima*), live for one year only and tend to germinate with the autumn rains, grow slowly through the winter and then quickly develop with the spring rainfall and increasing ground temperature. They flower and set seed in spring and early summer then die.

Desert and semi-desert habitats can be differentiated by the density of the ephemeral and ephemeroid plant species cover, which tends to grow as a 'mat' between the perennial bushes, and the nature of their root systems. In the desert habitat the plant cover does not generally exceed 40% - 45% and the roots of individual plants do not form an interconnecting turf. Conversely in the semi-desert the plant cover may be as high as 75% and the roots are interconnected. The same species are frequently present in both habitat types.

The amount of cover given by the 'mat' varies and can often be patchy. Various factors determine the amount of vegetative cover. The soils of areas that are heavily grazed have a higher nutrient content due to animal dung, and this encourages the growth of ephemeral and ephemeroid species. Flat plateaux or plain areas can also have a high mat cover and this is possibly due to reduced soil erosion by water. Manmade factors in the form of physical disturbance eg vehicular traffic and trampling by stock will reduce the amount of cover.

Due to the ephemeral nature of many of the herbaceous species in desert and semi-desert plant communities and the different seasonal rhythms of the different vegetation groups, it is the varying dominances of perennial bush species that are used as a basis for vegetation classification. Generally one or two species will form the basis for a vegetation type. Combinations of three or four dominant species are rare.

Four main types of desert, based on the soil type, were distinguished in the former USSR: clay, solonchak (pale salty soils), sand and stone. Changes in vegetation cover are closely associated with changes in soil type. The main soil type along the pipeline route is clayey and is most often dominated, or co-dominated by communities comprising mugwort species (*Artemisia fragrans*) and / or saltwort species (*Salsola nodulosa*). Solonchak desert occurs to a lesser extent. According to Knystautas (1987) this type of desert is associated with river terraces where salt rich water has accumulated. This habitat also occurs in the lower lying areas of the pipeline route in Gobustan and on the Shirvan Plain.

Table 1-11 provides information on the soil and salinity affinities of the main indicative desert and semi-desert plants which were observed during the field surveys.

Table 1-11 Main indicative desert and semi-desert shrubs and their soil and salinity affinities

SPECIES	SOIL AFFINITY
Mugwort sp (*Artemisia fragrans*)	low salinity, typically clay
Saltwort sp (*Salsola dendroides*)	slight salinity, clay and pale loam
Saltwort sp (*Salsola nodulosa*)	salty pale soils
Capparis spinosa	copper association
Saltwort (*Salsola ericoides*)	salinised clay
Saltwort (*Salsola crassa*)	salty pale soils (Solonchak)
Seablight sp (*Suaeda dendroides*)	salty pale soils (Solonchak)
Halocnemum strobilaceum	wet salty pale soils (Solonchak)
Kalidium caspicum	salty pale soils (Solonchak)

The desert and semi-desert communities in the Gobustan area represent the most ecologically important habitats, from a botanical point of view, along the proposed pipeline route. These are the most natural and extensive habitats of the region and are of national significance due to this area being a stronghold for mugwort species (*Artemisia fragrans*) deserts. The great age of many of the desert communities and their slow growth rate further enhance their botanical significance. The importance of this habitat type is one of the reasons that the Gobustan National Park has been proposed, so that some level of protection is offered to these deserts. Desert plant communities such as these, which develop very slowly are particularly susceptible to disturbance and are easily lost, taking many years to recover.

Besides having their own intrinsic value, the many plant species within these habitats also have a human value due to their use for medicines, oils and dyes. Several are strictly protected by law, while many others are used extensively for livestock grazing, particularly in the winter when mugwort species (*Artemisia fragrans*) is palatable to animals due to low concentrations of alkaloids. In the spring and summer alkaloid concentrations are high making the plants unpalatable. Saltwort species (*Salsola nodulosa*) is a plant of very high nutritional value and provides much more energy per gram than mugwort species (*Artemisia fragrans*).

Several Azerbaijan Red Data Book species are expected to occur in the Gobustan area one of which, *Iris acutiloba,* was confirmed during the April 2002 survey at KP 28. This species has also been confirmed to the west of Gobustan at KP 50. At this location plant densities up to 6 per square metere were recorded

1.5.1.1 Desert communities

The desert plant communities identified along the pipeline corridor are shown in Table 1-10.T The most widespread desert community complex comprises mugwort species (*Artemisia fragrans*) and saltwort species (*Salsola nodulosa*), either occurring as individual dominants or as co-dominants. Associated with these habitats are ephemerals and ephemeroids such as the grass (*Eremopyrum oriental)e,* saltwort species (*Salsola crassa*), bulbous meadow-grass (*Poa bulbosa*), *Torularia contortuplicata,* Perfoliate pepperwort (*Lepidium perfoliatum*), bur-medick (*Medicago minima*), *Noaea mucronata,* Alisons species (*Alyssum desertorum*), chive species (*Allium rubellum*), wall barley species (*Hordeum leporinum*), rye grass species (*Lolium rigidum*) and brome species (*Zerna rubens*).

On more salinised soils saltwort (*Salsola*) communities occur and the saltwort species *Salsola dendroides, Salsola ericoides* and *Salsola ericoides* and sea blight species (*Suaeda dendroides*) communities are quite common. Saltwort species (*Salsola dendroides*) is a species, which can dominate an area with high ground cover during early succession and thus often occurs in concentrations along the built section of the WREP. Associated species include spring herbs such as *Torularia contortuplicata,* bulbous meadow-grass (*Poa bulbosa*) and bur-medick (*Medicago minima*); and halophytes such as saltwort species (*Salsola crassa*).

Seablight species (*Suaeda dendroides*) communities are a widespread formation, which occur in small areas. Typical associated species include bur-medick (*Medicago minima*), wall barley species (*Hordeum leporinum*), the grass (*Eremopyrum orientale)* and ephedra (*Ephedra procera*) as well as halophytes such as sea lavender species (*Limonium spicatum*) and seablight species (*Suaeda altissima*).

The *Kalidium caspicum* saline community occurs only in small areas in Gobustan. Typical species recorded growing in this species-poor habitat included the salt-tolerant species saltwort species (*Salsola crassa*) and sea blight (*Suaeda microphylla*). Typical xerophytic species are wall barley species (*Hordeum leporinum*), Thunberg’s brome (*Bromus japonicus*) and *Torularia contortuplicata*. The saline hummock formation typical of the eastern Transcaucasian and Caspian plains is less obvious and absent in some areas.

The *Halocnemum strobilaceum* wet solonchak community is seen on moister, salt rich soils such as the site of the former Lake Shilyan (now drained) (KP 145) on the Shirvan Plain. It can be hummocky and is species-poor with halophytes such as sea lavender species (*Limonium meyerii*), saltwort species (*Salsola paulsenii*), seablight species (*Suaeda confusa*) and common glasswort species (*Salicornia europaea*).

The spineless caper (*Capparis spinosa)* community is associated with copper minerals and usually has a number of indicative constant species such as bulbous meadow-grass (*Poa bulbosa*), bur-medick (*Medicago minima*), Alisons species (*Alyssum desertorum*) and wall barley species (*Hordeum leporinum*). Of these, only wall barley species (*Hordeum leporinum*) was recorded in the one area where this habitat occurred along the WREP. Dominant camel prickle (*Alhagi pseudoalhagi*) also occurred suggesting that this is a disturbed form of this habitat. Desert communities, which contain camel prickle (*Alhagi pseudoalhagi*) and weeds such as *Karthamus glaucus* and chicory (*Cichorium intybus*), being indicative of disturbance, are classified as 'desert interzone'. These interzonal communities were typically found where anthropogenic influence was great.

The Ephemeral community occurs in the early stages of succession on de-vegetated desert/semi-desert sites. This community was evident in the Gobustan and Shirvan Plain area and comprises ephemeral species such as wall barley species (*Hordeum leporinum*), grass species *Eremopyrum triticum,* plantain species (*Plantago praecox*), bur-medick (*Medicago minima*) and bulbous meadow-grass (*Poa bulbosa*).

1.5.1.2 Semi-desert communities

In addition to the amount of vegetative cover and complexities of the root system, the semi-desert plant community is distinguished from the more xerophytic desert community by the presence of temperate species such as elder (*Sambucus nigra*) and common couch (*Elymus repens*) and by steppe species such as needle grass species (*Stipa szowitsiana*).

The mugwort (*Artemisietum)* community is the most frequently occurring type of semi-desert vegetation in Azerbaijan and it was the most frequently encountered semi-desert type along the proposed BTC pipeline. It is characterised by green grass in winter, due to autumn rains. Along the proposed pipeline it also occurs occasionally in conjunction with saltwort (*Salsoletum*) semi-desert vegetation forming a co-dominant community of mugwort species (*Artemisia fragrans*) and saltwort species (*Salsola dendroides* or *Salsola nodulosa*).

There are also arable communities, which contain semi-desert elements such as camel prickle (*Alhagi pseudoalhagi*), spineless caper (*Capparis spinosa)* and mugwort species (*Artemisia fragrans*), along with weeds such as *Karthamus glaucus* and chicory (*Cichorium intybus*). These communities are indicative of disturbance. Semi-desert interzonal communities were typically found where anthropogenic influence was great and they occurred uncommonly along the proposed BTC pipeline. These disturbed inter-zonal semi-desert areas are of less botanical significance since the species present are associated with disturbance.

1.5.2 Wetlands

Numerous small-scale wetlands are recorded along the proposed pipeline route and can be split into the following four types:

- Rivers
- Irrigation canals and ditches
- Lakes and ponds

- Marsh or chal meadow

The wetlands recorded along the proposed BTC pipeline vary in their morphology, salinity, naturalness and degree of permanence throughout the year. Additionally, some reveal signs of eutrophication in algal blooms and eutrophic species assemblage. This may be due to oil pollution, sewage water and in arable areas, to fertilizers.

1.5.2.1 Rivers

The proposed BTC pipeline has 21 principal river crossings and numerous minor stream and canal crossings. Apart from the Djeyrankechmes and Pirsagat rivers all of the other main rivers form part of the River Kura catchment.

The rivers often have a turbid flow and an unstable bed which restricts vegetation to side channels or the seasonally inundated margins. Species such as common reed (*Phragmites australis*), mint species (*Mentha spp*), water cress species (*Nasturtium spp*), water-milfoil species (*Myriophyllum spp*), pondweed species (*Potamogeton spp*) and buttercup species (*Ranunculus spp*) proliferate in silty pools and seasonal meanders.

The riverside vegetation generally comprises scrub and tree species such as tamarisk species (*Tamarix ramosissima*), bramble species (*Rubus spp*) ,rose species *(Rosa spp)*, oleaster (*Elaeagnus angustifolia*), willow species (*Salix spp*), pomengranate (*Punica granatum*) (Azerbaijan Red Data Book Species) and poplar species (*Populus spp*) as well as swamp species such as common reed (*Phragmites australis*), sea club rush (*Bolboschoenus maritimus*), water-pepper (*Polygonum hydropiper*) and galingale (*Cyperus longus*).

In the case of seasonally dry rivers, these are still able to support tamarisk species (*Tamarix ramosissima*), and common reed (*Phragmites australis*) and occasionally milk thistle (*Silybum marianum*), sun spurge species (*Euphorbia helioscopa)*, salwort species (*Salsola dendroides*) and various grasses.

1.5.2.2 Canals and ditches

The irrigation channels are much disturbed by man and their flora is largely limited to a swamp-like community comprising species such as common reed (*Phragmites australis*) (very common and abundant), bulrush (*Typha latifolia*) (widespread), sea club rush (*Bolboschoenus maritimus*), galingale (*Cyperus longus*), water-pepper (*Polygonum hydropiper*) and stranglewort (*Cynanchum acutum).*

The colourful purple loosestrife (*Lythrum salicaria*), which is a valuable invertebrate nectar source, is also common along the canal margins. In some instances salt-tolerant species such as common glasswort (*Salicornia europaea*) and sea lavender species (*Limonium meyerii*) occur. The banks commonly support species such as tamarisk species (*Tamarix ramosissima*), bramble species (*Rubus sanguineus*), orache species (*Atriplex tartarica*) and camel prickle (*Alhagi pseudoalhagi*).

The proposed Azerbaijan Red Data Book Species glabrose liquorice (*Glycyrrhiza glabra*) also occurs in some of the shallow ditches as, occasionally, does another Azerbaijan Red Data Book Species woodland grape (*Vitis sylvestris*) (eg KP 190).

1.5.2.3 Marsh / ‘chal meadow’

The ‘chal meadows’ represent a species-rich, natural plant community which is of high value ecologically, provides important animal fodder, through grazing and hay making and supports useful medicinal plants.

This marsh community develops in hollows and low-lying areas and is generally slightly saline. It is usually seasonally inundated, is species-rich and is widely encountered along the pipeline route. For example, the drained Lake Shilyan (KP 145), to the west of Kurdamir, is now largely dominated by ‘chal meadow’.

Typical species include glabrose liquorice (*Glycyrrhiza glabra*) (a proposed Azerbaijan Red Data Book Species), sea lavender species (*Limonium meyerii*), camel prickle (*Alhagi pseudoalhagi*), bermuda-grass (*Cynodon dactylon*), saltwort species (*Salsola dendroides*) and orache species (*Atriplex tartarica*). Scrub intrusion by tamarisk (*Tamarix spp*) was common.

1.5.2.4 Ponds and lakes

Several lakes were recorded along the proposed BTC pipeline, the most significant of which were the ox-bow lakes associated with the Kura at the eastern pipeline crossing. Vegetation was dominated by common reed (*Phragmites australis*) and tamarisk species (*Tamarix* spp).

1.5.3 Woodlands and scrub

Woodland is extremely restricted on the proposed BTC pipeline route. It is often planted and (*Rubus spp*)is often dominated by ash spp (*Fraxinus spp*), pedunculate oak (*Quercus robur*) and vardim oak (*Quercus longipes*) with much bramble (*Rubus spp*) and some common or black mulberry (*Morus nigra*) and smooth-leaved elm (*Ulmus foliacea*). The two Azerbaijan Red Data Book Species woodland grape (*Vitis sylvestris*) and pomengranate (*Punica granatum*) also occur. The artificial nature, isolation and limited size (generally < 500 m) of these plantations reduces their ecological value. However, it does provide valuable habitat for a range of fauna in an area, which has been seriously depleted of woodland habitat. Small woodland sections of approximately 150 to 600 m are crossed at KP 105.5, 106, 175, 192.5, 223, 387.5, 411.5 and 423.5.

Some small areas of scrub also occur along the proposed BTC pipeline at KP 175, 192.5 and 411.5. These are generally dominated by tamarisk species (*Tamarix ramosissima*) which may form a mosaic with other habitats such as ‘*chal meadow*’; or include species such as bramble species (*Rubus sanguineus*) which forms dense scrub along canal and river banks. Such areas provide useful cover and food for fauna.

The floodplain Tugay forest habitat is associated mainly with the alluvial silt floodplains of the Kura river and its existence depends on maintaining high local water table levels. It is present in the Barda State Forbidden Area and the Karayazo-Akstafa State Forbidden Area and Karayazi State Nature Reserve. These reserves are 6 km, 0.5 km and 4 km from the proposed pipeline route respectively. Tugay forest is an internationally recognised, mature forest environment that has historically been found along banks of the Kura river. Previously, the forest thrived on the flood plain of the Kura river, which used to flood its banks frequently, providing suitable conditions for the forest species. The forest habitat has been seriously degraded since the construction of the Mingachevir dam and due to deforestation, associated with the lack of energy / primary fuel in the regions. This has created an extremely fragmented habitat, with small pockets of forest isolated from each other. The ability of the forest to function as a wildlife corridor has therefore been lost.

Close to the river where groundwater is high, willow species (*Salix australis*), grey popular (*Populus canescens*) and black popular (*Populus nigra*) are found. Many of the popular species (*Populus spp*) trees are over 100 years old and heavily laden with ivy (*Hedera helix*). Where willow species (*Salix spp*) trees are cut down or other events cause disturbance, then tamarisk species (*Tamarix ramosissima*), sea buckthorn (*Hippophae rhamnoides*) and oleaster species (*Elaeagnus spp*) often grow. Other species indicative of disturbance and stoney, riparian communities often invade when these areas are used for grazing in summer, including small reed species (*Calamagrostis pseudophragmites*), common spike rush (*Eleocharis palustris*), jointed rush (*Juncus articulatus*) and fleabane spp (*Pulicaria uliginosa*). Other species observed include cocklebur species (*Xanthium spp*) and thorn-apple (*Daturna stramonium*).

Further back from the river, where groundwater is deeper, oak species (*Quercus pedunculiflora*) and smooth elm (*Ulmus carpinifolia*) grow. Other species observed in the woodlands include Caucasian hornbeam (*Carpinus caucasica*), seablight species (*Suaeda australis)*, hawthorn species (*Crataegus spp*), common privet (*Ligustrum vulgare*) and large quantities of the lianas *Smilax excelsa*, travellers joy/old mans beard (*Clematis vitalba*), woodland grape (*Vitis sylvestris*) and ivy (*Hedera helix*). Many streams run into the forest from the irrigation canals feeding the adjacent agricultural land. The wetter areas support common reed (*Phragmites australis*).

Characteristic mosses of these floodplain forests are *Camypylium chrysophyllum, Brachytectum mildeanum, Fissidens taxifolius* and *Amblystegium serpens*.

1.5.4 Protected plant species

Several species which are included in the Azerbaijan Red Data Book or which have been proposed for inclusion in the revised Azerbaijan Red Data Book have been recorded along the proposed pipeline route (Table 1-12).

Table 1-12 Azerbaijan Red data book plant species recorded along the proposed BTC pipeline

SPECIES	STATUS	OCCURRENCE
Glabrose Liquorice (*Glycyrrhiza glabra*)	pRDB	Confirmed (AIOC, 1997) (ERM, 2000), (AETC, 2001)
Iris (group) (*Iris acutiloba*)	RDB	Confirmed (AIOC, 1997)
Merendera trigyna	pRDB	Confirmed (AETC, 2001)
Pomengranate (*Punica granatum*)	RDB	Confirmed (AIOC, 1997)
Woodland grape (*Vitis sylvestris*)	RDB	Confirmed (AIOC, 1997)

Iris species (*Iris acutiloba*) is one of several rare species expected in the Gobustan area and was recorded during the 1996 AIOC survey. The survey had been carried out late in the season however and this may have led to the under-recording and mapping of the distribution of this species. The presence of *Iris acutiloba* was confirmed at KP 28 and 50 during a survey for this species during April 2002. *Merendera trigyna* was recorded at KP 51, to the east of Kazi-Magomed at the western extent of the Gobustan desert area during 1996, but was not found in 2002. Both of these species are bulbs and could be translocated to protect them during construction activities.

Glabrose liquorice (*Glycyrrhiza glabra*) was recorded in many of the artificial watercourses and chal meadow areas along the pipeline route. This species is a useful medicinal plant and is used in over 100 medicinal preparations, and in 22 industrial sectors (eg food and paint).

The two species woodland grape (*Vitis sylvestris*) and pomengranate (*Punica granatum*) were recorded at several locations, generally associated with canals, ditches and river banks. However, these species will not be included in the revised edition of the Azerbaijan Red Data Book since further assessment of their status found it to be unnecessary.

1.6 FAUNA

1.6.1 General

Many species of fauna are present along the proposed pipeline route and within the survey corridor, the majority of which are common and widespread. The information obtained from literature reviews and the field surveys serves to give an indication of the general faunal assemblages along the proposed pipeline which are associated with different habitat types and to highlight those species which are of national or international importance.

The fauna within the Kura plain is made up of elements of the European and Asian zoogeographical regions. However, some species, particularly reptiles, of the Asian zoogeographical group, which is at its north-western limits in Azerbaijan, are undergoing a reduction in distribution towards the south-east. This is mainly as a result of habitat loss due to agriculture.

The faunal assemblages present along the proposed pipeline route are most easily split into those found in desert and semi-desert, woodland and scrub, agricultural and wetland habitats. The following sections describe the faunal assemblages of the different taxonomic groups along the proposed pipeline and also highlights those species which are rare or protected which have been identified as being present along the proposed pipeline route.

1.6.2 Mammals

The desk study (AIOC, 1997) identified 51 mammal species which are, or were, known to occur in the central part of the Kura River Plain from Gobustan to the Georgian border. However, this desk study was largely reliant on literature sources dating from 1940 to 1980. The more recent research for which papers are available has concentrated on bats.

Extensive human modification of many habitats, hunting pressure on various game animals eg wild boar (*Sus scrofa*) and goitered gazelle (*Gazella subgutterosa*) and killing of large predators has taken place during and since many of these papers were written. This makes it likely that several of the recorded species are no longer present in the region.

There are 14 species of mammal which are rare, either on a national or international scale, which have the possibility of being present in the vicinity of the proposed BTC pipeline (Table 1-13). Five of these are already included in the Red Data Book for Azerbaijan (1989), while a further six are proposed for inclusion in the revised Azerbaijan Red Data Book and six are listed as being internationally rare by the 2000 IUCN Red List of Threatened Species.

Table 1-13 Mammals of conservation importance which may occur along the proposed BTC pipeline

SPECIES	STATUS	OCCURRENCE
Water vole (*Arvicola terrestris*)	Prdb	Confirmed (AIOC, 1997)
Barbastelle bat (*Barbastella barbastellus*)	Iv	Confirmed (AETC, 2001)
Reed cat (*Felis chaus*)	PRDB	Possible
Wild field cat (*Felis lybica*)	RDB	Confirmed (AETC, 2001)
Goitered gazelle (*Gazella subgutterosa*)	RDB	Confirmed (A. Pritchard, 1998)
Edible, fat or squirrel-tailed dormouse (*Glis glis*)	IIr	Confirmed (AIOC, 1997)
Striped hyaena (*Hyaena hyaena*)	RDB, IIr	Possible
Porcupine species (*Hystrix indica*)	PRDB	Confirmed (ERM, 2000)
Eurasian otter (*Lutra lutra*)	pRDB, Iv	Probable
Schreiber's bat (*Miniopterus schreibersii*)	RDB	Possible
Greater horseshoe bat (*Rhinolophus ferrumequinum*)	IIr	Confirmed (AETC, 2001)
Lesser horseshoe bat (*Rhinolophus hipposideros*)	pRDB, Iv	Confirmed (AETC, 2001)
Pygmy white-toothed shrew / Eurasian shrew (*Suncus etruscus*)	PRDB	Possible
Marbled polecat (*Vormela peregusna*)	RDB	Probable

Wild field cat (*Felis lybica*) is generally confined to the Gobustan region and Tugay Forest but is said to be present in the region of KP 349 (just to the south of the Shamkir State Forbidden Area) from discussions with the local population (AETC, 2001). Goitered gazelle (*Gazella subgutterosa*) no longer occurs regularly outside the Shirvan reserve, to the south of the proposed BTC pipeline, although two were seen during other fieldwork in April 1998 just to the north of proposed route in the Gobustan area (A. Pritchard, *pers. com.*) and therefore do cross the region.

Porcupine species (*Hystrix indica*) is the largest of the rodents in Azerbaijan, which tends to live in holes on river banks and feeds on invertebrates. Survey information over the last 60 years suggests that it is increasing its distribution. During the ERM survey, spines of this species were recorded at KP 171.5 (bank of the Geychay river), KP 315 (near Kushkarachay river), and KP 320.5 (near Karasu river) (ERM, 2000). With respect to various references it could be expected to be present between KP 170 – 400 of proposed route.

The *g*reater horseshoe bat (*Rhinolophus ferrumequinum*), lesser horseshoe bat (*Rhinolophus hipposideros*) and barbastelle bat (*Barbastella barbastellus*) are known to be present in the Gobustan region as a result of recent field surveys (AETC, 2000). They, along with Schreiber's bat (*Miniopterus schreibersii*) may utilise buildings or caves as roost sites and may feed in the desert areas along the proposed pipeline route.

Water vole (*Arvicola terrestris*), which is a species occurring in grasslands and edible, fat or squirrel-tailed dormouse (*Glis glis*), known from Tugay forest areas, were both recorded along the route of the WREP (AIOC, 1997).

Striped hyaena (*Hyaena hyaena*) (RDB) is reported only in the Tugay forest areas. Eurasian otter (*Lutra lutra*) is a wetland species mainly confined to rivers and major waterbodies.

Pygmy white-toothed shrew / Etruscan shrew (*Suncus etruscus*) is one of the smallest recorded mammals in Azerbaijan and although it was not recorded during any field surveys is likely to be found between KP 47 - 155, in the Kura-Araks lowland.

The population and distribution of marbled polecat (*Vormela peregusna*) has dramatically decreased due to agricultural conversion of areas of steppe and desert and the use of rodenticides making its main prey scarce. It is thought that they would be expected between KP 43 –160.

Reed cat (*Felis chaus*) is distributed along the River Kura, River Araz and their tributaries. It is possible that it may be present along the proposed pipeline route in the water and swamp habitats of the Geychay, Turianchay, Kura, Shamkir region (KP 330 - 370) and Karayazo State Nature Reserve (KP 410 - 441).

The remainder of mammals recorded during all of the field surveys are generally those, which are common and widespread throughout Azerbaijan. It should be noted that many burrowing mammals, particularly small rodents, have excavated in the backfill soil over the WREP. This is probably because it is softer and easy to dig.

Species, which have been recorded and are ubiquitous to the entire route include the brown hare (*Lepus europaeus*), the rodents: red-tail sanderling (*Meriones erythrourus*), house mouse (*Mus musculus*), common wood mouse (*Apodemus sylvaticus*), striped field mouse (*Apodemus agrarius*) and Gunther's vole (*Microtus socialis*) and the carnivores red fox (*Vulpes vulpes*), golden jackal (*Canis aureus*), wolf (*Canis lupus*) and Eurasian badger (*Meles meles*).

The rodents, small jerboa (*Allactaga elater*) and mountain Asian jerboa (*Allactaga williamsi*) were recorded in the desert regions of Gobustan and Kazi-Magomed and tend to be restricted to these areas (AETC, 2001). The insectivores long-tailed white-toothed shrew (*Crocidura guldenstaedti*) and long-eared desert hedgehog / ear shrew (*Hemiechinus auritus*) are also known to be present in the Gobustan region (AETC, 2001). Other commonly expected mammals in the desert and semi-desert include eastern European hedgehog (*Erinaceus concolor*), Kuhl's pipistrelle (*Pipistrellus kuhli*) and desert serotine bat (*Eptesicus bottae*) (ERM, 2000).

The Gobustan region in the vicinity of the pipeline route supports important habitats for mammals as well as other faunal groups due to the vegetation and variety of niches present. These are the Jeirankechmes River and the Jingirdag and Azraildag heights.

Reed thickets along canals, rivers and other wetland habitat provide suitable habitat for brown rat (*Rattus norvegicus*), wild boar (*Sus scrofa*) and coypu (*Myocastor coypus*), which is an introduced species.

The Tugay forest habitat on the floodplains of the Kura River is very rich in animals, and represents the last refuge in the area for a number of species due to loss of habitat elsewhere. This area is not crossed by the proposed pipeline route. Thirty-five mammal species are found in the area, several of which are included in the 2000 IUCN list of threatened species, including Eurasian otter (*Lutra lutra*) and striped hyaena (*Hyaena hyaena*). An isolated population of red deer (*Cervus elaphus*) is known from the Tugay forest area, which also supports three endemic species grey hamster (*Cricetulus migratorius*), Brandt's hamster (*Mesocricetus brandti*) and Shelkovnikov's water shrew (*Neomys shelkownikowi*). There are also confirmed populations of wild boar (*Sus scrofa*), Libyan jird species (*Meriones lybicus*) and other small mammals (AIOC, 1997) and whiskered bat (*Myotis mystacinus*) and forest dormouse (*Dyomys nitedula*) (ERM, 2000).

Species recorded in mid-November 1996 (AIOC, 1997) included footprints of red deer (*Cervus elaphus*), red fox (*Vulpes vulpes*) and wild cat (*Felis silvestris*) and the scats of brown hare (*Lepus europaeus*) along the river banks. Golden jackel (*Canis aureus*) was seen crossing a track.

1.6.3 Birds

Bird assemblages can change dramatically throughout the year due to their high mobility and ability to migrate such that species can be summer breeders, resident, wintering or migratory. Bird assemblages also vary between different habitats.

Desert and semi-desert areas or seasonal/chal meadow and marshes, where productivity in terms of food resources is low, lead to a low density of birds of generally fewer species than can be found in more productive habitats. Such species include crested lark (*Galerida cristata*), lesser short-toed lark (*Calandrella rufescens*), northern wheatear (*Oenanthe oenanthe*), isabelline wheatear (*Oenenthe isabellina*), Finsch's wheatear (*Oenanthe finchii*) and calandra lark (*Melanocorypha calandra*).

Agricultural areas and areas which are becoming more degraded by anthropological activities, such as winter grazing on desert pasture and in Tugay forests, as well as hay mowing, lead to the bird assemblage consisting of species which are common and widespread throughout the country and which have been regularly recorded during all the field surveys. These include bee-eater (*Merops apiaster*), tree sparrow (*Passer montanus*), house sparrow (*Passer domesticus*), sand martin (*Riparia riparia*), roller (*Coracias garrulous*), magpie (*Pica pica*), starling (*Sturnus vulgaris*), rook (*Corvus frugilegus*), carrion crow (*Corvus corone*). White stork (*Ciconia ciconia*) (Ev) and heron species (*Ardea* spp.) are frequently seen feeding with cattle, which disturb the insects they feed on.

Wetland areas, such as river, canals, lakes and marsh, often support a relatively diverse mixture of waterfowl and waders, the more ubiquitous of which include heron (*Ardea* spp), egret (*Egretta* spp), coot (*Fulica atra*), mallard (*Anas platyrhynchos*) and gull (*Larus* spp).

Tugay forest areas, associated with the River Kura flood plain, which have not been degraded, are very rich habitats supporting a wide range of bird species. A desk top study (AIOC, 1997) estimated that 98 species of bird nest in the Tugay forest, twenty of which are associated with aquatic habitats, eleven are birds of prey. Nests of the following species of conservation concern have been recorded in the vicinity of the pipeline corridor: white-tailed eagle (*Haliaeetus albicilla*) (RDB, Er, Ilr), grey partridge (*Perdix perdix*) (Ev), black francolin (*Francolinus francolinus*) (RDB, Ev). Other Ciconiiformes found nesting in the floodplain forests are grey heron (*Ardea cinerea*), night heron (*Nycticorax nycticorax*) (Ed) and little bittern (*Ixobrychus minutes*) (Ev).

Surveys in October and mid-November 1996 (AIOC, 1997) recorded long-legged buzzard (*Buteo rufinus*) (Ee), black kite (*Milvus migrans*), and lesser spotted eagle (*Aquila pomarina*) over the forest. Herring gull (*Larus argentatus*), grey heron (*Ardea cinerea*), little egret (*Egretta garzetta*), and white wagtail (*Motacilla alba alba*), kingfisher (*Alcedo atthis*) and cormorant (*Phalacrocorax carbo*) associated with water. Blackbird (*Turdus merula*), jay (*Garrulus glandarius*), long-tailed tit (*Aegithalus caudatus*) and great tit (*Parus major*). Buzzard (*Buteo buteo*) was heard calling.

Table 1-14 Birds of conservation importance which may occur along the proposed BTC pipeline

SPECIES	STATUS	RESIDENCY*	OCCURRENCE
Kingfisher (*Alcedo atthis*)	Ed	R	Confirmed (AETC, 2001)
Chukar (*Alectoris chukar*)	Ev	R	Confirmed (AIOC, 1997), (AETC, 2000)
Golden eagle (*Aquila chrysaetos*)	RDB, Er	R	Confirmed (AIOC, 1997)
Tawny Eagle (*Aquila rapax ssp. nipalensis & orientalis*)	RDB, Ev	M/W	Confirmed (AIOC, 1997), (ERM, 2000)
Squacco heron (*Ardeola ralloides*)	Ev	M/W	Confirmed (AIOC, 1997)
Bittern (*Botaurus stellaris*)	Ev	M/W	Confirmed (AIOC, 1997), (AETC, 2001)
Stone curlew (*Burhinus oedicnemus*)	Ev	S	Confirmed (AIOC, 1997), (AETC, 2001)
Long-legged buzzard (*Buteo rufinus*)	pRDB, Ee	R/M	Confirmed (AIOC, 1997), (ERM, 2000), (AETC, 2001)
Nightjar (*Caprimulgus europaeus*)	Ed	S/ M	Confirmed (AIOC, 1997)
Sociable plover (*Chettusia gregaria*)	RDB	M	Confirmed (ERM, 2000)
White-tailed plover (*Chettusia leucura*)	RDB	S	Confirmed (ERM, 2000)
White stork (*Ciconia ciconia*)	Ev	S	Confirmed (AIOC, 1997)
Hen harrier (*Circus cyaneus*)	Ev	W	Confirmed (AIOC, 1997), (AETC, 2001)
Lesser Kestrel (*Falco naumanni*)	Ev, Iv	R	Probable
Eurasian kestrel (*Falco tinnunculus*)	Ed	R	Confirmed (AETC, 2001)
Back francolin (*Francolinus francolinus*)	RDB, Ev	R	Confirmed (AIOC, 1997), (AETC, 2001)
Collared pratincloe (*Glareola pratincola*)	Ee	S	Probable
Black-winged pratincole (*Glareola nordmanni*)	RDB, Er	S	Confirmed (ERM, 2000)
Crane (*Grus grus*)	Ev	M	Confirmed (AIOC, 1997)
White-tailed eagle (*Haliaeetus albicilla*)	RDB, Er, Ilr	R	Confirmed (ERM, 2000), (AETC, 2001)
Blue rock thrush (*Monticola solitarius*)	Ev	S	Confirmed (AETC, 2001)
Egyptian Vulture (*Neophron percnopterus*)	Ee	R/M	Confirmed (AIOC, 1997), (AETC, 2001)
Red-crested pochard	Ed	M	Confirmed (AIOC,

Table 1-14 Birds of conservation importance which may occur along the proposed BTC pipeline

SPECIES	STATUS	RESIDENCY*	OCCURRENCE
(*Netta rufina*)			1997)
Night heron (*Nycticorax nycticorax*)	Ed	M/W	Confirmed (AIOC, 1997)
Osprey (*Pandion haliaetus*)	RDB, Er	S	Confirmed (ERM, 2000)
Pygmy cormorant (*Phalacrocorax pygmeus*)	Ev, Ilr	M	Confirmed (AETC, 2001)
Glossy Ibis (*Plegadis falcinellus*)	pRDB, Ed	S	Confirmed (ERM, 2000)
Purple gallinule (*Porphyrio porphyrio*)	RDB, Er	W	Confirmed (AETC, 2001)
Ruddy Shelduck (*Tadorna ferruginea*)	Ev	S/R	Confirmed (AETC, 2001)
Little Bustard (*Tetrax tetrax*)	RDB, Ev	W	Confirmed (AETC, 2001)
Grey partridge (*Perdix perdix*)	Ev	R	Confirmed (AIOC, 1997)
Quail (*Coturnix coturnix*)	Ev	S	Confirmed (ERM, 2000)
Little bittern (*Ixobrychus minutes*)	Ev	M	Confirmed (AIOC, 1997)

* - Residency: R = resident and breeding; S = summer and breeding; W = wintering; M = passage migrant

The remainder of this section discusses those bird species which have been recorded along the proposed pipeline route and are of some nature conservation significance on a national, European or international scale.

Many species of birds of prey have been recorded, normally flying, over the proposed pipeline route. It is likely that they hunt for food in the vicinity of the proposed pipeline or pass through the area on migration. However, it is unlikely that any of them breed on the proposed pipeline route since the larger eagles and buzzards require rocky crags or large trees to nest in and the Eurasian kestrel (*Falco tinnunculus*) nests in buildings or trees.

Eurasian kestrel (*Falco tinnunculus*) was recorded regularly along the proposed pipeline route, but most frequently in the western part of the route. Long-legged buzzard (*Buteo rufinus*) has been recorded at KP 216.5, but mainly in the Shamkir region at KP 338.5 and KP 349.5. Osprey (*Pandion haliaetus*) is a fish-eater and prefers river and wetland habitats. It was recorded at KP 395 (west Kura crossing). White-tailed eagle (*Haliaeetus albicilla*) is a large eagle normally found in plains areas. During the survey this species was recorded at KP 0, KP 328, KP 402.5 and KP 414. The Egyptian vulture (*Neophron percnopterus*) has been recorded at KP 10 and KP 40 in the Gobustan area. The tawny eagle (*Aquila rapax*) (which has the subspecies *nipalensis and orientalis)* prefers semi-desert plain areas and was recorded twice during the 2000 survey at KP 81 and KP 98. Records from 1996 (AIOC, 1997) indicated that the golden eagle (*Aquila chrysaetos*) (RDB, Er) was observed at KP 22.

Harriers unlike other birds of prey do nest on the ground. One species of European conservation status, hen harrier (*Circus cyaneus*), has been recorded on the route at KP 386 and KP 411.5.

Lesser kestrel (*Falco naumanni*) may also occur in the area, but like the rest of the birds of prey is likely to only hunt over the proposed pipeline route.

Other birds of conservation importance are ground nesting species, which live in the plains, deserts and sometimes in the more agricultural areas. These species are of more concern with respect to pipeline construction since they could nest within the working area.

These species include stone curlew (*Burhinus oedicnemus*) (Ev) in the Gobustan region at KP 13.5. Chukar (*Alectoris chukar*) may breed in the Gobustan area, and was recorded at KP 12 as well as KP 291.5 around the Korchay River along with the other ground nesting bird, black francolin (*Francolinus francolinus*). Both these species have also been recorded in potentially suitable nesting habitats around KP 106.5.

Many birds associated with wetlands, such as wildfowl and waders are also ground nesting and several such species of conservation importance have been recorded.

Black-winged pratincole (*Glareola nordmanni*) at KP 79. White-tailed plover (*Chettusia leucura)* prefers shallow lakes and flooded swamp habitats. It was recorded at KP 116, 315 and 411.5. Sociable plover (*Chettusia gregaria*) was confirmed at KP 140.5. Glossy Ibis (*Plegadis falcinellus*) was recorded three times during the survey: as a singleton within a group of little egret (*Egretta garzetta*) near irrigation canal (KP 145.5), a flock of more than 15 birds in wetland habitat of Gush-Garachay (KP 319) and one at KP 396.5.

Blue rock thrush (*Monticola solitarius*) was recorded at the East Kura crossing (KP 223.5).

Kingfisher (*Alcedo atthis*) was recorded at the west Kura crossing area at KP 411 and nests in holes in river banks.

White stork (*Ciconia ciconia*) was proved nesting (KP 205). Collared pratincole (*Glareola pratincola*) may be present in the area. It feeds on arable farmland and grazing land and nests on the ground in grassland, often near wetlands.

Species, which only winter in the region include little bustard (*Tetrax tetrax*) and bittern (*Botaurus stellaris*) which were recorded at KP 291.5. Bittern (*Botaurus stellaris*) has also been recorded at KP 223.5 (east Kura crossing) and KP 311. Nightjar (*Caprimulgus europaeus*) has been recorded and was probably a passage migrant. Purple gallinule (*Porphyrio porphyrio*) was recorded near the west Kura crossing at KP 408 during the January 2001 survey. Other species of concern in the European context, which were recorded at KP 311, include night heron (*Nycticorax nycticorax*), squacco heron (*Ardeola ralloides*), red-crested pochard (*Netta rufina*) and crane (*Grus grus*). The last two species were certainly passage migrants and the others may be migrants or wintering birds. The internationally rare pygmy cormorant (*Phalacrocorax pygmeus*) was also recorded at the east Kura crossing (KP 223.5) but is known only as a passage migrant in Azerbaijan.

1.6.4 Amphibians

The 1996 desk study (AIOC, 1997) noted five amphibian species, which had been recorded in the region of the proposed pipeline. These are generally found in canals, rivers, lakes and swampy areas except for European treefrog (*Hyla arborea*) (Ilr), which is found in vegetation. Table 1-15 indicates species of conservation concern, which may occur along the proposed pipeline route.

The 1996 survey regularly recorded green toad (*Bufo viridis*) and marsh frog (*Rana ridibunda*) along the WREP and spadefoot toad (*Pelobates syriacus*) in Tugay forest. Marsh frog (*Rana ridibunda*) was again recorded in abundance during the 2000 survey (ERM, 2000) and common toad (*Bufo bufo*) (RDB), the biggest of the toads in Azerbaijan was recorded near an irrigation canal at KP 140.5 and on the edge of Tugay forest in a hollow fallen tree at KP 223.5.

Table 1-15 Amphibians of conservation importance which may occur along the proposed BTC pipeline

SPECIES	STATUS	OCCURRENCE
European tree frog (*Hyla arborea*)	Ilr	Possible
Common toad (*Bufo bufo*)	RDB	Confirmed (ERM, 2000)

No amphibians were recorded during the 2001 survey (AETC, 2001) since it was during January and the main hibernation period.

1.6.5 Reptiles

The 1996 (AIOC, 1997) literature review noted that 27 species had been recorded from habitats in the vicinity of the proposed pipeline. There are two main groups of reptiles; those which inhabit arid desert and semi-desert regions and those which inhabit wet lowland marsh, forest and waterbodies. Table 1-16 indicates which reptiles of conservation significance may be found along the proposed pipeline route.

Those which were commonly recorded in the desert and semi-desert areas, during the 1996 (AIOC, 1997) and 2000 (ERM, 2000) surveys include, gecko (*Gymnodactylus caspius*), the lizards: Caucasian agama (*Agama caucasica*), sand lizard (*Lacerta agilis*), Balkan green lizard (*Lacerta triliniata*) (which is rare but not Red listed) (AIOC, 1997) and rock lizard (*Lacerta saxicola*), blunt-nosed viper (*Vipera lebetina*) and spur-thighed tortoise (*Testudo graeca*) (RDB, Iv). Other species likely to be recorded include Caspian green lizard (*Lacerta strigata*), lizard species (*Lacerta raddei*), rapid fringed-toed lizard (*Eremias velox*), Schmidt's whipsnake (*Coluber schmidti*) and Caucasian sand boa (*Eryx jaculus*).

In the wetland areas, along canals and in low terrain forest areas widespread species such as freshwater terrapin species (*Clemmys caspica*) (pRDB), European pond terrapin (*Emys orbicularis*) (pRDB), European grass snake (*Natrix natrix*) and water snake (*Natrix tesselata)* were commonly recorded. Other reptiles may also be recorded including snake-eyed lizard (*Ophysops elegans*), and Montpellier snake (*Malpolon monspessulanus*).

No reptiles, except for spur-thighed tortoise (*Testudo graeca*) (RDB, Iv), were recorded during the 2001 survey (AETC, 2001) since it was during January and the main hibernation period.

Table 1-16 Reptiles of conservation importance which may occur along the proposed BTC pipeline

SPECIES	STATUS	OCCURRENCE
Freshwater terrapin species (*Clemmys caspica*)	PRDB	Confirmed (AIOC, 1997), (ERM, 2000)
Ladder snake spp (*Elaphe hohonackeri*)	PRDB	Confirmed (AIOC, 1997)
European pond terrapin (*Emys orbicularis*)	PRDB	Confirmed (AIOC, 1997)
Long-legged skink (*Eumeces schneideri*)	RDB	Possible

SPECIES	STATUS	OCCURRENCE
Spur-thighed tortoise (*Testudo graeca*)	RDB, Iv	Confirmed (AIOC, 1997), (ERM, 2000), (AETC, 2001)

Several species of conservation concern were recorded during the surveys and are described below. Ladder snake (*Elaphe hohonackeri*), was recorded towards the western end of the proposed pipeline route (KP 311.5) (AIOC, 1997).

Two species of terrapin, fresh water terrapin (*Clemmys caspica*) and European pond terrapin (*Emys orbicularis*) were recorded regularly in wetland areas along the proposed pipeline route during the 1996 and 2000 surveys, however it was impossible to distinguish between the two species in the field. It possible, therefore, that either of these species may be presented at the following KP points: 33, 97, 106, 114.5, 130.5, 141.5, 143, 146, 152.5, 153.5, 154, 155.5, 157, 167.5, 183.5, 189, 192, 203.5, 213, 216, 219, 220, 225, 228.5, 247, 319, 321, 362, 394, 402, 413 and 423.5.

The spur-thighed tortoise (*Testudo graeca*) (RDB, Iv) was recorded frequently in the desert, semi-desert and scrub habitats, mainly in the west of the proposed pipeline route and particularly the Shamkir region, during all three periods of survey. The population is relatively high within Azerbaijan but they are very susceptible to persecution and other anthropogenic impacts. They live in holes and usually hibernate during the winter, although they were recorded during the January 2001 AETC survey.

This herbivorous tortoise is found most frequently where soft soil hummocks form on the sides of vegetation. This habitat provides ideal places for burrowing and laying of egg clutches (three clutches per year). They are especially apparent during the first warm days of the year when they begin to pair (usually around early April).

Table 1-17 Breeding and incubation periods for spur-thighed tortoise

Common name	Event	Month											
		J	F	M	A	M	J	J	A	S	O	N	D
Spur-thighed tortoise	Breeding												
	Incubation												

Spur-thighed tortoise has been recorded at the following KP points: 17, 146, 304, 311, 314, 349.5, 351, 359, 361.5, 363, 399, 401, 402.5, 412, 421.5, and 441.5.

A more detailed survey of the route will be undertaken during spring 2002 to determine the precise location of animals and burrows in relation to the pipeline route.

1.6.6 Fish

This section is based on the information collated for the WREP (AIOC, 1997). The proposed pipeline crosses 21 principal rivers and numerous minor watercourses, mostly in the central and western parts of the proposed route. With the exception of the Djeyrankechmes and Pirsagat, which occur in the eastern part of the proposed pipeline route and flow directly into the Caspian, all the rivers form part of the Kura catchment.

More than 50 species occur in the Kura and its tributaries, with over 20 having some commercial value. However, stocks of some species are now depleted, with the construction of the Mingechaur Reservoir being a major contributory factor.

The fish fauna can be divided into two groups. The first, which includes the Cyprinids: common crab (*Cyprinus carpio*), Caspian roach (*Rutilus rutilus caspicus*) and bream (*Abramis brama orientalis*) mainly spawn in April to June during spring floods. The second group are principally migrants, which run up the Kura and its tributaries from the Caspian at different times, mainly in the period from October to March. Some of these species spawn directly on arrival, others later. In practice, a number of species may be migrating up or down river or spawning in any month.

Table 1-18 lists the 10 species of fish, which are of conservation importance which are found within the Kura river and its tributaries. The Kura holds all of these species, while its tributaries will hold at least one species. The Djeyrankechmes and the Pirsagat do not hold any Red Data Book fish species.

Table 1-18 Fish of conservation importance which may occur along the proposed BTC pipeline

SPECIES	STATUS	OCCURRENCE
White-eyed bream (*Abramis sapa*)	pRDB	Probable
Blackbrow (*Acanthalburnus microlepis*)	pRDB	Probable
Sturgeon ship (*Acipenser nudiventris*)	pRDB, Ie	Probable
Barbel spp (*Barbus brachycephalus*)	pRDB	Probable
Chanari barbel (*Barbus capito*)	pRDB	Probable
Murtsa barbel (*Barbus mursa*)	pRDB	Probable
Caspian lamprey (*Caspiomyzon wagneri*)	RDB	Probable
Chub (*Leuciscus cephalus*)	pRDB	Probable
Bleak spp (*Pelecus cultratus*)	RDB	Probable
Brown trout (*Salmo trutta fario*)	RDB	Probable

1.6.7 Invertebrates

The desk study (AIOC, 1997) found records of over 1,700 arthropod invertebrate species including nearly 1,600 insect species in the vicinity of the proposed pipeline. In addition, several hundred Protozoans are listed. In total, nine Azerbaijan Red Data Book Species may occur on the proposed pipeline route (Table 1-19). This includes two species of bumble bee (*Bombus persicus* and *Bombus daghestanicus),* two species of beetle (*Megacephalus euphraticus* and *Anchylocheria salmoni),* two species of butterfly (*Colias aurorina* and *Tomares romanovi)* and two species of hawk moth (*Manduca atropos* and *Daphnis nerii).* The crayfish (*Astacus pyzlowi*) was listed in the Red Data Book of the USSR and is known to exist in one of the rivers to be crossed by the proposed pipeline.

As with the other faunal groups, there is a particularly rich invertebrate fauna found within the Tugay forest areas. Many in the area of the proposed pipeline are included in the Red Data Book of the USSR and include the Lepidopterans: death's-head hawkmoth (*Manduca atropos*), heath species of butterfly (*Coenonympha saad*), swallowtail (*Papillo machaon*) and scarce swallowtail (*Iphiclides podalirius*) and the Hymenopterans: *Mellituga clavicornis*, *Xylocapa valga*, *Bombus lagsus*, *Bombus muscorum*, *Anthrophora nigriceps* and *Bombus* *argillaceous* the latter two being Caucasian endemics. However, of these species only death's-head hawkmoth (*Manduca atropos*) has been included in the Red Data Book of Azerbaijan.

Table 1-19 Red Data Book Species which may occur on the proposed BTC pipeline route

SPECIES	STATUS	OCCURRENCE
Bettle spp (*Anchylocheria salmoni*)	RDB	Possible
Crayfish (*Astacus pyzolwi*)	USSR RDB	Probable
Daghestan bumble-bee (*Bombus daghestanicus*)	RDB	Possible
Bumble-bee spp (*Bombus persicus*)	RDB	Possible
Clouded yellow spp (*Colias aurorina*)	RDB	Possible
Oleander hawkmoth (*Daphnis nerii*)	RDB	Possible
Death's-head hawkmoth (*Manduca atropos*)	RDB	Confirmed (ERM, 2000)
Bettle spp (*Megacephalus euphraticus*)	RDB	Possible
Hairstreak spp (*Tomares romanovi*)	RDB	Possible

The field surveys in 1996 (AIOC, 1997) and 2000 (ERM, 2000) noted many invertebrate species including molluscs, spiders, grasshoppers and bush-crickets, beetles, flies, bees, ants, dragonflies and butterflies. No invertebrates were recorded during the AETC, 2001 survey because in January very few species are active.

The ERM 2000 survey recorded the death's-head hawkmoth (*Manduca atropos*) (RDB), which can have a length of up to 15 cm at KP 140.5 and 397.5.

It is also likely that the crayfish (*Astacus pyzolwi*) is present in many of the watercourses.

In practice, it is almost impossible to undertake a complete invertebrate survey, even over a small area, because many hundreds of species may be present, including communities in the soil, in rock crevices, within plant stems and concealed in other areas.

Further, many are active for only a few days in the entire year. Thus the normal practice is to look for uncommon habitat types or scarce plants which may have associated invertebrates that are rare by reason of the scarcity of the habitat or food plant. Measures to minimise the impact on important habitats and plants along the route will safeguard any scarce invertebrates, which occur in association with them.

CULTURAL HERITAGE MANAGEMENT PLAN

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1 CULTURAL HERITAGE MANAGEMENT PLAN

1.1 SCOPE

This plan describes the management of archaeological and cultural features that are on or close to the route of the BTC pipeline through Azerbaijan. The BTC pipeline corridor is 442km long within Azerbaijan, extending from the terminal at Sangachal to the Azerbaijan/Georgian border.

The cultural heritage of an area may be profoundly affected by a large-scale construction project, if it is not handled sensitively. With careful management, however, it is possible to complete the project with minimal impact on the cultural resources and, in addition, provide a substantial increase in the quantity of archaeological evidence available for a region.

This Cultural Heritage Management Plan and its supporting information has been developed as part of the ESIA process and in line with the Azerbaijan law and the environmental standards of international lending agencies. Specifically, the Plan complies with the International Finance Corporation (IFC) Operational Note OPN 11.03 (1986) entitled 'Cultural Property'. It is the policy of BTC Co. to advance the objectives of cultural heritage protection in all of its projects and to comply with all specific applicable national and international heritage requirements.

1.2 REGULATORY FRAMEWORK

Archaeological monuments are under state protection in Azerbaijan. The monuments of Azerbaijan are divided into three classes according to their importance:

- Monuments of worldwide importance: 64 architectural and archaeological monuments are currently listed
- Monuments of national importance: Includes 583 architectural monuments and 3109 archaeological monuments
- Monuments of local importance: These comprise 3318 architectural monuments, 195 monuments of garden-and-park culture and landscape architecture, and approximately 2000 archaeological monuments

A number of national reserves have been established by the Order of the Cabinet of Ministers of the Azerbaijan Republic. Currently, 14 historical-and-architectural, historical-and-archaeological, historical-and-cultural, and historical-and-ethnographical reserves exist. Portable artefacts are also protected and are the property of the State.

The relevant legislation of the Azerbaijan Republic for the protection of cultural heritage is the Law on '*Protection and Utilisation of the Cultural and Historical Monuments'*. This states:

"*Article 18, Archaeological Studies on the Territories of New* Constructions.

The governmental *and non-governmental enterprises/ companies/ organisations carrying out a construction and economic activity shall apply to the adequate governmental bodies and the Azerbaijan Academy of Science at the stage of feasibility studies. In the case of the presence of an archaeological monument on the territory concerned, the* *enterprise/company/organisation carrying out construction works shall make a contract with the Academy of Science and provide for the investigation of the archaeological monument at its own expense. It is prohibited to carry out the construction and economic activity without the adequate scientific measures."*

The legislative arrangement has recently been altered to ensure that the Ministry of Culture is responsible for issuing permits for the excavation of archaeological and heritage sites. Decisions on the granting of this permission are made following advice from the Academy of Sciences.

1.3 ARCHAEOLOGICAL STRATEGY FOR THE BTC PROJECT IN AZERBAIJAN

The archaeological strategy for the BTC Pipeline Project in Azerbaijan is shown below:

Phase 1 Baseline Surveys including desktop studies, walk through surveys and examination of aerial photographs leading to the development of a Cultural Heritage Management Plan

Phase 2 Intrusive work-trial pits and preliminary investigation

Phase 3 Full investigation of threatened sites

Phase 4 Activities during construction, watching brief and excavation of newly discovered sites

Phase 5 Post construction work, analysis of finds, archiving and reporting, dissemination of the results of the work by various means

This document represents the Cultural Heritage Management Plan. It describes how each element of the strategy has been, or will be, implemented during the course of the project. This is a live document and will be updated as the project progresses.

1.4 ARCHAEOLOGICAL STRATEGY PHASE 1: BASELINE SURVEYS

Table 1-1 Participation in Baseline Surveys

PARTICIPATION IN BASELINE SURVEYS	
Purpose:	Preliminary, non-intrusive, identification and recording of known or potential archaeological sites within the BTC pipeline corridor. Ranking of sites in terms of importance
Who:	Institute of Archaeology and Ethnography (IoAE) (various) Environmental Representative on topographic survey (Nigel Buchanan) BTC Project archaeologist (Dave Maynard) Aerial photographs (Rog Palmer)
When:	Completed, assuming no further re-routes (August 2000 – July 2001)
Where:	Pipeline corridor in Azerbaijan
How:	Archaeological participation in all baseline surveys

Table 1-1 Participation in Baseline Surveys

PARTICIPATION IN BASELINE SURVEYS	
	GPS recording and annotation onto maps of all potential sites Including an archaeological specialist on the topographic survey Meetings and discussions between BTC Co. and IoAE Field survey of key sites by Project archaeologist and IoAE
Deliverables:	All potential sites listed, described, and locations recorded using GPS and entered onto the GIS system Photographic record of all potential sites Minor route modifications to avoid sites Agreed list of key sites requiring additional pre-construction work List of key archaeological concerns in ITT for construction contract

Representatives of the Institute of Archaeology and Ethnography (IoAE) have participated in all baseline surveys conducted along the BTC Pipeline corridor.

These surveys have identified approximately 70 potential sites on, or close to the proposed pipeline route. These sites range in character from extensive deposits of stratified material covering many periods to simple spreads of pottery. The extent and nature of many of the sites is not yet known. The identification of a site is at present based upon the recognition of cultural material on the surface or other indications. There is also the potential for other sites, as yet unknown, to be found during work along the pipeline route.

The baseline survey work has followed a phased approach following the gradual selection and improvement of the pipeline routing and design as summarised in Table 1-2.

Table 1-2 Baseline surveys

SURVEY DATES	SURVEY COVERAGE
August 2000	Survey of existing Western Route Export Pipeline
August 2000	Survey of existing Azerigaz pipeline
January-February 2001	Survey of re-route sections
March-April 2001	Archaeological input to topographical survey of proposed BTC pipeline corridor
July 2001	Archaeological surveys of key sites with BTC project archaeologist
January 2002	Examination of aerial photographs

The initial surveys conducted in August 2000 involved a representative of the IoAE working as part of a wider environmental team on a survey of the length of the proposed pipeline corridors (as known at the time). The archaeological objective of these relatively rapid surveys was to identify and record all potential or known sites within the corridor.

A similar exercise was conducted in January 2001 along re-routed sections, where no coverage was available from the August surveys. This work reflects the requirement to maintain a comprehensive coverage of data as the project design evolves.
The next stage in baseline work involved a more comprehensive assessment of each of the potential sites, and an initial decision on the most appropriate management of the site. In March

2001 a representative of the IoAE accompanied the topographical survey team along the proposed pipeline corridor. The overall aim of the topographic survey was to fine-tune the route of the pipeline within the defined corridor. The archaeological objective was to look at each of the known or potential sites identified during earlier work, and to select the most appropriate management option for that site. Options included:

- No additional work; pipeline construction to continue as normal
- Archaeological watching brief during construction
- Re-route of pipeline to avoid the site
- Intrusive work prior to construction

The preferred option was to re-route the pipeline to avoid potential sites wherever feasible, thereby avoiding any impacts upon features from construction or excavation activities. In some cases this was not possible given other engineering, routing or environmental constraints, or the perceived surface extent of the site.
This work has been followed by the development of the Cultural Heritage Management Plan for the Project as shown in Table 1-3

Table 1-3 Development of Cultural Heritage Management Plan

DEVELOPMENT OF CULTURAL HERITAGE MANAGEMENT PLAN	
Purpose:	To describe how archaeological and cultural heritage issues will be managed during the design and construction of the BTC Pipelines Project
Who:	BTC ESIA Manager (Phil Middleton) BTC Project archaeologist (Dave Maynard)
When:	Finalised for issue with ITT for construction (end October 2001) Live document – to be regularly updated.
Where:	Produced in Baku and UK
How:	Initial draft prepared by Dave Maynard, based on WREP AMP Comments provided by Project ESIA team Amended and updated by Phil Middleton. Rev 01 issued for further comment
Deliverables:	AMP as supporting document for construction ITT

The potential sites have been assessed and ranked in terms of potential significance, using the methodology described above. This has resulted in a list of areas that will be subject to more detailed, pre-construction, archaeological assessment as part of Phase 2 of the Archaeological Strategy for the BTC pipeline. These sites have been identified in the 'Environmental Construction Constraints and Concerns – Azerbaijan, a document issued with the construction ITT, and are listed in the section below.

The intensive study of a fairly wide corridor across Azerbaijan has confirmed the records of known sites and identified many new areas. The recognition of the intensive occupation of the area through which BTC will pass as one where there has been intensive settlement for the past several thousand years will require further study in order to record the evidence to be found on the pipeline route.

1.5 ARCHAEOLOGICAL STRATEGY PHASE 2: TRIAL TRENCH INVESTIGATION OF POTENTIAL SITES

The provisional list of areas where trial investigations on the BTC pipeline are needed was identified in Phase 1. Further locations will be added to this list as areas of rerouted pipeline are surveyed and the understanding of the archaeology along the route progresses. Other areas of potential archaeology may be examined at a later stage.

The locations identified for work with the BTC project are:

Gobustan (KP9-11) Sites 4, 5, 6
Kazi-Magomed (KP54) Sites 21, 22
Yevlakh (KP221) Sites 52, 53, 54
Neymatabad (KP236) Site 56
Mingechaur (KP248) Site 57
Nadirkand (KP276) Site 59
Dalimamedli (KP280) Site 60
Zayamchai (KP355) Sites 111, 112, 113
Girag Salakhli (KP 05) Site 138

The aim of the trial trenching operation is to define the nature and extent of the archaeology in those locations. Following this, an appropriate mitigation measure will be prepared; this may include a change of the pipeline route, the excavation of affected features or no further work being needed at this location.

For each of the areas identified, a method statement will be prepared showing the following:

- The location and description of the site
- Details of pipeline construction requirements
- Extent and duration of the proposed archaeological works
- Ownership details of the land
- Access arrangements to the site
- Health and Safety requirements specific to the site
- Contact details for the BTC staff
- Contact details for other pipelines and services specific to the site

1.6 ARCHAEOLOGICAL STRATEGY PHASE 3: INVESTIGATION OF SITES

Once the areas of significant archaeology have been defined and the appropriate mitigation strategy defined, the full excavation of the features will commence. The work will be limited to the area where features will be impacted by construction and may extend to the limits of the pipeline right-of-way.

A method statement will be prepared for these sites as that outlined for the trial trench work. As this work will involve the actual disturbance of archaeological deposits (rather than potential disturbance in the case of trial trenching) a permit for the conduct of archaeological excavations will be required from the Ministry of Culture.

1.7 ARCHAEOLOGICAL STRATEGY PHASE 4 PIPELINE CONSTRUCTION ACTIVITIES

A suitably qualified field archaeologist shall accompany each construction team. The function of this archaeologist is:

- Provide advice to survey and right of way teams in the area of known archaeological sites
- Record archaeological features discovered during pipeline construction activities
- Provide advice to the construction superintendent on the significance and implications of new archaeological discoveries on the pipeline route

The following guidance shall be followed in the event of new archaeological discoveries.

1.7.1 Archaeological discoveries of minor significance

This type of archaeological discovery would be of fairly small size, such as an isolated feature or findspot. It is anticipated that the Construction Archaeologist should be able to adequately record the feature by himself. The discovery should provide no delay or hindrance to the construction process.

The discovery will be reported by the Construction Archaeologist to the Construction Superintendent at the earliest convenient opportunity, and then to the Institute of Archaeology and Ethnography, Baku and BTC Environment Department, probably on a monthly basis.

1.7.2 Archaeological discoveries of local significance

This type of archaeological discovery would be of small to medium size, such as a group of features or single burials. The Construction Archaeologist would be unable to record the discoveries by himself. Assistance would be required in the form of other archaeologists or labour to assist in the excavation and recording of the discovery. The discovery, and the recording process, may cause a limited disruption to construction activity, although mainline activities should continue. Arrangements may need to be made to demarcate the archaeological deposits from construction vehicles to prevent damage.

The discovery will be reported by the Construction Archaeologist to the Construction Superintendent immediately, who will then inform the BTC Environment Department, who will pass on the information to the Institute of Archaeology and Ethnography. Appropriate arrangements will have been made prior to this time for a small team of archaeological technicians, who may be despatched to assist in the recording of the features.

1.7.3 Archaeological discoveries of major significance

This type of archaeological discovery would have fairly major significance such as a settlement site or group of burials. The archaeological features would cover the working width of the pipeline easement such that construction vehicles and equipment would not be able to pass down the right of way without causing damage to the archaeological deposits. The excavation and recording of these deposits may take a considerable period of time and cause some disruption to construction activities, which may need to find an alternative right of way in the vicinity of the site.

The discovery will be reported by the Construction Archaeologist to the Construction Superintendent immediately, who will then inform the BTC Environment Department, who will pass on the information to the Institute of Archaeology and Ethnography. Appropriate arrangements will have been made prior to this time for a small team of archaeological technicians, who may be despatched to assist in the recording of the features.

1.8 ARCHAEOLOGICAL STRATEGY PHASE 5 POST CONSTRUCTION ACTIVITIES

Following the completion of major earthmoving activities, a short report shall be prepared by the Institute of Archaeology and Ethnography for BTC Environmental Department. The report shall outline the results of the archaeological monitoring of construction. The report will contain proposals for the processing and analysis of archaeological material found on the pipeline. The proposals shall indicate, the need and extent to which publication of results of the archaeological studies is required. This publication may include all the phases of the archaeological study of the pipeline route.

Table 1-4 Identified Archaeological Sites Close to the Pipeline (route 9)

SITE	NAME	KP	DATE	TYPE	COMMENTS
1	Sangachal	1	Medieval	Pottery scatter	Features identified during survey of Sangachal terminal, there are a number of different sites identified here in the various surveys, all consisting of pottery scatters
2	Karadag	1			
3	Sangachal	3	Medieval	Brick scatter	
4	Jeirankechmaz 1	8	Medieval	Pottery scatter	Within Gobustan Reserve
5	Jingirdag	10	Medieval	Pottery scatter	Within Gobustan Reserve
6	Azraildag	10	Medieval		Within Gobustan Reserve
10	Koch Nohur 3	14			
12	Djingir 1	16	Medieval	Pottery and brick scatter	
13	Djingir 2	16	Medieval	Pottery scatter	
14	Turagay	24	Medieval	Pottery scatter	
15	Kazi Magomed 1	49	Medieval	Pottery scatter	
16	Turagay	49	Medieval	Pottery scatter	
17	Kazi Magomed 2	50	Medieval	Pottery scatter	
18	Kazi Magomed 3	51	Antique, Medieval	Pottery scatter	
21	Kazi Magomed 4	53	Medieval	Pottery scatter	Site 21 lies in an area of many Azerigaz facilities.
22	Kazi Magomed 5	54	Medieval	Pottery scatter	Site 22 lies in an area of many Azerigaz facilities.
26		71	Medieval	Pottery scatter	
35	Kerrar	87	Medieval	Pottery scatter	Pottery scatter around which the pipeline has been re-routed
47	Ali Bayramli	159	Medieval	Pottery scatter	
50	Laki	210	Medieval	Pottery scatter	
52	Lacky	220	Medieval	Pottery scatter, graveyard	The route appears to lie in an area of former river channel leading to an ox-bow lake
53	Yevlakh 1	220	Medieval	Pottery scatter	Possibly in former river channel
54	Yevlakh 2	221	Medieval	Pottery scatter	
56	Neymatabad	235-237	Medieval	Pottery scatter	Intensive spread of pottery over the pipeline route extends around 500m along the pipeline
57	Mingechevir	247-	Medieval	Pottery scatter	Pottery spread, few in number but extends up to 1Km along the WREP

SITE	NAME	KP	DATE	TYPE	COMMENTS
		250			
58	Goran	257	Medieval	Brick and pottery scatter	Bricks lying in ploughed field east of Goranchai, nothing is visible in the vicinity of the river crossing, there are former quarry workings or river erosion products in the area to the west of the river
59	Nadirkand	276	Medieval	Settlement mound	Settlement (tepe) mound through which the WREP passes. The pipeline passes through a cultivated field to the south west of the tepe.
60	Dalmamedli 1	280	Medieval	Pottery scatter	Pipeline re-routed to the west, but the pottery scatter continues
62	Sarab	285	Medieval	Pottery scatter	
65	Guneshli	287	Medieval	Pottery scatter	
67	Fahraly	289	Medieval	Pottery scatter	
68		289	Medieval	Pottery scatter	
70		290	Medieval	Pottery scatter	
71		291	Medieval	Pottery scatter	
72	Korchay	291	Medieval	Pottery scatter	
73	Agasybeyli	292	Medieval	Pottery scatter	
74		293	Medieval	Pottery scatter	
76	Ali Bayramli	295	Antique, Medieval	Pottery scatter	
77		295	Medieval	Pottery scatter	
78	Ganchai 1	295	Medieval	Pottery scatter	
81	Hodjaly 1	300	Medieval	Pottery scatter	
82	Hodjaly 2	301	Medieval	Pottery scatter	
83	Yenikend 1	301	Medieval	Pottery scatter	
84	Yenikend 2	302	Medieval	Pottery scatter	
85	Hodjaly 5	302	Medieval	Pottery scatter	
86	Hodjaly 6	303	Medieval	Pottery scatter	
88	Samukh 2	305	Medieval	Pottery scatter	
96	Qarasu	320	Medieval	Pottery scatter	
97	Shamkir Memorial	328	Medieval	Pottery scatter	
101	Shamkir Memorial 3	335	Medieval	Pottery scatter	

SITE	NAME	KP	DATE	TYPE	COMMENTS
103	Shamkir 4	347	Medieval	Pottery scatter	
104	Shamkir 1	348	Medieval	Pottery scatter	
105	Shamkir 3	348	Medieval	Pottery scatter	
106	Shamkir 2	350	Medieval	Pottery scatter	
108	Shamkir 5	350	Medieval	Pottery scatter	
110	Zayem 1	354	Medieval	Pottery scatter	
111	Zayem 2	355	Neolithic to Medieval	Settlement mound	Extensive Neolithic to Medieval settlement deposits up to 1.5m deep visible. A reroute of the pipeline to the south west avoids main features
113	Zayamchai 1	356	Bronze Age	Pottery scatter	Bronze Age settlement, lies ?20m north of pipeline
114	Zayamchay Vadnal	356	Bridge remains	Bridge remains	100m distant from pipeline crossing of Zayamchay
116		357	Medieval	Pottery scatter	
118	Diyarly	358	Medieval	Pottery scatter	
119	Asagi Ayibli 1	358	Medieval	Pottery scatter	
121	Asagi Ayibli 2	360	Medieval	Pottery scatter	
122	Asagi Ayibli 3	361	Medieval	Pottery scatter	
123	Asagi Ayibli 4	362	Medieval	Pottery scatter	
124	Asagi Ayibli 5	362	Medieval	Pottery scatter	
133		390	Medieval	Pottery scatter	
134	Girag Kasamanly	399	Medieval	Pottery scatter	
135	Girag Kasamanly 2	400	Medieval	Pottery scatter	
138	Girag Salakhli	405	Antique, Medieval	Cemetery, settlement mound	
139	Girag Kasamanly 2	407			
150		422	Medieval	Pottery scatter	Recent dump of material, includes asbestos, no features visible in river bank
156	Beyouk Kesik 4	437	Medieval	Pottery scatter	

AERIAL INTERPRETATION REPORT

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1 ARCHAEOLOGY FROM AERIAL PHOTOGRAPHS

1.1 SUMMARY

A series of aerial photographs of the BTC pipeline route were examined for archaeological features. The photographic coverage was a corridor approximately 4km wide along the route from the Caspian to the Azerbaijan - Georgian border. Just under 1500 features were observed of all origins, with 67 features thought to be of archaeological origin. A large number of other features were recorded; these represent evidence of the past use of the area by nomadic groups. This study represents the first known analysis of large parts of the Azerbaijan landscape by aerial archaeologists using high-quality sets of data. The information obtained gives greater information on the environment of known archaeological sites and has shown the range of information that can be obtained for landuse of all periods through Azerbaijan.

1.2 METHOD OF PHOTO-EXAMINATION

Vertical photographs, taken in June 2001 at a contact scale of 1:15,000, were provided as scanned digital images on a series of CDs. These had been compressed using ER Mapper to reduce them to files of about 11-15 MB and on-screen examination was made using ER Viewer. Scan quality was excellent and allowed a considerable degree of zooming-in to examine detail.

The photographs had been taken for stereoscopic viewing so adjacent frames overlapped by 60%. This meant that the complete route could be examined on screen by viewing alternate frames. Since the route of the pipeline was not necessarily central to the photographs, examination was made of the complete frame. A subsequent assessment was then conducted to identify sites close to the pipeline. The pipeline route current at the time of the survey was Route 9.

Before work commenced on the photographs, several known archaeological sites were examined on prints and scanned images. Not all were visible and it remained uncertain how useful that particular set of photographs might be for archaeological investigation. Their summer date and lack of shadows do not make them ideal for recording slight earthwork features or minor colour changes and use of the digital images precluded stereoscopic examination that may have helped identify certain types of feature.

Photo-examination was made using an initial magnification of about 4x, with enlargement as appropriate to examine features identified. This scale of enlargement was sufficient to find obvious, and probably recent, features, but it became apparent that many of the more interesting possible archaeological features were noticed because the view had been zoomed to look at something else. It is possible, therefore, that some features were not identified. The alternative – to examine the photos at the level required – would require several months of work.

Photo-examination was carried out by two archaeologists experienced in the interpretation of aerial photographs simultaneously viewing the screen. The two-person approach allowed discussion of problem sites as necessary and provided an efficient way of tabulating results and manipulating the images.

There were two immediate problems due to use of digital images:

1. Stereoscopic examination was not possible
2. Photographs had been set with approximate North to the top. This meant that shadows fell away from the viewer and so caused problems with the correct interpretation of topography. [Vertical photos are best viewed with shadows falling towards the viewer. This helps the brain correctly read 'up' and 'down'.]

The aerial photographs were not ortho-rectified at the time of the analysis. Therefore it has not been possible to include the accurate BTC pipeline route on the photographs shown in this report. However, the alignment of the pipeline in relation to the identified features was judged based on comparison with the available route mapping. Ortho-rectified aerial photos for the route in Azerbaijan will be available in May 2002.

Photo examination began at the Azerbaijan-Georgia border and progressed to the East. An initial list (Table 1) was compiled of features identified. This used CD number, line number and photo number as the main source, and screen co-ordinates. In all but two cases (Lines 53 and 54) the origin was the Northwest corner of each frame and co-ordinates give distances from the West and then the North. Conversion of these to centimetres using a factor of 11000/23 gives a value of pixels per centimetre that enables sites to be located on the photographic prints.

1.3 RESULTS

Some 1460 features are listed in Table 1, many of which are likely to be 'recent' in date. Features thought to be archaeological, or possibly archaeological, are identified using an 'A'. Among the 'recent' features is a high number that are thought likely to remain from shepherds' camping and gathering sites. These were particularly dense south of the road between Ujar and Sighirli and, in places, showed superimposition that suggests that 'recent' could span a considerable time.

Table 1 was refined and shortened to produce a list of 223 sites that fulfilled the following criteria:

- Archaeological sites anywhere on the photographs. 67 were identified that were thought to be archaeological, or possibly archaeological.
- Cemeteries anywhere on the photographs. 38 cemeteries or probable cemeteries were identified.
- Features lying within approximately 200m of Route 9. 128 are listed and include some archaeological sites and cemeteries.

The 223 sites were given Pulkovo co-ordinates of their estimated position on the reduced 1:10000 maps, and site numbers using an easting value followed by a unique identifying number (eg 8517/1). Sites were also referenced to a 1:10000 map number and the nearest kilometre point. This shortened list is Table 2.

Reference to route maps in the tables is divided between two sets. Map numbers 347 to 377 refer to the Revision FC1 (25-01-01), other sheets are Revision D2 (19-10-01) that shows a more recent pipeline route and was received after photo interpretation had begun. No checks were made to verify whether sites tabulated as 'not on map' are within the maps of Revision D2.

Table 1 includes some known inconsistencies. Some features were noted when they were first identified but as photo examination progressed their nature became apparent and not all examples were tabulated. An example is the so-called 'keyboard' or 'piano keys' whose function was unknown when they were first noticed but which, it was later seen, appeared to derive from construction of roads. In some areas, and often associated with the shepherds' structures, were ponds. Some appeared to be artificially enclosed, others more natural. Some, but by no means all of these, are listed in Table 1.

Figures used in this report have been rotated 180° to help read form and topography. Photographic north (see flight traces) is now at the bottom of each figure.

1.3.1 Archaeological

In the United Kingdom (UK), 'archaeological sites' may have dates between the distant past and 1945. The most recent cut-off date for Azerbaijan archaeological sites is not known but those listed as such in the Tables are thought to have origins well before the medieval period. If a more recent date is acceptable for archaeological monuments, then many more of the sites identified are likely to qualify as such, although confirmation of that can only come from field investigation.

The abbreviated descriptions in the Tables tend to identify shapes of features rather than their function although it is likely that most indicate the presence of former occupation sites. Use of 'enclosure' and 'feature' in the Tables may require clarification. 'Enclosure' is used to identify features that were constructed to enclose, and examples include walled enclosure, embanked enclosure, or rectangular enclosure. 'Features' may often have the same shape as 'enclosures' but are usually smaller and were constructed for other purposes. Examples include sub-rectangular feature, circular feature. In most cases structures are defined by walls or banks that sometimes had an accompanying ditch. Walls and banks were often eroded or reduced in height. Ditch-defined enclosures were identified in only one locality, un-named but south of KP 118 (Pulkovo 8777 area).

Surface discoloration can indicate archaeological sites in this part of the world (Donoghue *et al* 2002; Philip *et al* 2002) but were not noted during on-screen examination of the photographs. Colour change plus height, as would be apparent from stereoscopic examination of prints, may identify possible sites, but all would require surface confirmation.

A small number of known archaeological sites, or features adjacent to them, were independently identified on aerial photographs. Most features in the tables were recognised only on the photographs and are unknown from ground investigation. The distribution shows concentrations of sites on the uncultivated higher ground at the east and west of the BTC pipeline route. This is an expected result as the central part of the route crosses low-lying arable land over which this particular set of photographs was unresponsive to any sub-surface features (archaeological or natural). Cultivation in that area may have destroyed evidence of former land use.

Only three suggested archaeological sites lie within 200m of the BTC pipeline route. They are illustrated and briefly described as follows:

Site 8543/1 comprises a group of at least three adjoining walled or embanked enclosures on locally high ground. The site was identified during the ground survey and is coincident with Archaeology Site 135 (see Volume 2 Environmental Mapping).

Figure 1 Archaeological site 8543/1.

Walled or embanked enclosures on high ground. Archaeology Site 135. Source photograph: 6126.

Site 8575/1 was identified as an isolated mound with parts of a possible enclosing wall and an irregular internal surface. On the basis of the air photo evidence it was suggested to be a settlement. The site was identified during the ground survey and it coincides with known Archaeology Site 112 (see Volume 2, Environmental Route Maps).

Figure 2 Archaeological site 8575/1.

An isolated mound that appears to have parts of an enclosing wall. Archaeology Site 112. Source photograph: 6075.

Site 8585/2 is a rectangular walled or embanked enclosure with internal features. It is likely to be a settlement site and its eroded appearance suggests it to be of some antiquity.

Figure 3 Archaeological site 8585/2. A rectangular embanked or walled enclosure with internal features that may indicate that the site was a settlement. Source photograph: 6056.

Comments on other archaeological sites identified are in Section 1.3.4 below.

1.3.2 Cemeteries

Cemeteries were fairly easy to identify on the aerial photographs. Most were within enclosed areas and all showed a mixture of small graves and larger tombs. They are also marked on the 1:10000 maps, and that helped confirm their identification on the photographs. It was not possible from the photographs to determine which cemeteries were in use, which disused, but several of them had space for expansion within their boundaries.

Seven cemeteries are within 200m of the pipeline. One, 8587/1, has the WREP route immediately to its north and the BTC pipeline is mapped about 50m north of the WREP route. Some 500m east of 8587/1 is another cemetery, 8586/2. The BTC pipeline is shown 50m to its south. The other five cemeteries are between 80m and 200m from the BTC pipeline.

1.3.3 Features within 200m of the pipeline

Features located within 200m of the pipeline are indicated in the tables and include the above categories of site and others of less certain types and dates. Many are described simply as ‘sub-rectangular features’ but show variations in size, form and grouping that may be of relevance to understanding them. They are thought likely to remain from migratory shepherds’ camps and individual structures are likely to be short-lived and seasonal. Superimposition of features shows that locations were revisited but the photographs give no indication of the time-span that these features represent. Examination of the photographs suggested each feature to comprise parallel long sides that may be slightly embanked and within which there is darker soil that could be slight hollowing and/or occupation debris. Ground visits in February 2002 confirmed this interpretation and noted that ‘sub-rectangular features’ are probably the remains of reed and mud structures. Although the structures themselves may be insubstantial, their ruined form, on non-arable land, may be capable of long-term survival and raises the question of the duration of use that occurred at some of these sites. The pipeline is routed through some of these structures and may provide opportunities for samples of these features to be examined by excavation.

Examples of the types and groupings of these sites are provided by the following small selection of illustrations.

Figure 4 Site 8813/2 and 3.

The left-right line on Figure 4 is the WREP route. In this area, the BTC pipeline will be some 70m to its north (bottom) and cuts through a densely-packed area of features of various forms. This group (8813/2) comprises mostly sub-rectangular features but includes some of rectangular form and a number of small circular or near-circular enclosures. Group 8813/3, at the top of the figure, includes a line of sub-rectangular features, all with 'entrances' on the south side, and some of which abut larger trapezoid enclosures that may be for stock. Source photograph: 6230.

Figure 5

Figure illustrates the apparent clustering of sub-rectangular features around modern buildings or sites of buildings. The photograph also shows some of the groupings and forms of design of these features. At the upper right centre of the photograph is a pond. This group of features is in easting 8813 and the central buildings are some 600m south of the pipeline. Source photograph: 6230.

Figure 6 Site 8619/3.

Figure 6 includes several listed sites of which 8619/3 is near the left-centre of the frame and provides and example of eroded rectangular features. This site is very close to the pipeline route. Just left of the upper centre is 8619/12 which shows the pairing of large with small rectangular features that can also be seen elsewhere. Source photograph: 6412.

Figure 7

Sites 8777/2 and 3. The group of features on the right of Figure 7 includes ‘scoops’ (so-called because their raised edges almost surround the interior) and somewhat eroded rectangular features. Some superimposition of features can be seen in this group and the modern track overlays or abuts others. The smaller group on the left of the photograph also includes both types of feature. Details of both sites are surveyed on the 1:10,000 map, showing they were present and visible at that date. Source photograph: 6289.

Figure 8 Part of Site 8815/1.

This further illustrates the range of shapes and groupings of the sub-rectangular features and their associated enclosures. It also shows some of the stages of decay that occur after abandonment of the temporary structures. Of interest near the top of this figure is the walled or embanked rectangular enclosure with its cultivated land within. The walls, it may be suggested, are to exclude stock. This enclosure and its approach track are shown on the 1:10,000 as are many of the sub-rectangular features. Source photograph: 6230.

Figure 9 Sites 8816/1-3.

The arc of sub-rectangular features and variants on the right of Figure 9 (8816/1) surrounds an area of lighter ground, possibly indicating wear from stock. Left of that site are two enclosures or features each within a slight circular enclosure. A smaller circular enclosure, with no internal structure, is immediately below the more centrally placed circle (8816/2). On the left of the figure is one end of an arc of wide-spaced features (see Fig 1.10, 8816/4). Source photograph: 6228.

Figure 10 Sites 8816/1-5, 8817/1.

Figure 10 shows a broader context to sites in the previous figure (seen here at the upper right). The line of wide-spaced sub-rectangular features (8816/4) extends from the vicinity of 8816/3 (upper right centre) and appears to end by a cluster and line of smaller variants on the left of the photograph. This line of features has been cut by the WREP pipeline, and the BTC pipeline will lay parallel to this and about 100m north. Site 8817/1 is a double walled square enclosure (or three sides of an enclosure) with sub-rectangular features at its open end. This has been listed as ‘archaeological’ but the freshness of the walls suggests it may be somewhat recent in origin. The more degraded feature of similar size to the right of 8817/1 may be the remains of an earlier and similar enclosure. Source photograph: 6228.

Other types of site close to the pipeline include:

Figure 11 Site 8566/1.

An area of conjoined long rectangular features showing as possible scoops with raised or embanked edges. Each has an open end facing a modern track and they are likely to be recent in date. Areas of light colour may indicate worn ground or levelled features. Source photograph: 6114.

Figure 12 Site 8863/1.

One of several rows of 'spots' identified during photo examination. No explanation can be given for these features. Source photograph: 6189.

Figure 13 Site 8869/5.

Part of a long straight row of 'spots' that appears to lay parallel to a linear feature – although the latter may be a vehicle track. The cause or purpose of the spots is unknown. Source photograph: 6177.

1.3.4 A selection of other archaeological features identified on the photographs

Examination of the complete area photographed has identified a total of 67 archaeological or possible archaeological sites, the majority of which are at distances greater than 200m from the pipeline route. These sites provide a wider range of examples that give context that may help interpretation of those on the route. The increased numbers of sites also suggest there to be some local types – something that would not have been apparent with a narrower search corridor.

In very general terms, the enclosed sites identified are of three main types:

- Walled enclosures, of rectilinear or curvilinear plan, which are sometimes conjoined. Some may be mis-identifications of ponds – which can also be walled. They occur more often in the western parts of the route
- Ditch-defined enclosures, sometimes with an accompanying bank. Rectilinear and curvilinear forms occur as does at least one hybrid example. Some superimposition occurs, suggesting reuse of a favoured location. These features make a local group towards the east of the route and, within the area photographed, have a densely-packed distribution centred on easting 8777. Their date, or date range, is unknown but many of them would not be out of place in Neolithic Apulia (Bradford 1957; and recent unpublished aerial survey by Braasch and Musson) and are similar to Bronze Age and Iron Age enclosures in Britain (eg Palmer 1984, Figure 3)
- Small circular features that are either mounds or open rings and may indicate burial sites. Some single examples have been identified, others form small groups, and there are two large concentrations, both on adjacent local outcrops cut by easting 8641

Traces of cultivation have also been observed. On the higher western ground these tend to be terraces and include many examples that are likely to be recent or in current use. The densest terraces occur in the western part of Azerbaijan and are north of the pipeline route.

Towards the east of the route are small areas of ridged cultivation that are reminiscent of ridge and furrow of the English midlands. The slightly curved strips suggest that they may have been ploughed using animal traction and a simple heavy plough (Bowen 1960, 8). Some parcels of strips are walled, others are apparently unfenced. Tracks may cut across ridges, but in at least one case (8775/1) ridges overlay a linear feature that is likely to have been a track. Much of the ridged cultivation occurs in the area of ditched enclosures but their chronological relationships are not always clear.

Types of feature identified are illustrated by the following examples in which the relevant features are central to each figure unless otherwise noted. The figures span the pipeline from west to east and include a number of sites with X-prefixes. These did not fall within the area of the 1:10000 maps provided and could not be assigned accurate eastings references. Their neighbours in Table 1 will indicate an approximate location and greater precision will be obtained by use of the photo numbers and co-ordinates.

Figure 14 Site 8525/1. Walled curvilinear enclosure on locally high ground. Possible occupation site. Source photograph: 6024.

Figure 15 Site 8528/1. Five or more small circles on high ground between two watercourses. Possible occupation or burial sites. Source photograph: 6026.

Figure 16 Site X2. A walled curvilinear enclosure with internal divisions which probably indicates a settlement site. Source photograph: 6028.

Figure 17 Site 8530/2.

Walled curvilinear enclosure, possibly a pond rather than occupation? Source photograph: 6030.

Figure 18 Site 8533/6.

Two (possibly more) small circles adjacent to a disturbed area that may indicate quarrying. Source photograph: 6032.

Figure 19 Site 8535/1.

A row of at least three small circles. Their eroded appearance may suggest them to be archaeological but other similar sites in the vicinity (eg 8535/2, 8536/1) appear more recently made. Possibly burial sites, but very uncertain. Source photograph: 6032.

Figure 20 Site 8540/4.

An oval mound of bare soil with surface irregularities. This is similar in appearance to known occupation sites but the presence of a second such mound in the upper right corner suggests they may be associated with modern farming. Source photograph: 6130.

Figure 21 Site X3.

A mound surmounted by a circular rampart within which is uneven ground. This is likely to be a settlement site. Source photograph: 6108.

Figure 22 Site 8560/1.

A group of circular features on high ground between watercourses. Possibly occupation sites. The rectangular features to their right are similar to others associated with shepherds' camps (see Figs 1.5, 1.6). Figure 23 overlaps the lower part of this photograph. Source photograph: 6091.

Figure 23 Site 8560/2.

An area of slight rectangular features, possibly indicating a settlement site. Figure 22 overlaps the upper part of this photograph. Source photograph: 6091.

Figure 24 Site X4.

A walled enclosure on high ground in a fairly mountainous area. Source photograph: 5569.

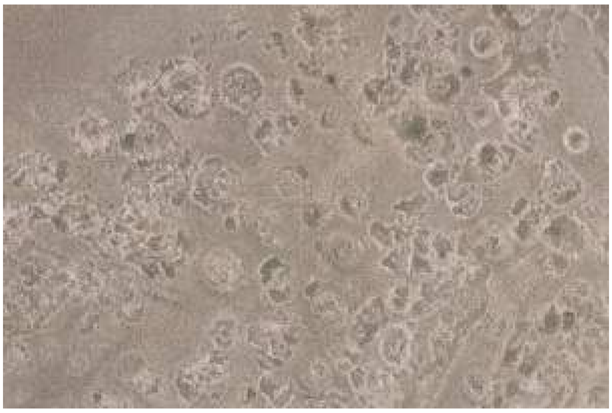
Figure 25 Site 8618/4.

Two D-shaped conjoined enclosures at the foot of an escarpment overlooking a watercourse. Possibly an occupation site, more probably recent. Source photograph: 6412.

Figure 26 Site 8641/1.

Local outcrop with many circular and other features that may indicate burials or may result from localised erosion. A part-enlargement is below as Figure 27. Some 1.5km to the north is a similar, but larger, outcrop (site 8640/2). Source photograph: 6384.

Fig 1-27 Site 8641/1.



An enlarged area of Figure 26. Source photograph: 6384.

Figure 28 Site 8735/1.

An embanked or walled enclosure with internal structures. Located at the confluence of two extinct rivers. Source photograph: 6272.

Figure 29 Site 8775/2.

A ditched curvilinear (oval) enclosure with traces of an internal bank. Two linears cross over the enclosure and the unidentified dark spots also seem to post-date it. In the lower right corner of the figure is some ridged cultivation that possibly indicates the most recent activity in this figure. Source photograph: 6288.

Figure 30 Site X5.

A double-ditched curvilinear (oval) enclosure with possible internal and external features. A modern hut has been placed between the two ditches suggesting that they are visible on the ground. Several tracks cross the enclosure. Source photograph: 6288.

Figure 31 Site 8777/5.

A ditched curvilinear enclosure with superimposed cultivation. Source photograph: 6289.

Figure 32 Site 8778/1.

Figure 32 may illustrate three phases of activity. Ridged cultivation and a ditched curvilinear enclosure are superimposed in a manner which makes it difficult to identify which was earlier. Above both of these is a curvilinear wall or bank that was constructed within, but not concentric to, the ditched enclosure. Source photograph: 6289.

Figure 33 Site 8778/4.

Central to the figure is a ditched sub-rectangular enclosure and to its lower left an oval enclosure with concentric double-ditches. Ridged cultivation appears to overlay both. Source photograph: 6289.

Figure 34 Site X8.

Two superimposed multivallate enclosures that overlay a single ditched enclosure. Ridged cultivation on the right side of the figure may be overlain by the most recent enclosure. Source photograph: 6289.

Figure 35 Site X13.

Central to the figure is a ditched oval enclosure that is probably overlain by ridged cultivation. The rectangular enclosure (X10) on the left of the figure has a less clear relationship to the cultivation, but appears to overlay the dark-toned linear features (?ditches) that cross within it. X10 may also overlay the curving linear ditch that crosses the figure. Source photograph: 6289.

Figure 36 Site 8799/2.

In the centre of Figure 36 is a small circular feature comprising an external bank, a possible ditch and a central mound or platform within which there is a pit. This may indicate a burial monument. To the left are several phases of sub-rectangular features remaining from shepherds' camps. Source photograph: 6240.

Figure 37 Site 8818/1.

Seven, possibly more, slight walled enclosures in a range of sizes. Similar enclosing walls have been noted in areas frequented by shepherds (see Figure 9), but there are none of their usual structures in this vicinity. Source photograph: 6228.

1.4 References

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1.5 Appendix 1: Results of field visits to selected areas of aerial photographic features

During February 2002, David Maynard visited a number of areas identified during the aerial survey analysis. These sites were chosen at random while travelling along the pipeline route, rather than for their interest as aerial photographic sites. The visits were without the benefit of copies of the photographs, so only the most obvious features could be seen; subsequent viewing of the air photographs showed how much had been missed in these visits.

8799/1-5

There are numbers of embankments or hollows that are shown to some extent on the 1:10000 mapping. The only dating evidence is a spread of sandstone building blocks and some modern rubbish at 8798780, 4460421, the 1:10000 map shows a building at this location.

A circular earthwork is at 8798792, 4460561. This is 6m diameter externally, slight bank to the outside, hollow area 1-1.5m wide, 0.3m deep, steep sided with flat bottom. The centre is 1.5m diameter and may be higher than the surrounding ground, but not much. It is flat topped rather than a mound.

An oval version of the above at 8798762, 4460573, this is 10m by 7m externally.

There are shepherds' huts spread about, but in the short, square, version, say 6m by 6m. Other features seem to be large depressions shown by irregular banks, possibly holding pens for livestock.

8640/2

The setting is steep sided hillocks that appear to have a denuded origin. The ground surface is liberally covered with small boulders or large stones. There are small mounds and circular elements that can be seen on the aerial photographs.

The mounds are c. 5m diameter and 1m high. The circular elements appear to be a fairly level circular part with a small mound again maybe 4-5m externally for each unit. There is no evidence of modern activity or rubbish.

These small hills could be burial mounds or kurgans, although there are large numbers of them and some of the features appear to have a natural origin. There is another larger area of similar mounds to the south east, site 8640/1 and two further examples can be seen in the area on a black and white set of aerial photographs held by BP.

8874

An area of former dwellings not identified in the air photographic survey was visited to the east of the Djeyranchachmas River at 8874200, 4459500. A supply system to bring water from the Djeyranchachmas into a set of concrete storage tanks was accompanied by concrete sheep watering troughs and a pond to collect surplus water. More than 6 scooped sunken-floored shepherds' huts were scattered around. A series of large rectangular buildings was shown by the remains of foundations. There had possibly been an episode of removing sandstone blocks from the buildings for use elsewhere. A large quarry to the south east, possibly acted as an alternative economic base for the settlement.

All these features could be matched with evidence seen on the aerial photograph of the site, and compare well with other examples seen in this part of the pipeline route.

8869

This is part of the site shown in figure 1.13. The typical features were again visible at this site around 8869000, 4460600. There are standing walled enclosures of sandstone blocks, that are probably in use at the present time. One of the scooped structures was furnished with sidewalls of sandstone, the only example of this to have been seen. The settlement was equipped with a water supply and storage system similar to the example by the Djeyranchachmas. The air photographs show many similar looking structures in the valley to the east, together with a small cemetery.

8871 North side of Djeyranchachmas

The air photographs show the location of individual rocks and boulders, together with evidence of some rough stone walling, in addition to the topographic setting of the site. A printed version of the photograph would be very useful in locating and recording individual rock carvings

1.6 TABLES

Results from examination of aerial photographs were tabulated as work proceeded. Table 1 includes sites of all types that were identified during that work. Table 2 is a sub-set of Table 1 and lists three types of site only: those thought to be archaeological, cemeteries, and any site within 200m of the pipeline route.

Columns show the following information:

- CD, Line, and Frame numbers of the non geo-referenced photographs
- Coord x and y and Scrn x and y show print and screen co-ordinates respectively. Print co-ordinates were calculated by multiplying the on-screen pixels by 11000/23 to give a measurement in centimetre that enables sites to be located on the photographic prints
- Comment is a brief description of the type of feature identified (see 1.3.1 above)
- Arch, Cem and <200m identify sites thought to be archaeological, cemeteries and sites within 200m of the pipeline. The latter includes some archaeological sites and cemeteries
- Site No is derived from the Pulkovo 1km Easting followed by a unique number. Fifteen archaeological sites that are outside the areas of the 1:10000 maps have been given numbers prefixed by X
- Polkovo E and N are co-ordinates, taken using a roamer, from the reduced 1:10000 maps. Use of geo-referenced photographs may slightly alter these. Not all sites in Table 1 have Pulkovo co-ordinates
- Map is the 1:10,000 map number. Reference to maps in the tables is divided between two sets. Map numbers 347 to 377 refer to the Revision FC1 (25-01-01), other sheets are Revision D2 (19-10-01) that shows a more recent pipeline route and was received after photo interpretation had begun. No checks were made to verify whether sites tabulated as ‘not on map’ are within the maps of Revision D2
- KP shows the KP number for sites within 200m of the pipeline route.

Add Table 1 and 2

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
28	17	6015	6.79	3.22	3247	1541	Cemetery		C			not	on map		
28	17	6017	10.08	10.38	4821	4964	Curvilinear area enclosed by hollow 'ditch' adjacent to modern cemetery.		C		8517/1	851760	458575	377	
28	17	6020	19.01	7.43	9092	3553	Suggestion of structures on high ground surrounded by water courses.	A			8522/1	852210	458295	376	
28	17	6024	15.14	13.73	7241	6567	Curvilinear enclosure, possibly walled.	A			8525/1	852545	457939	375	
28	17	6024	15.68	13.32	7499	6371	Curvilinear enclosure, possibly walled.	A			8525/2	852549	457944	375	
28	17	6024	14.53	15.38	6949	7356	Small curvilinear enclosure	A			8525/3	852521	457922	375	
28	17	6026	21.50	10.27	10283	4912	Five or more small circles. Possible burial sites.	A			8528/1	852880	457775	375	
28	17	6028	14.86	1.79	7107	856	Suggestion of enclosures on high ground.	A			X1	not	on map		
28	17	6028	16.08	2.42	7690	1157	Suggestion of enclosure on high ground. Dubious.	A			8530/1	853005	457433	374	
28	17	6028	17.03	0.61	8145	292	Curvilinear walled enclosure with internal subdivisions.	A			X2	not	on map		
28	17	6030	21.08	15.11	10082	7227	Sub-rectangular enclosure damaged by modern vehicles. Rectangular structures on N side of road.	A			8532/1	853244	457397	374	
28	17	6030	8.58	20.89	4103	9991	Curvilinear walled structure.	A			8530/2	853029	457442	374	
28	17	6032	21.48	7.29	10273	3487	Row of three small circles, possibly burials.	A			8535/1	853530	457348	373	
28	17	6032	18.78	5.01	8982	2396	Small circle, possibly burial.	A			8535/2	853536	457402	373	
28	17	6032	11.26	11.19	5385	5352	Group of small circles.	A			8533/6	853366	457387	373	
28	17	6032	9.72	11.08	4649	5299	Single circle cut by track.	A			8533/5	853341	457411	373	
28	17	6032	22.62	6.44	10818	3080	Walls of unknown origin.								
28	17	6032	10.33	8.20	4940	3922	Area of recent rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
28	17	6032	10.84	9.46	5184	4524	Curvilinear walled structure. Possibly an eroded example of recent scoops (see 8.86, 10.43).								
28	17	6032	19.99	18.71	9560	8948	Two groups of probable trenches.				8534/1			373	
28	17	6032	18.94	18.95	9058	9063	Rectangular structures. Probably recent.				8533/1			373	
28	17	6032	17.40	19.48	8322	9317	Rectangular structures. Probably recent.				8533/2			373	
28	17	6032	15.30	18.18	7317	8695	Rectangular structures. Probably recent.				8533/3			373	
28	17	6032	11.26	17.85	5385	8537	Rectangular structures. Probably recent.				8533/4			373	
28	17	6032	8.51	17.08	4070	8169	Group of rectangular structures. Probably recent.				8532/1			373	
28	17	6034	14.44	7.17	6906	3429	Two circles, possibly burials.	A			8536/1	853658	457251	373	
28	17	6034	12.81	9.19	6127	4395	Two, possibly three small circles (?burials). Adjacent features may be recent.	A			8536/2	853615	457254	373	
28	17	6034	13.60	10.19	6506	4874	Two circles, possibly burials.	A			8536/3	853621	457222	373	
28	17	6034	14.00	21.54	6696	10302	Rectangular structures. Recent.			Y	8535/3	853527	457065	372	415
28	17	6034	8.30	2.22	3970	1062	Row of four sub-rectangular structures. Possibly recent.								
28	17	6034	8.34	7.61	3989	3640	Probably recent.								
28	17	6034	9.98	10.99	4773	5256	Rectangular features. Probably recent.								
28	17	6034	12.09	11.73	5782	5610	Rectangular features. Probably recent.								
28	17	6034	16.56	15.20	7920	7270	Unknown.								
28	17	6036	2.13	5.73	1019	2740	Unknown.								
28	17	6036	21.19	13.74	10134	6571	Rectangular structures. Recent.								
28	17	6036	15.29	14.80	7313	7078	Area of rectangular structures. Recent.								
28	17	6036	3.43	19.72	1640	9431	Rectangular structures. Recent.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
28	17	6036	6.18	17.94	2956	8580	Rectangular features. Probably recent.				8536/1			372	
26	18	6134	12.35	3.53	5907	1688	Rectangular features. Probably recent.								
26	18	6134	10.43	5.38	4988	2573	Rectangular features. Probably recent.								
26	18	6134	15.52	10.29	7423	4921	Row of small scoops. Recent.								
26	18	6132	17.81	4.56	8518	2181	Circular feature. Unknown origin.								
26	18	6132	16.41	5.87	7848	2807	Area with many former structures, possibly recent camp.								
26	18	6130	5.10	11.24	2441	5376	Oval area of ?bare soil, which includes mound with surface irregularities.	A			8540/4	854055	456495	371	
26	18	6130	15.43	17.48	7380	8360	Rectangular features. Probably recent. Next to Archaeological Site 138.			Y	8540/1	854052	456320	371	405
26	18	6130	10.75	1.50	5141	717	Recent foundation.								
26	18	6130	1.59	2.87	760	1373	Rectangular features. Probably recent.								
26	18	6130	10.69	2.72	5113	1301	Rectangular features. Probably recent.								
26	18	6130	15.49	2.81	7408	1344	Rectangular features. Probably recent.								
26	18	6130	7.56	6.07	3616	2903	Group of rectangular structures. Probably recent.								
26	18	6130	4.24	11.92	2029	5700	Oval area of ?bare soil, which includes surface irregularities.				8540/5			371	
26	18	6130	11.39	20.66	5447	9881	Rectangular features. Probably recent.				8539/1			371	
26	18	6130	14.75	20.69	7054	9895	Rectangular feature. Probably recent.				8539/2			371	
26	18	6130	15.99	22.15	7647	10593	Unknown.				8539/3			371	
26	18	6130	20.48	22.33	9795	10680	Small circle.				8540/2			371	

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
26	18	6128	12.23	19.13	5849	9149	Squareish features. Unknown origin.			Y	8541/3	854135	456104	370	403
26	18	6128	12.61	18.72	6031	8953	Linear spread of squareish features. Unknown origin.			Y	8541/2	854142	456102	370	403
26	18	6128	16.38	18.52	7834	8857	Area of scoops. Probably recent.			Y	8541/4	854168	456050	370	403
26	18	6128	19.81	7.84	9474	3750	Rectangular features. Probably recent.								
26	18	6128	18.88	7.60	9030	3635	Rectangular features. Probably recent.								
26	18	6128	7.75	11.64	3707	5567	Rectangular structure. Probably recent.								
26	18	6128	7.86	12.56	3759	6007	Pits. Recent.								
26	18	6128	8.82	9.78	4218	4677	Rectangular features. Probably recent.								
26	18	6128	13.26	12.51	6342	5983	Rectangular features. Probably recent.								
26	18	6128	20.43	11.15	9771	5333	Linear features. Unknown origin.								
26	18	6128	8.28	19.28	3960	9221	Unknown.				8541/1			370	
26	18	6128	13.30	20.10	6361	9613	Rectangular features. Probably recent.				8541/5			370	
26	18	6128	12.58	21.01	6017	10048	Rectangular features. Probably recent.				8541/6			370	
26	18	6128	5.12	20.92	2449	10005	Rectangular features. Probably recent.				8540/3			370	
26	18	6126	11.84	17.32	5663	8283	Walled small enclosures on local mound. Archaeological site 135.	A		Y	8543/1	854286	455886	370	400
26	18	6126	13.12	2.81	6275	1344	Possible walled enclosures.								
26	18	6126	21.20	4.95	10139	2367	Rectangular feature. Probably recent.								
26	18	6126	14.67	5.15	7016	2463	Rectangular feature. Probably recent.								
26	18	6126	1.46	9.15	698	4376	Group of rectangular structures. Probably recent.								

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26	18	6126	8.46	12.83	4046	6136	Group of rectangular structures. Probably recent.								
26	18	6126	20.08	12.79	9603	6117	Group of rectangular structures. Recent.								
26	18	6126	6.61	20.65	3161	9876	Pits. Probably recent.				8542/2			370	
26	18	6124	14.51	0.74	6940	354	Recent buildings. Levelled.								
26	18	6124	17.36	3.26	8303	1559	Recent buildings. Levelled.								
26	18	6124	15.48	5.03	7403	2406	Probable recent AA position with adjacent structures.								
26	18	6124	1.39	6.36	665	3042	Rectangular structure. Probably recent.								
26	18	6122	18.70	12.95	8943	6193	Rectangular features. Probably recent.			Y	8546/1	854671	455334	368	393
26	18	6122	10.60	4.18	5070	1999	Rectangular structures. Probably recent.								
26	18	6122	6.37	4.87	3047	2329	Group of rectangular structures. Recent.								
26	18	6122	21.52	17.65	10292	8441	Group of rectangular structures. Recent.								
26	18	6122	20.72	19.26	9910	9211	Group of rectangular structures. Recent.								
26	18	6120	6.26	10.12	2994	4840	Group of rectangular features, which follow trench. Recent.			Y	8547/1	854729	455285	368	393
26	18	6120	7.38	3.00	3530	1435	Rectangular structure. Recent.								
26	18	6120	8.83	3.07	4223	1468	Rectangular features. Probably recent.								
26	18	6120	9.09	2.70	4347	1291	D-shaped enclosure with external features.								
26	18	6120	20.92	3.27	10005	1564	Circular enclosure with possible annex on N side.								
26	18	6120	15.16	12.76	7250	6103	Probably recent scoops.								
26	18	6120	17.40	16.58	8322	7930	Two curvilinear enclosures, attached to track.								

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26	18	6118	9.04	1.98	4323	947	Rectangular structures. Probably recent.				8549/1			368	
26	18	6118	19.76	5.29	9450	2530	Rectangular structures. Probably recent.				8549/2			367	
26	18	6118	18.74	12.62	8963	6036	Circular walled enclosure. Rectangular features near modern buildings.								
26	18	6117	7.06	8.38	3377	4008	Foundation of rectangular buildings.								
26	18	6117	10.75	8.08	5141	3864	Rectangular features. Recent.								
26	18	6117	16.99	13.78	8126	6590	Curvilinear enclosure, attached to track. Adjacent rectangular features.								
26	19	6101	11.28	2.88	5395	1377	Rectangular feature. Probably recent.								
26	19	6101	18.24	2.73	8723	1306	Circular enclosure with possible annex on N side.								
26	19	6101	21.33	8.22	10201	3931	Rectangular features. Probably recent.								
26	19	6101	4.85	6.48	2320	3099	Two curvilinear enclosures, attached to track.								
26	19	6101	4.01	22.45	1918	10737	Group of pits.								
26	19	6101	17.43	21.75	8336	10402	Circular walled enclosure. Rectangular features near modern buildings.								
26	19	6101	20.88	21.66	9986	10359	Group of rectangular structures. Recent.								
26	19	6101	21.27	22.69	10173	10852	Rectangular features. Probably recent.								
26	19	6099	20.88	4.89	9986	2339	Group of small rectangular and other structures, adjacent to modern building.								
26	19	6099	21.77	10.92	10412	5223	Oval enclosure with internal features.								

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26	19	6099	6.49	19.34	3104	9250	Rectangular features. Probably recent.								
26	19	6097	21.24	4.93	10158	2358	Rectangular features. Probably recent.								
26	19	6097	4.22	5.80	2016	2772	Embanked pond adjacent to water course.								
26	19	6097	5.30	19.67	2535	9407	Rectangular feature. Probably recent.								
26	19	6095	16.63	8.67	7953	4147	Unidentified human activity on top of hill.								
26	19	6095	14.48	7.80	6925	3730	Groups of pits. Possibly craters.								
26	19	6095	5.08	5.77	2430	2760	Group of rectangular features.								
26	19	6095	3.84	5.51	1837	2635	Groups of rectangular features.								
26	19	6095	11.74	15.78	5615	7547	Rectangular structure with adjacent curvilinear feature.								
26	19	6094	8.24	0.63	3941	301	Rectangular features adjacent to farm.								
26	19	6094	6.82	1.80	3262	861	Rectangular feature. Probably recent.								
26	19	6094	19.89	18.90	9513	9039	Row of rectangular features. Probably recent.								
26	19	6094	17.15	17.48	8202	8360	Group of rectangular features.								
26	19	6094	9.70	22.59	4639	10804	Rectangular structures.								
29	51	6038	14.18	16.90	6782	8083	Rectangular features. Unknown origin.			Y	8549/3	854940	455016	368	389
29	51	6038	10.72	19.29	5127	9226	Group of rectangular features.			Y	8548/1	854875	455058	368	390
29	51	6038	2.40	3.40	1148	1626	Area of recent activity. Old camp, rectangular features, fenced area with mast.								
29	51	6038	5.94	2.86	2841	1368	Site of possible buildings within embanked area.								
29	51	6038	6.88	2.64	3290	1263	Circle with unknown linear features adjacent.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
29	51	6038	7.10	2.52	3396	1205	Circular feature with adjacent rectangle.								
29	51	6038	15.64	4.16	7480	1990	Rectangular feature. Recent								
29	51	6038	3.57	12.64	1707	6045	Large embanked rectangular enclosure.								
29	51	6040	21.41	8.97	10240	4290	Cemetery.		C			not	on map		385
29	51	6040	4.94	4.37	2363	2090	Group of rectangular features adjacent to modern farm.								
29	51	6040	11.40	21.78	5452	10417	Rectangular feature.								
29	51	6042	13.90	6.59	6650	3150	Cemetery.		C			not	on map		383
29	51	6042	5.49	20.48	2626	9795	Group of rectangular features.								
29	51	6042	8.53	19.24	4080	9202	Group of rectangular features.								
29	51	6044	9.81	20.57	4690	9840	Cemetery.		C			not	on map		
29	51	6045	18.63	20.08	8912	9604	Cemetery.		C			not	on map		
29	52	6102	14.60	12.97	6983	6203	Group of rectangular features.								
29	52	6104	21.70	8.98	10378	4295	Group of rectangular features adjacent to modern building.								
29	52	6104	15.84	19.55	7576	9350	Group of rectangular features adjacent to huge modern buildings.								
29	52	6106	13.72	1.95	6562	933	Group of rectangular features.								
29	52	6106	19.79	6.04	9465	2889	Group of rectangular features adjacent to modern farm.								
29	52	6106	9.63	8.13	4606	3888	Rectangular features. Unknown origin.								
29	52	6106	5.63	8.30	2693	3970	Rectangular features. Probably recent.								
29	52	6106	4.68	8.01	2238	3831	Rectangular features adjacent to modern farm.								
29	52	6106	11.17	16.96	5342	8111	Rectangular features adjacent to modern farm.								
29	52	6106	6.22	14.05	2975	6720	Rectangular features adjacent to modern farm.								

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29	52	6106	6.14	14.90	2937	7126	Rectangular features adjacent to modern farm.								
29	52	6106	13.90	19.84	6648	9489	Rectangular and other features on high ground.								
29	52	6108	5.63	2.43	2693	1162	Circular rampart enclosing uneven area. Some external features. Possible settlement.	A			X3	not	on map		
29	52	6108	11.46	4.09	5481	1956	Rectangular features. Probably recent.			Y		not	on map		373
29	52	6108	9.14	4.59	4371	2195	Circular and other features on high ground.			Y		not	on map		374
29	52	6108	8.48	4.14	4056	1980	Walled small enclosures.			Y		not	on map		374
29	52	6108	6.49	3.24	3104	1550	Group of rectangular features. Probably modern.								
29	52	6108	8.58	1.06	4103	507	Pond.								
29	52	6108	11.11	1.11	5313	531	Scattered of rectangular features of various freshness.								
29	52	6108	14.71	1.61	7035	770	Group of rectangular features. Some appear to indicate former buildings. Other seem to be recent extraction, possibly for construction of nearby buildings.								
29	52	6110	21.81	10.17	10431	4864	Rectangular features adjacent to modern farm.			Y		not	on map		369
29	52	6110	8.15	0.58	3898	277	Group of rectangular and other structures.								
29	52	6110	18.56	5.91	8877	2827	Rectangular features adjacent to modern building.								
29	52	6110	13.07	5.56	6251	2659	Rectangular features. Probably recent.				8563/1			364	
29	52	6110	10.81	11.69	5170	5591	Group of small mounds, some appear to be damaged.								

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29	52	6110	14.06	13.49	6724	6452	Circular walled feature adjacent to modern farm. Nearby rectangular features.								
29	52	6112	16.65	13.81	7963	6605	Rectangular feature.			Y		not	located		368
29	52	6112	4.09	0.80	1956	383	Scoop.								
29	52	6112	18.54	3.24	8867	1550	Rectangular walls, probably building. Recent.								
29	52	6112	18.45	1.56	8824	746	Rectangular feature.								
29	52	6112	20.01	1.69	9570	808	Semicircular rampart.								
29	52	6112	19.61	3.80	9379	1817	Row of ridges, crossed by modern track. Looks like huge keyboard.								
29	52	6112	15.64	3.41	7480	1631	Rectangular features on irregular surface. Possibly enclosed.								
29	52	6112	9.28	4.56	4438	2181	Group of rectangular features.								
29	52	6112	10.10	2.80	4830	1339	Rectangular feature.								
29	52	6112	8.63	3.52	4127	1683	Circular feature. Unknown origin.								
29	52	6112	2.99	4.32	1430	2066	Circular feature. Unknown origin.								
29	52	6112	6.85	6.50	3276	3109	Rectangular feature adjacent to new linear construction.								
29	52	6112	12.49	6.41	5973	3066	Curvilinear feature.								
29	52	6112	17.83	5.44	8527	2602	Rectangular feature.								
29	52	6112	21.94	7.53	10493	3601	Rectangular features.								
29	52	6112	16.65	17.50	7963	8370	Rectangular features. Probably recent.								
29	52	6112	14.84	20.41	7097	9761	Circular feature. Probable pond.								
29	52	6112	19.30	20.03	9230	9580	Rectangular scoop.								
29	52	6112	21.63	22.27	10345	10651	Rectangular features adjacent to modern farm.								
29	52	6114	4.58	10.83	2190	5180	Linear and rectangular features.			Y	8566/1	856666	453867	363	366
29	52	6114	6.53	10.33	3123	4940	Linear features.			Y	8566/2	856697	453872	363	366
29	52	6114	6.69	13.19	3200	6308	Rectangular features.			Y	8566/3	856696	453828	363	366
29	52	6114	6.45	2.15	3085	1028	Rectangular features adjacent to modern farm.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
29	52	6114	5.45	4.26	2607	2037	Rectangular features.								
29	52	6114	11.61	1.36	5553	650	Rectangular and other features.								
29	52	6114	17.73	1.62	8480	775	Circular feature.								
29	52	6114	19.48	3.24	9317	1550	Piano keys'								
29	52	6114	21.06	3.90	10072	1865	Piano keys'								
29	52	6114	4.83	8.65	2310	4137	Curvilinear enclosure.								
29	52	6114	20.15	11.50	9637	5500	Rectangular feature.								
29	52	6116	5.51	17.05	2635	8154	Rectangular feature.			Y		not	on map		363
29	52	6116	9.76	17.78	4668	8503	Rectangular features.			Y	8569/2	856981	453727	363	362
29	52	6116	9.03	5.64	4319	2697	Rectangular feature.								
29	52	6116	5.07	4.57	2425	2186	Piano keys'								
29	52	6116	10.44	10.02	4993	4792	Small revetted enclosure.								
29	52	6116	11.11	12.93	5313	6184	Group of rectangular features. Some appear to indicate former buildings. Other seem to be recent extraction, possibly for construction of nearby buildings.								
29	52	6116	8.90	20.79	4257	9943	Rectangular features.				8569/3			363	
16	20	6093	2.36	1.93	1129	923	Rectangular feature.								
16	20	6093	15.32	4.72	7327	2257	Rectangular features.								
16	20	6093	16.19	7.19	7743	3439	Rectangular features and circular pit.								
16	20	6093	22.00	10.04	10522	4802	Rectangular features.								
16	20	6093	18.72	10.11	8953	4835	Group of rectangular features.								
16	20	6093	4.41	9.78	2109	4677	Group of circular pits.								
16	20	6093	16.30	14.33	7796	6853	Rectangular feature, partially destroyed by track.								
16	20	6091	18.65	8.99	8920	4300	Group of circular features. Adjacent rectangular features.	A			8560/1	856029	454705	366	
16	20	6091	18.59	7.94	8891	3797	Area of slight rectangular features. ?Possible settlement.	A			8560/2	856039	454725	366	
16	20	6091	18.62	7.29	8905	3487	Unknown.								
16	20	6089	8.96	0.35	4285	167	Trapezoid enclosure.								
16	20	6089	21.36	6.28	10216	3003	Group of rectangular features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
16	20	6089	14.10	7.07	6743	3381	Large group of rectangular features alongside river valley.								
16	20	6089	20.50	9.17	9804	4386	Group of rectangular features.								
16	20	6089	21.44	11.09	10254	5304	Rectangular features.								
16	20	6089	20.36	10.96	9737	5242	Rectangular features.								
16	20	6089	16.38	10.59	7834	5065	Curvilinear and rectilinear walled structure.								
16	20	6089	9.11	13.48	4357	6447	Rectangular features adjacent to modern farm.								
16	20	6089	12.37	12.76	5916	6103	Rectangular features adjacent to modern farm.								
16	20	6089	10.60	13.20	5070	6313	Group of rectangular features.								
16	20	6089	11.45	13.76	5476	6581	Rectangular scoops.								
16	20	6089	21.47	13.98	10268	6686	Curvilinear and rectilinear features.								
16	20	6089	19.51	13.56	9331	6485	Rectangular features.								
16	20	6089	21.51	17.47	10287	8355	Rectangular feature.								
16	20	6089	17.40	21.94	8322	10493	Group of rectangular features.								
16	20	6087	3.88	7.00	1856	3348	Group of rectangular features.								
16	20	6087	2.68	11.55	1282	5524	Rectangular features.								
16	20	6087	3.86	11.68	1846	5586	Rectangular features.								
16	20	6087	6.26	13.05	2994	6241	Unknown.								
16	20	6087	10.49	11.40	5017	5452	Rectangular features adjacent to modern farm.								
16	20	6087	11.19	19.50	5352	9326	Rectangular feature.								
16	20	6087	12.17	19.85	5820	9493	Circular feature.								
16	20	6087	19.08	18.76	9125	8972	Rectangular features.								
16	20	6087	20.74	19.25	9919	9207	Curvilinear features.								
16	20	6087	16.76	21.55	8016	10307	Rectangular features adjacent to modern farm.								
16	20	6085	4.92	3.29	2353	1573	Rectangular structures on high ground.	A			8565/1	856530	454388	364	
16	20	6085	22.52	5.15	10770	2463	Rectangular features adjacent to modern farm.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
16	20	6085	19.51	4.14	9331	1980	Irregular shaped scoops.								
16	20	6085	5.47	6.59	2616	3152	Line of rectangular features.								
16	20	6085	17.85	9.97	8537	4768	Rectangular features adjacent to modern farm.								
16	20	6085	10.78	11.71	5156	5600	Rectangular features adjacent to modern buildings.								
16	20	6085	10.06	9.49	4811	4539	Row of scattered scoops.								
16	20	6085	5.06	14.05	2420	6720	Two groups of rectangular features.								
16	20	6085	11.00	15.86	5261	7585	Scoop.								
16	20	6085	19.98	19.16	9556	9163	?Enclosure attached to modern track. Adjacent rectangular features.								
16	20	6085	17.15	17.07	8202	8164	Group of rectangular features.								
16	20	6085	11.43	19.40	5467	9278	Curvilinear enclosure.								
16	20	6085	2.95	18.19	1411	8700	Two curvilinear enclosures, separated by track.								
16	20	6085	10.64	21.63	5089	10345	Rectangular features adjacent to modern buildings.								
16	20	6083	1.29	1.51	617	722	Rectangular features following stream.								
16	20	6083	14.75	5.52	7054	2640	Spread of rectangular features.								
16	20	6083	8.04	9.71	3845	4644	Arc of embanked feature.								
16	20	6083	12.74	8.46	6093	4046	Rectangular features adjacent to buildings.								
16	20	6083	12.46	11.01	5959	5266	Two groups of rectangular features.								
16	20	6083	12.58	14.16	6017	6772	Rectangular feature.								
16	20	6083	14.03	14.85	6710	7102	Walled enclosure at intersection of tracks.								
16	20	6083	17.90	18.30	8561	8752	Rectangular features.								
16	20	6083	12.72	19.75	6083	9446	Rectangular features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
16	20	6079	4.02	13.51	1923	6461	Spread groups of rectangular features. Next to Archaeological Site 123.			Y	8569/1	856986	453701	363	362
16	20	6079	15.52	12.26	7423	5863	Probable quarries, separated by track.			Y	8571/1	857127	453606	362	361
16	20	6079	2.73	8.17	1306	3907	Rectangular features adjacent to modern buildings.								
16	20	6079	5.60	17.07	2678	8164	Spread of rectangular features.								
16	20	6077	14.35	6.79	6863	3247	Rectangular features adjacent to modern buildings.								
16	20	6075	12.13	4.68	5800	2240	Isolated mound. Possible settlement site. Archaeological Site 112.	A		Y	8575/1	857541	453368	361	356
16	20	6075	14.81	8.86	7083	4237	Small features, possibly with adjacent wall. Nearby sub-rectangular features.			Y	8575/2	857523	453293	361	355
16	20	6075	13.67	10.83	6538	5180	Rectangular features adjacent to trenches.								
16	20	6075	18.57	11.00	8881	5261	Rectangular features adjacent to modern buildings.								
16	20	6075	19.19	14.01	9178	6700	Two mound alignments.								
17	21	6046	14.32	8.94	6849	4276	Rectangular features.			Y	8575/3	857324	453362	361	356
17	21	6046	12.89	16.02	6165	7662	Group of rectangular features.								
17	21	6046	14.13	14.86	6758	7107	Rectangular features adjacent to trenches.								
17	21	6046	16.12	13.66	7710	6533	Group of rectangular features.								
17	21	6046	20.12	20.73	9623	9914	Unknown features adjacent to modern road.								
17	21	6046	18.34	19.41	8771	9283	Two mound alignments.								
17	21	6046	18.64	17.24	8915	8245	Rectangular features adjacent to modern building.								
17	21	6050	17.09	0.62	8173	297	Scatter of rectangular features.								
17	21	6050	10.74	6.73	5137	3219	Scatter of rectangular features, one cut by modern track.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
17	21	6050	3.75	4.41	1793	2109	Building. Site of.								
17	21	6050	20.14	12.92	9632	6179	Rectangular features.								
17	21	6050	22.07	11.30	10555	5404	Circular features.				8581/1			360	
17	21	6050	7.58	16.48	3625	7882	Rectangular features.								
17	21	6052	11.26	4.91	5385	2348	Group of rectangular features.				8582/1	858235	453178	360	
17	21	6052	9.69	5.51	4634	2635	Group of rectangular features adjacent to modern buildings.				8582/2	858211	453173	360	
17	21	6052	8.19	5.66	3917	2707	Group of rectangular features.								
17	21	6054	9.76	8.77	4668	4194	Group of rectangular features.				8584/1	858438	453058	360	
17	21	6054	15.96	8.92	7633	4266	Spread of rectangular features.			Y	8585/1	858537	453018	359	345
17	21	6054	21.38	9.76	10225	4668	Rectangular features.			Y	8586/1	858616	452990	359	344
17	21	6054	4.87	5.11	2329	2444	Mound row.								
17	21	6054	7.88	3.55	3769	1698	Group of rectangular features.								
17	21	6054	12.61	4.93	6031	2358	Group of rectangular features.								
17	21	6054	21.20	12.19	10139	5830	Scatter of rectangular and other features.								
17	21	6054	14.99	12.61	7169	6031	Rectangular features.								
17	21	6054	14.28	15.21	6830	7274	Rectangular features.								
17	21	6054	14.99	17.57	7169	8403	Rectangular features adjacent to modern building.								
17	21	6056	3.18	11.54	1521	5519	Rectangular walled enclosure.	A		Y	8585/2	858575	452972	359	344
17	21	6056	14.98	7.62	7162	3645	Cemetery. Archaeological Site.102.		C	Y	8587/1	858778	452959	359	342
17	21	6056	10.25	9.23	4901	4415	Probable cemetery.		C	Y	8586/2	858699	452960	359	343
17	21	6056	22.35	12.66	10688	6054	Cemetery.		C		8588/1	858855	452850	359	341
17	21	6056	6.64	7.96	3176	3807	Rectangular feature.			Y	8586/3	858660	452986	359	344
17	21	6056	21.87	4.54	10460	2171	Scatters of rectangular features and scoops.								
17	21	6056	8.49	5.64	4060	2697	Rectangular features adjacent to modern buildings. Recent.								
17	21	6056	6.74	7.08	3223	3386	Scoop.								
17	21	6056	4.95	15.31	2367	7322	Large embanked enclosure.								
17	21	6058	10.24	7.95	4897	3802	Embanked feature.			Y	8589/1	858958	452900	359	340
17	21	6058	15.46	11.45	7394	5476	Rectangular features.			Y	8590/1	859022	452828	359	339

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
17	21	6058	4.92	6.05	2353	2893	Scoop.								
17	21	6058	4.33	4.74	2071	2267	Area of rectangular features and scoops.								
17	21	6058	18.08	13.07	8647	6251	Rectangular features.								
17	21	6058	19.12	14.05	9144	6720	Circular enclosure.								
17	21	6058	11.88	14.52	5682	6944	Unknown.								
17	21	6058	8.41	15.31	4022	7322	Rectangular features. Recent.								
17	21	6058	8.43	18.14	4032	8676	Mound row. Possibly field clearance.								
17	21	6060	6.62	4.85	3166	2320	Rectangular features adjacent to modern farm								
17	21	6062	19.81	22.26	9476	10648	Cemetery.		C		8595/1	859543	452488	357	
17	21	6064	11.19	11.83	5350	5658	Cemetery.		C		8597/1	859717	452584	357	
17	21	6068	12.78	14.16	6110	6772	Cemetery.		C	Y	8602/1	860230	452370	356	326
17	21	6070	18.10	4.10	8657	1961	Unknown. Possibly erosion. Adjacent rectangular features.			Y	8606/2	860662	452432	356	321
17	21	6070	18.82	5.03	9001	2406	Unknown. Possibly erosion.			Y	8606/1	860645	452407	356	321
17	21	6072	11.08	21.37	5300	10222	Cemetery.		C			not	on map		
17	21	6073	15.79	11.66	7552	5577	Rectangular features adjacent to modern farm								
17	21	6073	15.90	13.34	7604	6380	Rectangular features.								
18	22	5567	17.39	11.59	8317	5543	Rectangular feature linked to track.			Y	8611/10	861102	452621	355	315
18	22	5567	17.61	11.74	8422	5615	Linear feature. Probably recent.			Y	8611/9	861150	452617	355	315
18	22	5567	15.53	11.89	7427	5687	Scoops and linear features.			Y	8611/8	861115	452612	355	316
18	22	5567	19.34	16.34	9250	7815	Rectangular feature.			Y	8611/5	861182	452570	354	315
18	22	5567	20.19	17.00	9656	8130	Rectangular feature.			Y	8612/1	861209	452557	354	316
18	22	5567	16.40	3.67	7843	1755	Rectangular structures near modern buildings.								
18	22	5567	14.62	2.48	6992	1186	Scatter of rectangular features.								
18	22	5567	14.38	2.92	6877	1397	Two parallel features, that appear to extend W of modern road. Probably recent.								

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18	22	5567	13.90	3.48	6648	1664	Two sides of what may be a rectilinear enclosure.								
18	22	5567	15.24	4.38	7289	2095	Disturbed area. Origin unknown.								
18	22	5567	13.38	6.92	6399	3310	Rectilinear feature.								
18	22	5567	15.04	7.39	7193	3534	Possible feature.								
18	22	5567	15.83	7.89	7571	3773	Scatter of rectangular features.								
18	22	5567	17.10	8.18	8178	3912	Line of rectangular and other features.								
18	22	5567	17.66	7.52	8446	3597	Scatter of rectangular features.								
18	22	5567	14.36	3.43	6868	1640	Small rectangular feature.								
18	22	5567	16.24	6.00	7767	2870	Scoops.								
18	22	5567	20.20	9.33	9661	4462	Group of rectangular and curvilinear features.								
18	22	5567	20.62	12.35	9862	5907	Rectangular feature.				8611/1			354	
18	22	5567	20.09	11.68	9608	5586	Rectangular feature.				8611/2			354	
18	22	5567	19.90	12.66	9517	6055	Rectangular feature.				8611/3			354	
18	22	5567	18.50	11.31	8848	5409	Rectangular feature linked to track.				8611/4			354	
18	22	5567	20.34	18.50	9728	8848	Rectangular feature.								
18	22	5567	18.38	16.98	8790	8121	Linear feature.								
18	22	5567	12.15	16.70	5811	7987	Rectangular feature.								
18	22	5567	12.51	17.80	5983	8513	Rectangular feature.								
18	22	5569	17.58	4.45	8408	2128	Walled enclosure.	A			X4	not	on map		
18	22	5569	3.29	15.90	1573	7604	Rectangular and linear features.			Y	8611/6	861175	452573	354	315
18	22	5569	9.92	22.45	4744	10737	Rectangular features.			Y	8613/1	861330	452512	354	313
18	22	5569	0.70	3.07	335	1468	Group of rectangular features.								
18	22	5569	6.14	0.99	2937	473	Rectangular feature.								
18	22	5569	11.00	3.30	5261	1578	Rectangular feature.								
18	22	5569	11.58	1.73	5538	827	Clusters of irregular features.								
18	22	5569	12.95	4.93	6193	2358	Unknown.								
18	22	5569	12.09	4.86	5782	2324	Rectangular enclosure with adjacent features.								
18	22	5569	11.05	4.94	5285	2363	Rectangular feature.								
18	22	5569	10.55	3.83	5046	1832	Linear feature								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
18	22	5569	7.37	3.53	3525	1688	Rectangular feature.								
18	22	5569	6.57	4.33	3142	2071	Group of rectangular features.								
18	22	5569	11.88	10.47	5682	5007	Rectangular features.								
18	22	5569	11.09	9.48	5304	4534	Rectangular feature.								
18	22	5569	11.66	8.48	5577	4056	Rectangular features.								
18	22	5569	10.27	8.68	4912	4151	Rectangular feature.								
18	22	5569	12.63	7.14	6040	3415	Rectangular feature.								
18	22	5569	13.23	6.98	6327	3338	Rectangular feature.								
18	22	5569	12.64	6.09	6045	2913	Irregular shaped features.								
18	22	5569	14.48	7.29	6925	3487	Rectangular features.								
18	22	5569	13.77	5.88	6586	2812	Rectangular feature.								
18	22	5569	16.82	5.40	8044	2583	Rectangular features.								
18	22	5569	19.82	6.72	9479	3214	Lines of rectangular features.								
18	22	5569	20.27	6.44	9694	3080	Lines of rectangular features.								
18	22	5569	20.42	7.14	9766	3415	Lines of rectangular features.								
18	22	5569	22.12	11.60	10579	5548	Lines of rectangular features.								
18	22	5569	18.98	11.95	9077	5715	Linear feature.								
18	22	5569	16.55	12.27	7915	5868	Group of rectangular and other features.								
18	22	5569	15.69	11.38	7504	5443	Group of rectangular features.								
18	22	5569	14.92	9.85	7136	4711	Surface activity, similar to forestry ploughing.								
18	22	5569	11.92	10.53	5701	5036	Group of rectangular features.								
18	22	5569	11.11	9.50	5313	4543	Rectangular features.								
18	22	5569	4.07	8.90	1947	4257	Scatter of rectangular features.								
18	22	5569	3.40	12.18	1626	5825	Group of rectangular features.				8611/7			354	
18	22	5569	11.41	13.19	5457	6308	Rectangular feature.								
18	22	5569	13.24	12.39	6332	5926	Group of rectangular features.								
18	22	5569	14.46	12.26	6916	5863	Rectangular feature.								
18	22	5569	17.95	12.93	8585	6184	Group of rectangular features.								
18	22	5569	16.55	14.93	7915	7140	Lines of rectangular features.								
18	22	5569	15.81	16.31	7561	7800	Lines of rectangular features.								
18	22	5569	17.37	15.32	8307	7327	Rectilinear embanked enclosure.								
18	22	5569	11.85	14.29	5667	6834	Scoops.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
18	22	5569	11.26	15.39	5385	7360	Rectangular feature.								
18	22	5569	16.11	19.35	7705	9254	Lines of rectangular features.								
18	22	5569	16.08	17.19	7690	8221	Rectangular structure.								
18	22	5569	16.67	18.20	7973	8704	Rectangular features and embankments.								
18	22	5569	15.53	19.91	7427	9522	Group of four small square features.								
18	22	5569	18.99	18.05	9082	8633	Possible rectangular features.								
18	22	5569	15.47	20.56	7399	9833	Lines of rectangular features.								
18	22	5569	14.98	21.67	7164	10364	Group of rectangular features.								
18	22	5569	11.05	22.20	5285	10617	Rectangular feature.								
19	23	6418	11.16	2.98	5337	1425	Rectangular feature.								
19	23	6418	11.00	0.87	5261	416	Group of rectangular features.								
19	23	6418	11.37	3.17	5438	1516	Linear feature.								
19	23	6418	13.63	2.06	6519	985	sub-rectangular feature.								
19	23	6418	14.20	2.00	6791	957	Rectangular feature.								
19	23	6418	14.90	1.85	7126	885	Rectangular feature.								
19	23	6418	14.41	2.87	6892	1373	Irregular shaped features.								
19	23	6418	13.73	2.58	6567	1234	Two small rectangular features.								
19	23	6418	16.28	2.19	7786	1047	Rectangular feature.								
19	23	6418	16.58	2.13	7930	1019	Rectangular feature.								
19	23	6418	17.11	0.85	8183	407	Rectangular feature.								
19	23	6418	21.59	3.22	10326	1540	Group of rectangular features.								
19	23	6418	20.53	3.40	9819	1626	Group of rectangular features.								
19	23	6418	20.46	4.11	9785	1966	Group of rectangular features.								
19	23	6418	20.41	5.06	9761	2420	Rectangular and linear features.								
19	23	6418	17.82	4.48	8523	2143	Possible curvilinear feature.								
19	23	6418	16.76	3.78	8016	1808	Rectangular feature.								
19	23	6418	15.73	5.06	7523	2420	Rectangular and linear features.								
19	23	6418	15.46	2.93	7394	1401	Rectangular feature.								
19	23	6418	15.21	3.50	7274	1674	Rectangular and linear features.								
19	23	6418	14.57	3.64	6968	1741	Rectangular feature.								
19	23	6418	6.41	4.97	3066	2377	Rectangular feature.								
19	23	6418	12.54	3.41	5997	1631	Rectangular feature.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
19	23	6418	12.16	4.53	5816	2167	Group of rectangular features.								
19	23	6418	12.83	4.36	6136	2085	Rectangular feature.								
19	23	6418	15.71	5.06	7513	2420	Rectangular and linear features.								
19	23	6418	17.55	6.06	8393	2898	Group of rectangular features.								
19	23	6418	16.18	6.09	7738	2913	Rectangular feature.								
19	23	6418	17.18	8.03	8217	3840	Group of rectangular and other features.								
19	23	6418	15.07	6.26	7207	2994	sub-rectangular feature.								
19	23	6418	15.36	6.49	7346	3104	Building. Site of.								
19	23	6418	9.20	5.50	4400	2630	Rectangular feature.								
19	23	6418	9.42	6.51	4505	3113	Group of rectangular and other features.								
19	23	6418	9.05	7.27	4328	3477	Group of rectangular features, crossed by modern track.								
19	23	6418	5.80	5.79	2774	2769	Possible, but unlikely enclosure.								
19	23	6418	1.36	6.52	650	3118	Rectangular feature.								
19	23	6418	4.20	8.06	2009	3855	Rectangular feature.								
19	23	6418	7.98	9.49	3817	4539	Rectangular feature.								
19	23	6418	11.57	11.28	5533	5395	Scatter of rectangular features.								
19	23	6418	10.18	11.13	4869	5323	Rectangular features.								
19	23	6418	10.27	10.65	4912	5093	Scoop.								
19	23	6418	9.99	12.72	4778	6083	Rectangular and linear features.								
19	23	6418	8.84	13.06	4228	6246	Rectangular and other features.								
19	23	6418	8.50	12.30	4065	5883	Scatter of rectangular features.								
19	23	6418	7.97	13.57	3812	6490	Scatter of rectangular features.								
19	23	6418	7.82	14.37	3740	6873	Group of rectangular features.								
19	23	6418	4.63	11.08	2214	5299	Rectangular features adjacent to modern building.								
19	23	6418	3.23	12.81	1545	6127	Possible rectangular enclosure.								
19	23	6418	7.82	14.38	3740	6877	Group of rectangular features.								
19	23	6418	8.03	13.56	3840	6485	Group of rectangular features.								
19	23	6416	8.51	12.90	4070	6170	Rectangular features adjacent to modern building.			Y	8613/2	861345	452518	354	313

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
19	23	6416	13.31	17.66	6366	8446	Group of rectangular features, crossed by modern track.			Y	8613/3	861373	452429	354	312
19	23	6416	14.29	17.56	6834	8398	Rectangular feature.			Y	8613/4	861389	452431	354	312
19	23	6416	15.47	0.46	7399	220	Rectangular features.								
19	23	6416	18.78	2.08	8982	995	Rectangular features.								
19	23	6416	11.21	11.74	5361	5615	Line of irregular features.								
19	23	6416	12.20	11.65	5835	5572	Group of rectangular features.								
19	23	6416	12.46	12.20	5959	5835	Linear features.								
19	23	6416	13.25	12.15	6337	5811	Rectangular feature.								
19	23	6416	9.57	18.13	4577	8671	Rectangular features.								
19	23	6416	10.41	17.98	4979	8599	Linear features.								
19	23	6416	9.86	17.38	4716	8312	Rectangular features.								
19	23	6416	11.11	18.19	5313	8700	Rectangular features.								
19	23	6416	11.90	18.28	5691	8743	Linear feature.								
19	23	6416	12.88	18.89	6160	9034	Rectangular feature.								
19	23	6416	21.03	18.23	10058	8719	Rectangular feature.								
19	23	6416	22.27	18.88	10651	9030	Rectangular features adjacent to modern building.								
19	23	6416	22.45	17.83	10737	8527	Building. Site of.								
19	23	6416	20.78	19.41	9938	9283	Modern disturbance, creating rectangular features.								
19	23	6416	10.53	19.64	5036	9393	Rectangular and linear features.								
19	23	6416	10.89	19.98	5208	9556	Rectangular feature.								
19	23	6416	12.41	20.21	5935	9666	Rectangular feature.								
19	23	6416	13.43	20.95	6423	10020	Rectangular feature.								
19	23	6416	13.90	20.31	6648	9713	Rectangular feature.								
19	23	6416	14.59	20.28	6978	9699	Rectangular feature.								
19	23	6414	21.47	5.69	10268	2721	Group of eroded rectangular features.				8618/1			353	
19	23	6414	9.00	6.89	4304	3295	Rectangular feature.								
19	23	6414	7.71	6.00	3687	2870	Rectangular and linear features, adjacent to track.								
19	23	6414	2.23	6.46	1067	3090	Rectangular features adjacent to modern building.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
19	23	6414	2.07	9.04	990	4323	Rectangular feature.								
19	23	6414	6.24	9.04	2984	4323	Scoop.								
19	23	6414	11.53	7.96	5514	3807	Rectangular feature.								
19	23	6414	9.09	9.99	4347	4778	Rectangular and linear features.								
19	23	6414	10.96	13.55	5242	6480	Linear spread of rectangular features.								
19	23	6414	1.29	14.23	617	6806	Linear spread of rectangular features.								
19	23	6414	7.00	16.06	3348	7681	Scatter of rectangular features.								
19	23	6414	9.35	17.65	4472	8441	Rectangular features.								
19	23	6414	8.66	18.41	4142	8805	Rectangular features.								
19	23	6414	2.69	18.16	1287	8685	Rectangular feature.								
19	23	6414	3.88	18.84	1856	9010	Rectangular features adjacent to modern building.								
19	23	6414	4.15	17.76	1985	8494	Building. Site of.								
19	23	6414	9.87	19.12	4720	9144	Rectangular features.								
19	23	6414	10.69	18.72	5113	8953	Rectangular features.								
19	23	6414	11.48	19.80	5490	9470	Rectangular features.								
19	23	6414	11.43	18.06	5467	8637	Group of rectangular features.								
19	23	6414	11.31	17.94	5409	8580	Rectangular features.								
19	23	6414	12.86	17.43	6150	8336	Rectangular features adjacent to modern building.								
19	23	6414	19.18	21.62	9173	10340	Rectangular features.								
19	23	6414	17.76	22.12	8494	10579	Rectangular features.								
19	23	6412	12.13	20.36	5801	9737	Walled rectangular features.	A			8618/4	861822	452121	353	
19	23	6412	10.88	6.38	5203	3051	Rectangular features adjacent to area of different land use.			Y	8618/2	861875	452340	353	305
19	23	6412	14.95	10.99	7150	5256	Group of rectangular features.			Y	8619/3	861937	452230	353	304
19	23	6412	13.46	11.08	6437	5299	Unknown disturbance.			Y	8619/4	861905	452255	353	304
19	23	6412	18.20	9.63	8704	4606	Rectangular features.			Y	8619/7	861980	452226	353	304
19	23	6412	18.93	10.66	9053	5098	Rectangular features.			Y	8619/8	861991	452208	353	304
19	23	6412	10.18	0.57	4869	273	Rectangular feature.								
19	23	6412	11.68	2.27	5586	1086	Rectangular feature.								
19	23	6412	13.16	3.36	6294	1607	Rectangular and linear features.								

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19	23	6412	13.87	3.90	6633	1865	Rectangular and linear features.								
19	23	6412	14.86	2.97	7107	1420	Rectangular and linear features.								
19	23	6412	15.04	2.15	7193	1028	Rectangular and linear features.								
19	23	6412	16.08	2.33	7690	1114	Rectangular features.								
19	23	6412	14.33	0.85	6853	407	Rectangular feature.								
19	23	6412	16.27	2.35	7781	1124	Circular and linear features.								
19	23	6412	17.32	1.72	8283	823	Spread of small rectangular features.								
19	23	6412	18.15	2.41	8680	1153	Circular feature.								
19	23	6412	17.87	3.79	8547	1813	Group of rectangular features.								
19	23	6412	19.18	3.61	9173	1727	Group of rectangular features.								
19	23	6412	20.39	3.39	9752	1621	Rectangular and linear features.								
19	23	6412	19.39	4.67	9273	2233	Spread of rectangular scoops, focused on track. Recent.								
19	23	6412	18.04	5.54	8628	2650	Group of rectangular features.								
19	23	6412	19.69	5.83	9417	2788	Linear features.								
19	23	6412	14.60	4.72	6983	2257	Group of rectangular features.								
19	23	6412	14.80	5.24	7078	2506	Linear series of small scoops, parallel to modern track. Line extends E and W of given co-ordinates.								
19	23	6412	14.29	6.82	6834	3262	Rectangular feature.				8619/1			353	
19	23	6412	12.72	6.81	6083	3257	Scoops.				8619/2			353	
19	23	6412	7.33	4.43	3506	2119	Rectangular feature.								
19	23	6412	17.03	7.82	8145	3740	Rectangular features.				8619/5			353	
19	23	6412	18.05	7.80	8633	3730	Rectangular features.								
19	23	6412	17.56	8.76	8398	4190	Rectangular features.				8619/6			353	
19	23	6412	20.10	8.00	9613	3826	Spread of rectangular scoops.								
19	23	6412	16.80	12.67	8035	6060	Rectangular features.				8619/9			353	
19	23	6412	16.51	11.67	7896	5581	Rectangular features.				8619/10			353	
19	23	6412	15.66	12.06	7490	5768	Group of rectangular features.				8619/11			353	
19	23	6412	15.13	11.13	7236	5323	Group of rectangular features.				8619/12			353	
19	23	6412	14.33	13.04	6853	6237	Rectangular feature.								
19	23	6412	13.72	11.94	6562	5710	Group of rectangular features.				8618/3			353	

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19	23	6412	6.73	16.60	3219	7939	Group of rectangular features.								
19	23	6412	15.03	14.24	7188	6810	Linear features and scoops adjacent to modern buildings.								
19	23	6412	16.61	14.37	7944	6873	Rectangular features.								
19	23	6412	16.38	16.54	7834	7910	Rectangular feature.								
19	23	6412	13.15	19.15	6289	9159	Rectangular feature.								
19	23	6412	7.32	19.93	3501	9532	Group of rectangular features.								
19	23	6412	5.83	19.75	2788	9446	Linear spread of rectangular features.								
19	23	6412	0.98	20.81	469	9953	Rectangular features.								
19	23	6412	0.98	21.83	469	10440	Rectangular features.								
19	23	6412	3.05	21.86	1459	10455	Rectangular and linear features.								
19	23	6412	3.70	21.02	1770	10053	Rectangular features.								
19	23	6412	4.86	21.82	2324	10436	Scoop.								
19	23	6412	6.13	20.43	2932	9771	Rectangular features.								
19	23	6412	10.65	20.55	5093	9828	Spread of rectangular features.								
19	23	6412	12.95	19.70	6193	9422	Line of small scoops.								
19	23	6410	14.67	6.45	7016	3085	Eroded scoops.								
19	23	6410	12.12	7.26	5797	3472	Rectangular features near modern buildings.								
19	23	6410	10.17	11.70	4864	5596	Eroded rectangular feature.								
19	23	6410	8.43	14.00	4032	6696	Pond.								
19	23	6408	15.97	18.89	7638	9034	Rectangular feature. Recent				8623/1			352	
19	23	6406	10.20	15.95	4878	7628	Multivallate enclosure.				8625/1			352	
19	23	6404	11.27	22.42	5390	10723	Possible cemetery.		C		8627/1	862730	451547	351	
19	23	6402	5.81	17.48	2779	8360	Group of small rectangular buildings. Village-like in plan, but about half size.								
19	23	6398	8.71	11.20	4166	5357	Row of scoops.			Y	8630/1	863012	451455	351	292
19	23	6398	11.10	12.77	5309	6107	Unknown. Circular area, possibly enclosed.			Y	8630/3	863040	451533	351	292
19	23	6398	8.80	12.58	4209	6017	Group of rectangular features.				8630/2			351	
19	23	6398	9.35	13.46	4472	6437	Irregular features								
19	23	6398	6.53	18.02	3123	8618	Group of rectangular features.								

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19	23	6398	5.50	18.79	2630	8987	Unknown. Small area defined by tracks. Includes quarrying.								
19	23	6398	8.43	17.39	4032	8317	Area of small mounds. Possibly loads from field clearance.								
19	24	6396	8.36	17.11	4000	8182	Cemetery.		C	Y	8635/1	863509	451227	349	286
19	24	6394	4.24	12.38	2030	5921	Probable cemetery.		C	Y	8636/2	863606	451025	349	283
19	24	6394	20.80	12.52	9949	5989	Cemetery.		C	Y	8636/1	863682	450782	348	281
19	24	6394	6.13	13.22	2932	6323	Group of rectangular features.								
19	24	6394	12.41	14.60	5935	6983	Rectangular features. Probably recent building.								
19	24	6392	21.60	14.52	10330	6944	Rectangular feature.			Y	8636/3	863695	450505	348	278
19	24	6392	22.73	4.65	10871	2224	Circular feature, avoided by modern agriculture.								
19	24	6392	18.07	12.07	8642	5773	Rectangular feature.								
19	24	6390	16.03	16.27	7667	7781	Unknown. Small area defined by tracks. Includes quarrying.			Y	8637/1	863732	450311	347	276
19	24	6390	8.03	6.03	3840	2884	Rectangular features. Recent.								
19	24	6390	7.77	5.96	3716	2850	Rectangular features.								
19	24	6390	7.63	6.63	3649	3171	Rectangular feature.								
19	24	6390	7.59	7.89	3630	3773	Rectangular features.								
19	24	6390	8.45	8.12	4041	3883	Possible walled features.								
19	24	6390	5.41	11.32	2587	5414	Rectangular feature.								
19	24	6390	8.80	10.91	4209	5218	Rectangular features.								
19	24	6390	8.47	11.56	4051	5529	Rectangular features.								
19	24	6390	9.42	10.71	4505	5122	Area of scoops. Probably recent.								
19	24	6390	9.71	11.13	4644	5323	Line of scoops.								
19	24	6390	9.50	11.62	4543	5557	Group of scoops.								
19	24	6390	10.15	10.74	4854	5137	Lines of scoops next to river.								
19	24	6390	9.87	10.30	4720	4926	Rectangular feature.								
19	24	6390	9.13	8.78	4367	4199	Rectangular feature. Probably under construction.								
19	24	6390	8.13	13.32	3888	6370	Rectangular feature adjacent to former building.								
19	24	6390	8.92	12.93	4266	6184	Scatter of scoops.								

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19	24	6390	10.13	12.45	4845	5954	Rectangular features adjacent to modern building.								
19	24	6390	8.28	14.39	3960	6882	Rectangular features.								
19	24	6390	8.08	22.00	3864	10522	Rectangular feature.								
19	24	6388	17.96	5.85	8590	2798	Area of rectangular and other features.								
19	24	6388	13.89	12.26	6643	5863	Rectangular feature adjacent to modern compound.								
19	24	6388	6.87	12.88	3286	6160	Area of disturbed ground.								
19	24	6388	7.14	14.00	3415	6696	Former irrigation channel. Now levelled.								
19	24	6387	10.83	1.35	5181	646	Cemetery.		C		8640/1	864093	450027	347	
19	24	6387	15.23	2.85	7284	1363	Rectangular embanked enclosure, cut by modern fence and road, with slighter enclosure at its S end.								
19	24	6387	15.77	9.21	7542	4405	Rectangular feature.								
19	24	6387	16.96	8.99	8111	4300	Group of rectangular features.								
19	24	6387	17.76	9.22	8494	4410	Rectangular features.								
19	24	6387	18.50	11.52	8848	5510	Rectangular feature.								
19	24	6387	17.42	10.95	8331	5237	Rectangular feature.								
19	24	6387	17.83	12.18	8527	5825	Group of rectangular features.								
19	24	6387	18.75	12.43	8967	5945	Group of rectangular features.								
19	24	6387	19.27	13.59	9216	6500	Group of rectangular features.								
19	24	6387	21.61	15.00	10335	7174	Oval feature.								
19	24	6387	20.06	18.85	9594	9015	Group of rectangular features.								
20	25	6386	17.46	22.05	8350	10546	Rectangular features.								
20	25	6384	13.46	10.49	6435	5015	Large area of possible cairns.	A			8640/2	864070	450150	347	272
20	25	6384	19.26	21.75	9211	10402	Large area of mostly curvilinear features on high ground. ?Ring cairns or natural.	A			8641/1	864150	449970	347	
20	25	6384	16.70	23.05	7987	11024	Rectangular features.								
20	25	6384	14.98	22.97	7164	10986	Group of rectangular features.								
20	25	6378	18.26	2.23	8733	1067	Group of rectangular features.								

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20	25	6372	14.03	23.00	6710	11000	Cemetery.		C		8657/1	865770	450100	344	
20	26	6367	20.88	18.16	9986	8685	Group of rectangular and other features.								
20	26	6365	4.99	19.77	2387	9455	Group of rectangular features.								
20	26	6365	4.61	20.44	2205	9776	Rectangular features.								
20	26	6365	4.57	21.46	2186	10263	Group of rectangular features.								
20	26	6363	6.83	20.87	3267	9981	Scatter of rectangular and other features near modern buildings.								
20	26	6361	19.24	0.61	9200	290	Cemetery.		C		8669/1	866907	450148	341	
20	26	6358	19.97	3.21	9550	1535	Possible cemetery.		C		8673/1	867311	450010	341	
21	27	6357	11.20	4.18	5357	1999	Linear and rectangular features.								
21	27	6353	15.36	12.05	7348	5762	Cemetery.		C		8674/1	867458	449989	341	
21	27	6349	17.74	12.75	8484	6098	Recently demolished buildings.								
21	27	6349	18.62	20.45	8905	9780	Circular feature.								
21	27	6347	13.96	8.71	6677	4166	Linear and rectangular features.								
21	27	6347	13.10	9.48	6265	4534	Group of rectangular features.								
21	27	6347	11.65	8.49	5572	4060	Rectangular feature.								
21	27	6347	12.34	8.42	5902	4027	Row of 'spots' crossed by modern boundary.								
21	27	6347	13.48	10.43	6447	4988	Rectangular embanked area, cut by modern road.								
21	27	6347	17.80	15.12	8513	7231	Rectangular feature.								
21	27	6347	16.37	13.95	7829	6672	Rectangular feature.								
21	27	6345	4.50	2.30	2150	1100	Cemetery, war memorial, Mig 17 (or 15)		C		8683/1	868350	449810	339	
21	27	6344	14.97	21.34	7160	10206	Rectangular features adjacent to modern buildings.								
34	28	6339	10.00	5.05	4783	2415	Rectangular features adjacent to modern buildings.			Y	8687/1	868780	449794	338	220
22	29	6331	17.92	4.42	8570	2114	D-shaped feature. Unknown origin.								
22	29	6331	18.42	13.23	8810	6327	Rectangular features adjacent to modern buildings.								
22	29	6329	7.63	9.84	3649	4706	Rectangular feature.			Y	8696/1	869607	449597	337	211

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22	29	6329	6.67	13.29	3190	6356	Rectangular features.								
22	29	6329	15.20	20.92	7270	10005	Rectangular feature adjacent to modern buildings.				8695/1			337	
22	29	6327	16.10	1.08	7700	517	Sub-rectangular feature. Possibly linked to old water course.								
22	29	6323	18.40	10.18	8800	4869	Cemetery.		C		8705/1	870520	449218	335	
22	30	6322	16.86	7.00	8065	3350	Cemetery.		C		8702/1	870200	449340	336	
22	30	6322	1.83	20.44	875	9776	Circular feature.			Y	8699/1	869928	449438	336	208
23	31	6312	16.12	2.78	7708	1329	Cemetery.		C		8713/1	871303	448698	333	
23	31	6312	3.21	13.86	1534	6629	Cemetery.		C		8710/1	871099	448555	333	
23	31	6312	10.08	10.26	4821	4907	Three sides of ditched feature, which is continued to the E as a hedged boundary. Recent.			Y	8706/1	870695	448652	334	195
23	31	6312	13.72	9.79	6562	4682	Rectangular cut holes. Recent.			Y	8707/1	870751	448659	334	195
23	31	6304	20.76	17.12	9929	8188	Square enclosure attached to boundary. Recent. Similar to 8717/1			Y	8718/1	871849	448419	332	183
23	31	6304	10.18	22.37	4869	10699	Scoops								
23	31	6304	15.07	22.36	7207	10694	Square enclosure, previously marked as archaeology, but possibly irrigation feature. Similar to 8718/1				8717/1			332	
23	31	6302	7.52	7.84	3597	3750	Rectangular features, filled with water, adjacent to modern farm. Recent.								
23	31	6300	5.52	19.36	2640	9259	Hexagonal enclosure, which appears to overlay rectangular features in its SW corner. Dyke cuts off NE triangle of enclosure, which has been used as a modern cemetery. Cemetery extends outside E side of hexagonal enclosure and it is now within larger boundary.		C		8721/1	872160	448320	331	

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
23	31	6300	12.46	16.60	5959	7939	Large rectangular feature.								
24	33	6274	4.80	3.22	2294	1541	Cemetery.		C		8730/1	873000	448685	330	
24	33	6272	19.30	5.33	9230	2549	Embanked enclosure with internal structures. Located at junction of two extinct rivers.	A			8735/1	873559	448418	328	
24	33	6270	3.32	6.86	1588	3281	Small rectangular features, probably walls. Recent.								
24	33	6270	11.19	14.00	5352	6696	Rectangular features within embanked field. Recent.								
24	33	6268	19.59	17.76	9369	8494	Embanked enclosure with internal structures. Probably cemetery.		C		8741/1	874108	447930	327	
24	33	6268	2.71	15.63	1296	7475	Disturbed rectangular area. Recent.								
24	33	6264	8.93	11.51	4271	5505	Possible unenclosed cemetery. Probably recent.		C		8745/1	874578	447824	327	
24	33	6262	8.73	3.17	4175	1516	Probable enclosed cemetery.		C		8749/1	874941	447843	326	
24	33	6262	14.25	3.02	6815	1444	Large embanked area.								
24	33	6260	3.50	4.94	1674	2363	Enclosed area with internal features. Probable recent farm.								
24	33	6260	10.66	15.14	5098	7241	Rectangular banked enclosure, cut by modern boundary.								
24	33	6260	16.96	15.49	8111	7408	Group of eroded scoops.								
24	33	6260	14.45	17.17	6911	8212	Areas of small irregular features. Possibly scoops, possibly natural.								
24	33	6260	11.55	19.95	5524	9541	Conjoined circular and square embanked enclosure, respected by modern track.								
24	33	6260	12.25	20.61	5859	9857	Large area of rectangular and other features, adjacent to modern structures.								
24	33	6258	17.73	7.18	8480	3434	Row of rectangular features, adjacent to modern structures.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
24	34	6277	21.04	3.44	10063	1645	Curvilinear feature next to modern track.								
24	34	6277	20.42	5.86	9766	2803	Rectangular features adjacent to modern buildings.								
24	34	6277	19.70	6.12	9422	2927	Group of rectangular features adjacent to modern building.								
24	34	6277	19.84	7.13	9489	3410	Group of rectangular features adjacent to modern building.								
24	34	6277	20.25	6.70	9685	3204	Scatter of rectangular features adjacent to modern building.								
24	34	6279	14.79	12.95	7073	6193	Large enclosed area of small enclosures and rectangular features. Also modern buildings.								
24	34	6279	16.49	19.47	7887	9312	Rectangular features.								
24	34	6281	18.82	5.23	9000	2500	Cemetery.		C		8766/1	876655	447230	323	
24	34	6285	14.76	12.95	7059	6193	Area of tracks and rectilinear features. Probably recent.								
24	34	6285	4.01	21.03	1918	10058	Enclosed area with internal features. Access via modern track.								
24	34	6287	22.44	5.78	10733	2765	Cemetery.		C		8776/1	877643	446844	321	
24	34	6288	11.76	17.89	5622	8558	Small area of 'ridge and furrow'.	A			8775/1	877543	446599	321	
24	34	6288	12.41	18.33	5935	8766	Curvilinear enclosure.	A			8775/2	877556	446595	321	
24	34	6288	13.04	19.82	6235	9478	Sub-rectangular enclosure.	A			8775/6	877556	446570	321	
24	34	6288	13.16	20.23	6294	9674	Curvilinear enclosure.	A			8775/7	877555	446561	321	
24	34	6288	14.65	17.30	7006	8272	Possible curvilinear enclosure.	A			8775/3	877596	446611	321	
24	34	6288	13.92	20.07	6657	9600	Rectangular enclosure with internal subdivision.	A			8775/8	877570	446565	321	
24	34	6288	11.10	21.20	5311	10140	Sub-rectangular enclosure.	A			8775/5	877521	446561	321	
24	34	6288	15.00	22.59	7175	10804	Multivallate curvilinear enclosure.	A			X5	not	on map		
24	34	6288	11.30	22.31	5404	10668	Curvilinear enclosure.	A			8775/4	877511	446537	321	
24	34	6288	12.30	19.77	5883	9455	Two sub-rectangular features adjacent to linear feature.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
24	34	6288	10.03	19.03	4798	9100	Sub-rectangular features with adjacent long features.								
24	34	6288	18.96	19.41	9070	9281	Part of curvilinear enclosure within area of 'ridge and furrow'.								
24	34	6288	14.79	21.12	7073	10101	Group of rectangular and other features, adjacent to modern buildings.								
24	34	6288	15.18	22.39	7142	10586	Rectangular enclosure, plus smaller features, adjacent to modern buildings.								
24	34	6289	18.88	20.85	9030	9972	Curvilinear enclosure.	A			8778/2	877813	446459	320	
24	34	6289	18.11	20.83	8661	9962	Curvilinear enclosure. Possibly superimposed on 'ridge and furrow'.	A			8778/1	877803	446465	320	
24	34	6289	17.50	20.82	8370	9957	Curvilinear enclosure.	A			8777/4	877793	446471	320	
24	34	6289	17.44	21.38	8341	10225	Curvilinear enclosure.	A			8777/5	877791	446459	320	
24	34	6289	18.81	21.78	8996	10417	Curvilinear enclosure.	A			8778/3	877812	446441	320	
24	34	6289	17.07	22.14	8164	10589	Curvilinear enclosure.	A			8777/7	877778	446449	320	
24	34	6289	17.63	22.00	8432	10522	Curvilinear enclosure.	A			8777/6	877793	446447	320	
24	34	6289	18.57	22.02	8881	10531	Sub-rectangular enclosure.	A			8778/4	877805	446441	320	
24	34	6289	19.09	22.82	9130	10914	Sub-rectangular enclosure.	A			8778/5	877808	446418	320	
24	34	6289	17.41	22.96	8327	10981	Sub-rectangular enclosure.	A			8777/8	877784	446432	320	
24	34	6289	10.65	20.70	5093	9900	Area of undated cultivation. Similar in appearance to ridge and furrow. Superimposed on or by enclosures (above).	A			X6	not	on map		
24	34	6289	9.82	21.37	4697	10220	Sub-rectangular enclosure.	A			X7	not	on map		
24	34	6289	11.55	20.76	5524	9929	Superimposed multivallate enclosures with adjacent enclosures.	A			X8	not	on map		
24	34	6289	12.72	21.86	6083	10455	Part of curvilinear enclosure.	A			X9	not	on map		
24	34	6289	13.07	22.16	6251	10598	Rectangular enclosure.	A				not	on map		
24	34	6289	10.80	21.60	5165	10330	Sub-rectangular enclosure.	A			X10	not	on map		
24	34	6289	10.89	22.51	5208	10766	Sub-rectangular enclosure.	A			X11	not	on map		

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
24	34	6289	9.88	22.15	4725	10593	Sub-rectangular enclosure.	A			X12	not	on map		
24	34	6289	10.36	21.76	4955	10407	Curvilinear enclosure.	A			X13	not	on map		
24	34	6289	10.09	22.89	4826	10947	Curvilinear enclosure.	A			X14	not	on map		
24	34	6289	10.76	21.25	5146	10163	Area of undated cultivation. Similar in appearance to ridge and furrow.	A			X15	not	on map		
24	34	6289	16.04	12.39	7671	5926	Curvilinear feature avoided by modern track.			Y	8777/1	877799	446620	321	118
24	34	6289	14.53	12.88	6949	6160	Scoops adjacent to modern track.			Y	8777/2	877780	446630	321	118
24	34	6289	12.94	12.88	6189	6160	Group of scoops and rectangular features, some superimposed.			Y	8777/3	877752	446638	321	119
24	34	6289	7.28	11.12	3482	5318	Rectangular feature adjacent to modern building.			Y	8776/5	877648	446696	321	120
24	34	6289	18.43	18.21	8814	8709	Complex feature and adjacent linear ditch. Unknown.								
24	34	6289	18.32	18.61	8762	8900	Curvilinear enclosure.								
24	34	6289	18.86	19.18	9020	9173	Rectangular and other features adjacent to modern buildings.								
24	34	6289	17.95	19.89	8585	9513	Scatter of small rectangular features.								
24	34	6289	17.03	21.87	8145	10460	Arc of what may be curvilinear enclosure.								
24	34	6289	19.67	21.99	9407	10517	Small rectangular enclosure with adjacent features.								
24	34	6289	12.65	18.81	6050	8996	Scatter of scoops adjacent to modern buildings. Possible 'ridge and furrow'.								
24	34	6289	11.80	18.77	5643	8977	Rectangular feature abutting modern building.								
24	34	6289	11.14	18.91	5328	9044	Pond.								
24	34	6289	12.08	19.90	5777	9517	Rectangular and other features adjacent to modern buildings.								
24	35	6257	18.41	9.49	8805	4539	Suspect features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
24	35	6253	15.89	11.06	7600	5290	Rectangular and linear features adjacent to modern buildings.								
24	35	6253	15.92	11.81	7614	5648	Rectangular features adjacent to modern buildings.								
24	35	6253	10.59	22.69	5065	10852	Rectangular features adjacent to modern buildings.								
24	35	6251	21.54	4.24	10303	2026	Cemetery.		C		8786/1	878603	446640	319	
24	35	6249	18.84	3.85	9010	1841	Rectangular features adjacent to modern buildings. Recent.								
24	35	6249	20.29	3.57	9704	1707	Rectangular earthwork feature abutting modern drain.								
24	35	6249	20.32	4.31	9718	2061	L-shaped feature abutting modern drain.								
24	35	6249	20.71	4.72	9905	2257	Clump of trees, possibly enclosed, but more likely bounded by modern drains.								
24	35	6249	7.93	8.86	3793	4237	Smiley face.								
24	35	6249	22.16	12.76	10598	6103	Circular features. Unknown, possibly fungus rings.								
24	35	6245	16.80	22.60	8035	10809	Group of rectangular features.								
25	36	6244	6.95	8.44	3324	4037	Rectangular enclosure, possibly cut by modern track.								
25	36	6240	17.64	15.38	8437	7356	Conjoined circular enclosures with central spot. Possibly burials.	A			8799/1	879954	446039	317	
25	36	6240	16.67	15.21	7973	7274	Circular enclosure with central spot. Possibly a burial.	A			8799/2	879934	446046	317	
25	36	6240	15.50	15.40	7413	7365	Circular feature with internal spot. Possibly burial.	A			8799/3	879915	446010	317	
25	36	6240	15.64	16.10	7480	7700	Circular feature with internal spot. Possibly burial.	A			8799/4	879903	446031	317	
25	36	6240	15.87	15.97	7590	7638	Circular feature with internal spot. Possibly burial.	A			8799/5	879907	446037	317	
25	36	6240	6.87	12.52	3286	5988	Two conjoined square features.				8797/1			317	

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	36	6240	17.90	16.30	8561	7796	Hundreds of small sub-rectangular features in large area, which is also crossed by linear ditches, possibly parts of a field system. Superimposed within this system are other enclosures of distinctive shapes, which are listed individually below. The single modern field, that these features were in is cut by at least one recent, but now levelled, drain.								
25	36	6240	18.68	14.75	8934	7054	Linear ditches, possibly part of field system.								
25	36	6240	18.76	14.95	8972	7150	Curvilinear enclosure.								
25	36	6240	17.56	15.30	8398	7317	Sub-rectangular enclosure.								
25	36	6240	17.44	15.39	8341	7360	Sub-square enclosure.								
25	36	6240	17.58	15.84	8408	7576	Curvilinear enclosure.								
25	36	6240	17.05	15.48	8154	7403	Curvilinear enclosure.								
25	36	6240	16.72	16.43	7997	7858	Bivallate curvilinear enclosure, superimposed on or by linear feature.								
25	36	6240	16.97	16.88	8116	8073	Trapezoid enclosure.								
25	36	6240	17.78	16.23	8503	7762	Bivallate curvilinear enclosure, abutting linear feature.								
25	36	6240	18.13	16.16	8671	7729	Bivallate curvilinear enclosure, abutting linear feature.								
25	36	6240	17.78	16.40	8503	7843	Square enclosure, abutting linear feature.								
25	36	6240	18.81	16.84	8996	8054	Sub-rectangular enclosure.								
25	36	6240	18.61	16.76	8900	8016	Sub-rectangular enclosure.								
25	36	6240	18.45	16.76	8824	8016	Sub-rectangular enclosure.								
25	36	6240	18.63	16.71	8910	7992	C-shaped feature.								
25	36	6240	16.95	17.23	8107	8240	Multivallate curvilinear enclosure.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	36	6240	14.33	17.38	6853	8312	Bivallate curvilinear enclosure.								
25	36	6240	13.67	16.87	6538	8068	Circular feature.								
25	36	6240	13.58	17.60	6495	8417	Possible curvilinear enclosure.								
25	36	6240	15.95	16.71	7628	7992	Large rectangular area with partial 'fringe' of radially spread long rectangular features.								
25	36	6240	17.58	0.26	8408	124	Group of small sub-rectangular features.								
25	36	6240	18.94	1.78	9058	851	Group of very eroded small sub-rectangular features.								
25	36	6240	19.02	2.89	9097	1382	Group of small sub-rectangular features.								
25	36	6240	20.32	3.15	9718	1507	Group of small sub-rectangular features.								
25	36	6240	22.27	18.37	10651	8786	Group of small possible enclosures in farmyard.								
25	36	6238	8.38	3.57	4008	1707	Group of small sub-rectangular features.								
25	36	6238	9.18	4.69	4390	2243	Row of rectangular features.								
25	36	6238	10.78	4.95	5156	2367	sub-rectangular enclosure with radial 'fringe' of rectangular features.					880187	446161		
25	36	6238	11.81	5.28	5648	2525	Sub-rectangular enclosure with adjacent row of rectangular features.								
25	36	6238	18.78	4.83	8982	2310	Bivallate curvilinear enclosure cut by modern track.								
25	36	6238	12.29	5.55	5878	2654	Curvilinear enclosure.								
25	36	6238	10.44	6.49	4993	3104	Unknown, possibly natural.								
25	36	6238	14.36	15.20	6868	7270	Eroded scoops.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6238	20.41	16.08	9761	7690	Group of small sub-rectangular features with adjacent row of rectangular features. Slight traces of sub-rectangular features to the N, E and W.								
25	36	6238	22.13	17.99	10584	8604	Rows of rectangular and square features.								
25	36	6238	21.06	17.71	10072	8470	Possible group of rectangular features.								
25	36	6238	11.50	18.93	5500	9053	Rectangular features adjacent to modern buildings.								
25	36	6238	12.91	20.27	6174	9694	Bivallate curvilinear enclosure with radial 'fringe' of sub-rectangular features. Adjacent sub-rectangular enclosure.								
25	36	6238	11.70	20.07	5596	9599	Curvilinear enclosure with radial 'fringe' of sub-rectangular features. Adjacent sub-rectangular enclosure. Long rectangular features nearby may remain from recent buildings.								
25	36	6238	13.31	20.33	6366	9723	Sub-rectangular enclosure.								
25	36	6238	13.22	20.85	6323	9972	Sub-rectangular enclosure.								
25	36	6238	10.85	22.93	5189	10967	Sub-rectangular enclosure.								
25	36	6238	13.76	19.20	6581	9183	Curvilinear feature.								
25	36	6238	14.18	19.05	6782	9111	Curvilinear feature.								
25	36	6238	14.85	19.10	7102	9135	sub-rectangular enclosure.								
25	36	6238	18.53	19.99	8862	9560	Cluster of curvilinear and sub-rectangular features. Part superimposed on palaeochannel.								
25	36	6238	18.60	14.92	8896	7134	Embanked rectilinear enclosure with rounded corners. Built over on N site.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6238	20.79	16.18	9944	7737	Large area of sub-rectangular features.								
25	36	6236	13.94	2.70	6667	1291	Several rectangular features.								
25	36	6236	21.27	5.35	10173	2559	Possible curvilinear enclosure.								
25	36	6236	20.89	5.06	9991	2420	Possible curvilinear enclosure.								
25	36	6236	18.84	5.69	9010	2721	Trapezoid enclosure and adjacent small rectangular features.								
25	36	6236	17.53	5.59	8384	2673	Curvilinear feature, cut by modern track.								
25	36	6236	18.89	4.72	9034	2257	Spread of sub-rectangular enclosures.								
25	36	6236	18.36	4.99	8781	2387	Rectangular features adjacent to modern building.								
25	36	6236	17.55	5.19	8393	2482	Small group of sub-rectangular features.								
25	36	6236	17.56	6.39	8398	3056	Small group of sub-rectangular features.								
25	36	6236	21.55	13.13	10307	6280	Group of curvilinear features, some superimposed on paleochannels.								
25	36	6236	22.82	13.78	10914	6590	Conjoined rectangular and curvilinear enclosures.								
25	36	6236	21.65	15.26	10354	7298	Conjoined curvilinear enclosures with adjacent smaller features and arrangement of rectangular features, all of which appear to make one large 'enclosure.								
25	36	6236	21.52	14.71	10292	7035	Curvilinear enclosure.								
25	36	6236	22.93	15.00	10967	7174	Curvilinear enclosure.								
25	36	6236	21.80	14.71	10426	7035	Bivallate curvilinear enclosure.								
25	36	6236	22.26	14.51	10646	6940	sub-rectangular enclosure.								
25	36	6236	20.64	16.89	9871	8078	Cluster of rectangular features.								
25	36	6236	18.12	19.28	8666	9221	Line of sub-rectangular features.								
25	36	6236	19.48	18.38	9317	8790	Group of curvilinear features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6236	19.56	18.88	9355	9030	Group of curvilinear features.								
25	36	6236	18.87	19.04	9025	9106	Curvilinear features.								
25	36	6236	18.95	18.28	9063	8743	Rectangular features adjacent to modern buildings.								
25	36	6236	7.51	18.93	3592	9053	Sub-square enclosure with radial 'fringe' of sub-rectangular features.								
25	36	6236	7.36	19.57	3520	9360	Curvilinear and sub-rectangular enclosure with adjacent rows of rectangular features.								
25	36	6236	6.75	18.96	3228	9068	Spread of rectangular and sub-rectangular features.								
25	36	6236	8.90	20.21	4257	9666	Group of sub-rectangular features.								
25	36	6236	20.33	21.58	9723	10321	Sub-rectangular enclosures.								
25	36	6234	17.82	10.65	8523	5093	Sub-rectangular features, partly superimposed by modern track.			Y	8809/1	880915	445758	315	84
25	36	6234	9.67	12.63	4625	6040	Possible circular and square features.			Y	8807/1	880750	445786	315	86
25	36	6234	7.60	12.56	3635	6007	Possible circular and square features.			Y	8807/2	880708	445804	315	86
25	36	6234	8.59	13.38	4108	6399	Group of sub-rectangular features, cut by modern railway.			Y	8807/3	880721	445784	315	86
25	36	6234	10.97	0.80	5247	383	Sub-rectangular enclosures.								
25	36	6234	13.27	3.52	6347	1683	Possible sub-rectangular features.								
25	36	6234	13.51	1.57	6461	751	Rectangular enclosure abutting palaeochannel.								
25	36	6234	10.43	5.64	4988	2697	Curvilinear enclosure with adjacent row of sub-rectangular features.								
25	36	6234	9.73	5.64	4653	2697	Curvilinear enclosure with adjacent row of sub-rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6234	6.96	5.75	3329	2750	Curvilinear enclosure with adjacent row of sub-rectangular features.								
25	36	6234	6.80	5.42	3252	2592	Curvilinear enclosure with adjacent row of sub-rectangular features.								
25	36	6234	6.67	5.89	3190	2817	Group of sub-rectangular enclosures.								
25	36	6234	5.30	5.96	2535	2850	Spread of sub-rectangular enclosures.								
25	36	6234	11.07	15.51	5294	7418	Rectangular features.								
25	36	6234	10.02	15.05	4792	7198	Row of three sub-rectangular features.								
25	36	6234	9.60	14.02	4591	6705	Group of sub-rectangular features.								
25	36	6234	6.70	16.00	3204	7652	Rectangular features.								
25	36	6234	6.96	15.19	3329	7265	Sub-rectangular feature.								
25	36	6234	6.76	15.02	3233	7183	?Pits.								
25	36	6234	8.13	15.83	3888	7571	Circular feature.								
25	36	6234	7.86	16.06	3759	7681	Rectangular feature.								
25	36	6234	8.39	18.27	4013	8738	Sub-rectangular enclosures adjacent to paleochannels.								
25	36	6234	8.59	18.72	4108	8953	Sub-rectangular enclosures adjacent to paleochannels.								
25	36	6234	7.92	19.66	3788	9403	Part of possible enclosure.								
25	36	6234	8.64	20.17	4132	9647	Sub-rectangular enclosure.								
25	36	6234	10.49	20.18	5017	9651	Circular feature.								
25	36	6234	10.91	19.77	5218	9455	Straggle of sub-rectangular features.								
25	36	6234	10.34	19.78	4945	9460	Rectangular enclosures.								
25	36	6234	10.01	19.88	4787	9508	Sub-rectangular enclosure.								
25	36	6234	11.55	20.38	5524	9747	Rows and scatter of sub-rectangular features.								
25	36	6234	11.63	19.48	5562	9317	Rectangular enclosure.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6234	12.16	19.32	5816	9240	Rectangular enclosure.								
25	36	6234	12.27	19.61	5868	9379	Two conjoined circular enclosures.								
25	36	6234	11.84	19.05	5663	9111	Rows of sub-rectangular features, including 'paw print'.								
25	36	6234	13.78	19.65	6590	9398	Circular features.								
25	36	6234	15.00	17.71	7174	8470	Circular feature.								
25	36	6234	17.35	21.86	8298	10455	Scatter of sub-rectangular features.								
25	36	6232	20.33	8.90	9723	4257	Sub-rectangular features.			Y	8812/2	881274	445678	314	81
25	36	6232	19.16	8.66	9163	4142	Sub-rectangular features.			Y	8812/1	881248	445687	314	81
25	36	6232	8.35	1.25	3993	598	Group of rectangular and sub-rectangular features.								
25	36	6232	9.77	0.73	4673	349	Scatter of sub-rectangular features.								
25	36	6232	6.33	0.68	3027	325	Sub-rectangular enclosure superimposed by modern track.								
25	36	6232	10.28	0.94	4917	450	Scatter of sub-rectangular features.								
25	36	6232	11.82	0.33	5653	158	Sub-rectangular enclosures hiding under fiducial mark.								
25	36	6232	11.89	1.84	5687	880	Scatter of sub-rectangular features.								
25	36	6232	13.75	1.66	6576	794	Scatter of sub-rectangular features.								
25	36	6232	13.65	2.42	6528	1157	Scatter of sub-rectangular features.								
25	36	6232	14.49	2.90	6930	1387	Group of sub-rectangular features with adjacent rectangular features.								
25	36	6232	12.64	3.09	6045	1478	Scatter of sub-rectangular features with square enclosure superimposed.								
25	36	6232	7.02	1.43	3357	684	Enclosure', probably recent.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6232	7.64	1.20	3654	574	Enclosure', probably recent.								
25	36	6232	9.11	2.22	4357	1062	Enclosure', probably recent.								
25	36	6232	13.02	2.09	6227	1000	Enclosure', probably recent.								
25	36	6232	15.11	3.82	7227	1827	Enclosure', probably recent.								
25	36	6232	15.57	2.16	7447	1033	Scatter of sub-rectangular features.								
25	36	6232	16.13	4.12	7714	1970	Group of sub-rectangular features.								
25	36	6232	17.33	3.58	8288	1712	Group of sub-rectangular features.								
25	36	6232	18.15	0.80	8680	383	Row of sub-rectangular features.								
25	36	6232	20.48	2.02	9795	966	Group of rectangular and sub-rectangular features.								
25	36	6232	20.79	0.75	9943	359	Circular area of ?cairns.								
25	36	6232	21.95	2.01	10498	961	Scatter of sub-rectangular features.								
25	36	6232	21.77	1.39	10412	665	Two curvilinear enclosures with row of rectangular features between them.								
25	36	6232	19.70	2.95	9422	1411	Scatter of sub-rectangular features.								
25	36	6232	11.20	6.35	5357	3037	Two adjacent group of rectangular features.								
25	36	6232	11.50	5.13	5500	2453	Unknown, part cut by modern track.								
25	36	6232	13.55	4.71	6480	2253	Group of rectangular enclosures.								
25	36	6232	17.40	5.00	8322	2391	Group of near-square features, adjacent to modern building.								
25	36	6232	18.28	5.49	8743	2626	Groups of rectangular and near-square features plus larger enclosure.								
25	36	6232	20.00	5.00	9565	2391	Group of near-square features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	36	6232	18.41	7.53	8805	3601	Groups of rectangular and near-square features plus larger enclosures.								
25	36	6232	22.42	4.58	10723	2190	Group of near-square features.								
25	36	6232	22.17	6.35	10603	3037	Group of near-square features.								
25	36	6232	22.31	9.23	10670	4414	Large scatter of near-square enclosures.								
25	36	6232	21.42	8.16	10244	3903	Group of sub-rectangular features.								
25	36	6232	19.86	8.09	9498	3869	Group of sub-rectangular features.								
25	36	6232	14.63	8.17	6997	3907	Rectangular features and enclosures.								
25	36	6232	19.56	13.16	9355	6294	Unknown, part cut by modern track.								
25	36	6232	20.19	13.33	9656	6375	Sub-rectangular enclosure.								
25	36	6232	20.92	13.81	10005	6605	Sub-rectangular enclosure.								
25	36	6232	19.60	15.99	9374	7647	Group of sub-rectangular features.								
25	36	6232	8.17	18.39	3907	8795	Group of sub-rectangular features.								
25	36	6232	16.60	18.46	7939	8829	Oval enclosure, cut by modern track.								
25	36	6230	20.54	6.35	9823	3037	Extensive spread of groups of sub-rectangular features.			Y	8815/1	881590	445570	314	77
25	36	6230	12.97	6.33	6203	3027	Irregular enclosure.			Y	8814/1	881459	445630	314	79
25	36	6230	11.73	6.68	5610	3195	Rectangular enclosures.			Y	8814/2	881435	445635	314	79
25	36	6230	10.24	6.40	4897	3061	Sub-rectangular enclosures and ?stones.			Y	8814/3	881400	445645	314	79
25	36	6230	4.20	7.10	2009	3396	Sub-rectangular features.			Y	8813/1	881300	445679	314	80
25	36	6230	4.79	7.90	2291	3778	Group of sub-rectangular features.			Y	8813/2	881300	445663	314	80
25	36	6230	5.59	8.80	2673	4209	Group of sub-rectangular features with adjacent enclosure.			Y	8813/3	881310	445636	314	80

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	36	6230			4514	3760	Rectangular enclosure cut by WREP pipeline.			Y	8813/5	881384	445630	314	79
25	36	6230	9.58	8.57	4582	4099	Group of sub-rectangular features crossed by modern tracks.			Y	8813/4	881380	445620	314	79
25	36	6230	3.01	1.70	1440	813	Scatter of sub-rectangular features.								
25	36	6230	2.87	3.82	1373	1827	Group of sub-rectangular features.								
25	36	6230	3.60	0.60	1722	287	Group of sub-rectangular features.								
25	36	6230	5.13	0.57	2453	273	Group of sub-rectangular features.								
25	36	6230	5.77	3.37	2760	1612	Scatter of sub-rectangular features.								
25	36	6230	6.35	1.27	3037	607	Group of sub-rectangular features.								
25	36	6230	6.97	2.98	3333	1425	Curvilinear enclosure.								
25	36	6230	8.16	3.13	3903	1497	Groups of rectangular and near-square features.								
25	36	6230	9.78	4.00	4677	1913	Scatter of sub-rectangular features.								
25	36	6230	10.94	3.26	5232	1559	Group of rectangular features.								
25	36	6230	10.97	2.35	5247	1124	Sub-rectangular features and adjacent enclosures.								
25	36	6230	8.21	1.70	3927	813	?Collection of stones.								
25	36	6230	12.29	1.36	5878	650	Rectangular features.								
25	36	6230	13.02	3.18	6227	1521	Irregular enclosure.								
25	36	6230	13.07	1.76	6251	842	Irregular enclosure.								
25	36	6230	13.38	0.99	6399	473	sub-rectangular features with adjacent enclosures.								
25	36	6230	14.56	1.10	6963	526	Line of sub-rectangular features with adjacent enclosures.								
25	36	6230	13.50	6.24	6457	2984	Rectangular enclosures.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6230	9.70	4.00	4639	1913	Group of sub-rectangular features.								
25	36	6230	6.89	6.27	3295	2999	Group of sub-rectangular features.								
25	36	6230	6.11	5.04	2922	2410	Rectangular enclosure								
25	36	6230	5.08	5.20	2430	2487	Group of sub-rectangular features.								
25	36	6230	5.82	4.17	2783	1994	Sub-rectangular enclosure.								
25	36	6230	6.94	10.25	3319	4902	Sub-rectangular enclosure.								
25	36	6230	10.91	9.43	5218	4510	Group of sub-rectangular features crossed by modern tracks.								
25	36	6230	15.68	8.44	7499	4037	Rows of 'spots' with adjacent linear features.								
25	36	6230	18.28	9.32	8743	4457	Large rectangular enclosure with track leading into it.								
25	36	6230	21.72	10.97	10388	5247	Group of rectangular features adjacent to modern building.								
25	36	6230	20.31	11.57	9713	5533	Circular enclosure.								
25	36	6230	20.27	12.58	9694	6017	Circular enclosure.								
25	36	6230	20.23	13.23	9675	6327	Circular enclosure.								
25	36	6230	9.65	12.23	4615	5849	Scatter of sub-rectangular features.								
25	36	6230	8.28	10.80	3960	5165	Group of sub-rectangular features adjacent to modern building.								
25	36	6230	5.95	11.41	2846	5457	Group of sub-rectangular features.								
25	36	6230	5.68	10.38	2717	4964	Lines of sub-rectangular features.								
25	36	6230	21.00	17.93	10043	8575	Scoops surrounding area of uniform tone, possibly a former pond.								
25	36	6228	16.23	6.26	7762	2994	Spread of curvilinear enclosures. Look more eroded, possibly older, than others.	A			8818/1	881850	445484	313	

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6228	11.17	8.05	5342	3850	Rectangular enclosure with attached sub-rectangular feature.	A			8817/1	881732	445500	313	
25	36	6228	5.38	14.21	2573	6796	Cemetery with surrounding curvilinear features.		C		8815/2	881590	445435	314	
25	36	6228	6.69	10.78	3200	5156	Arc of conjoined rectangular features.			Y	8816/1	881638	445487	314	76
25	36	6228	7.17	11.08	3429	5299	Rectangular feature within circular enclosure.			Y	8816/2	881641	445480	314	76
25	36	6228	8.05	11.52	3850	5510	Rectangular feature within circular enclosure.			Y	8816/3	881656	445465	314	76
25	36	6228	9.70	10.07	4639	4816	Row of sub-circular features.			Y	8816/4	881699	445480	314	76
25	36	6228	8.32	9.09	3979	4347	Sub-rectangular features.			Y	8816/5	881672	445505	314	76
25	36	6228	12.99	3.19	6213	1526	?Collection of stones.								
25	36	6228	17.93	2.72	8575	1301	Lines of sub-rectangular features with adjacent 'eyebrows'.								
25	36	6228	18.47	2.03	8833	971	Irregular features.								
25	36	6228	18.74	2.55	8963	1220	Curvilinear enclosure.								
25	36	6228	18.87	3.27	9025	1564	Curvilinear enclosure.								
25	36	6228	5.94	11.35	2841	5428	Group of rectangular and other features.								
25	36	6228	7.15	11.68	3420	5586	Rectangular and other features.								
25	36	6228	9.74	8.14	4658	3893	Sub-rectangular features.								
25	36	6228	10.64	8.41	5089	4022	Irregular enclosure.								
25	36	6228	12.42	8.56	5940	4094	Row of small sub-rectangular features.								
25	36	6228	16.89	8.62	8078	4123	?Enclosure attached to modern track. Adjacent sub-rectangular features, including 'paw print'.								
25	36	6228	19.75	16.00	9446	7652	Very large group of densely packed sub-rectangular features with enclosures. Surrounding scatter of wider spaced features.								
25	36	6228	15.44	17.33	7384	8288	Rows of 'spots' with adjacent linear features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6228	14.65	15.06	7007	7203	Large group of small sub-rectangular features with adjacent larger features including 'paw print'								
25	36	6228	12.69	15.76	6069	7537	Group of sub-rectangular features.								
25	36	6228	12.24	14.42	5854	6897	Group of sub-rectangular features.								
25	36	6228	10.55	14.60	5046	6983	Square enclosure with scatter of curvilinear features.								
25	36	6228	8.95	16.48	4280	7882	Wide -spaced rows of sub-rectangular features, apparently within trapezoid enclosure.								
25	36	6228	8.19	12.56	3917	6007	Rectangular feature within circular enclosure.								
25	36	6228	7.12	12.13	3405	5801	Rectangular feature within circular enclosure.								
25	36	6228	7.55	12.42	3611	5940	Keyhole'-shaped feature.								
25	36	6228	5.96	12.54	2850	5997	Conjoined curvilinear features.								
25	36	6228	4.61	16.02	2205	7662	Sub-circular area, possibly old pond.								
25	36	6228	5.19	16.85	2482	8059	Linear feature.								
25	36	6228	8.08	18.77	3864	8977	Sub-circular area, possibly old pond.								
25	36	6228	7.59	18.19	3630	8700	Group of sub-rectangular features.								
25	36	6228	11.80	18.33	5643	8767	Circular feature.								
25	36	6228	15.46	17.33	7394	8288	Rows of 'spots' with adjacent linear features.								
25	36	6228	15.66	18.05	7490	8633	Group of sub-rectangular features.								
25	36	6228	14.38	18.06	6877	8637	Scatter of sub-rectangular features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	36	6228	19.08	17.92	9125	8570	Sub-circular area, possibly old pond.								
25	36	6228	20.76	18.00	9929	8609	Sub-circular area, possibly old pond.								
25	36	6228	21.53	18.26	10297	8733	Sub-circular area, possibly old pond.								
25	36	6228	20.77	18.51	9933	8853	Group of sub-rectangular features.								
25	36	6228	21.82	17.80	10436	8513	Scatter of sub-rectangular features.								
25	36	6228	15.68	19.47	7499	9312	Row of 'spots' with adjacent linear features.								
25	36	6228	11.90	20.12	5691	9623	?Collection of stones.								
25	36	6228	9.08	21.83	4343	10440	Rectangular feature, crossed by track.								
25	36	6228	10.81	22.02	5170	10531	Arcs of conjoined circular features.								
25	36	6228	12.34	22.58	5902	10799	sub-rectangular enclosure.								
25	36	6228	13.36	22.67	6390	10842	sub-rectangular enclosures.								
25	36	6226	8.37	12.43	4003	5945	Thin rectangular feature.			Y	8819/1	881946	445310	313	73
25	36	6226	7.89	12.51	3773	5983	Sub-rectangular feature.			Y	8819/2	881938	445310	313	73
25	36	6226	7.12	12.28	3405	5873	Curvilinear feature.			Y	8819/3	881925	445319	313	73
25	36	6226	13.63	13.96	6519	6677	Curvilinear feature.			Y	8820/1	882031	445249	313	73
25	36	6226	18.22	0.30	8714	143	Unknown.								
25	36	6226	19.74	0.34	9441	163	Unknown.								
25	36	6226	16.06	13.13	7681	6280	Unknown.								
25	36	6226	12.81	15.09	6127	7217	Sub-circular area, possibly old pond.								
25	36	6226	9.89	17.64	4730	8437	Group of rectangular features within curvilinear enclosure.								
25	36	6226	8.83	17.05	4223	8154	Curvilinear enclosure superimpose on or by track.								
25	36	6226	7.25	16.61	3467	7944	Sub-rectangular features adjacent to modern building.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	36	6226	9.03	19.02	4319	9097	Rectangular features.								
25	37	6222	21.72	14.34	10388	6858	Linear feature with adjacent 'dashes' and 'dots'.			Y	8822/1	882295	445051	312	68
25	37	6222	20.63	7.02	9867	3357	Possible eroded sub-rectangular features.								
25	37	6222	19.77	13.39	9455	6404	Wiggly linear feature.								
25	37	6222	10.58	15.89	5060	7600	?U-shaped bank, avoided by modern tracks.								
25	37	6222	5.93	15.63	2836	7475	Circular feature.								
25	37	6222	5.34	16.23	2554	7762	Circular feature.								
25	37	6220	14.74	14.01	7050	6700	Rectangular enclosure with adjacent features.			Y	8824/1	882442	444963	312	67
25	37	6220	20.58	4.31	9843	2061	Curvilinear feature.								
25	37	6220	19.78	7.00	9460	3348	Possible collection of stones.								
25	37	6220	11.18	5.34	5347	2554	Curvilinear feature.								
25	37	6220	8.74	4.42	4180	2114	Curvilinear feature.								
25	37	6220	11.51	7.39	5505	3534	Scatter of sub-rectangular features with square enclosure.								
25	37	6220	12.35	7.47	5907	3573	Curvilinear enclosure crossed by track.								
25	37	6220	14.00	10.70	6696	5117	Scatter of small features, adjacent to modern building.								
25	37	6220	17.82	8.97	8523	4290	Group of sub-rectangular features.								
25	37	6220	20.77	8.82	9933	4218	Wiggly linear features.								
25	37	6220	17.53	11.59	8384	5543	Curvilinear features, much eroded.								
25	37	6220	12.89	11.94	6165	5710	Circular feature.								
25	37	6220	11.95	12.52	5715	5988	Circular features.								
25	37	6220	11.62	15.67	5557	7494	Scatter of sub-rectangular features.								
25	37	6220	11.15	17.43	5333	8336	Sub-rectangular features.								
25	37	6220	10.07	17.50	4816	8370	Sub-rectangular features.								
25	37	6220	8.86	17.57	4237	8403	Sub-rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	37	6218	12.72	16.56	6083	7920	Scatter of sub-rectangular features.			Y	8826/1	882641	444800	312	64
25	37	6218	12.06	15.93	5768	7619	Square enclosure.			Y	8826/2	882630	444804	312	64
25	37	6218	7.52	16.61	3597	7944	Square feature.			Y	8825/1	882577	444837	312	65
25	37	6218	4.68	4.08	2238	1951	Sub-rectangular features.								
25	37	6218	7.73	1.75	3697	837	Sub-rectangular feature in circular enclosure.								
25	37	6218	8.18	1.64	3912	784	Sub-rectangular features.								
25	37	6218	10.07	3.24	4816	1550	Sub-rectangular feature.								
25	37	6218	16.22	3.11	7757	1487	Sub-rectangular feature.								
25	37	6218	16.61	1.34	7944	641	Curvilinear area, avoided by modern tracks.								
25	37	6218	17.21	1.88	8231	899	Curvilinear feature.								
25	37	6218	17.83	0.25	8527	120	Rectangular feature.								
25	37	6218	20.70	3.15	9900	1507	Curvilinear features, adjacent to row of sub-rectangular features.								
25	37	6218	10.06	3.22	4811	1540	Sub-rectangular feature.								
25	37	6218	4.08	4.96	1951	2372	Sub-rectangular features.								
25	37	6218	8.85	9.16	4233	4381	Scatter of sub-rectangular features.								
25	37	6218	11.13	9.26	5323	4429	Scatters of sub-rectangular features.								
25	37	6218	11.77	7.82	5629	3740	?Collection of stones.								
25	37	6218	16.40	7.21	7843	3448	Two irregular enclosures, one crossed by double row of 'spots'.								
25	37	6218	17.47	11.74	8355	5615	sub-rectangular features.								
25	37	6218	8.29	10.00	3965	4783	sub-rectangular features.								
25	37	6218	8.31	12.21	3974	5840	sub-rectangular features.								
25	37	6218	7.35	11.98	3515	5730	sub-rectangular features.								
25	37	6218	5.89	10.63	2817	5084	Row of sub-rectangular features.								
25	37	6218	11.38	13.60	5443	6504	sub-rectangular features.								
25	37	6218	19.97	14.95	9551	7150	Irregular feature. Probable pond.								
25	37	6218	21.55	13.52	10307	6466	Square feature and a row of spots.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	37	6218	14.61	18.09	6987	8652	Square feature.								
25	37	6216	14.85	12.47	7102	5964	Sub-rectangular feature.			Y	8830/1	883041	444613	311	60
25	37	6216	14.39	13.05	6882	6241	Sub-rectangular feature.			Y	8830/3	883022	444610	311	60
25	37	6216	14.27	12.51	6825	5983	Row of spots.			Y	8830/2	883030	444623	311	60
25	37	6216	18.13	13.33	8671	6375	Sub-rectangular feature.			Y	8830/4	883077	444595	311	59
25	37	6216	5.87	1.24	2807	593	Group of sub-rectangular features.								
25	37	6216	6.88	1.48	3290	708	Group of sub-rectangular features next to modern building.								
25	37	6216	7.12	1.00	3405	478	Irregular features. Probable ponds.								
25	37	6216	9.30	3.34	4448	1597	Irregular features. Probable ponds.								
25	37	6216	10.01	1.94	4787	928	Irregular feature. Probable pond.								
25	37	6216	11.75	3.75	5620	1793	Irregular feature. Probable pond.								
25	37	6216	13.28	2.95	6351	1411	Irregular feature. Probable pond.								
25	37	6216	11.91	3.87	5696	1851	Row of spots crosses width of picture. Extends on to 6214.								
25	37	6216	19.15	6.05	9159	2893	Row of three square features, partly obscured.								
25	37	6216	8.52	4.03	4075	1927	Group of sub-rectangular features.								
25	37	6216	6.73	6.22	3219	2975	Square feature.								
25	37	6216	7.84	8.90	3750	4257	Irregular feature. Probable pond.								
25	37	6216	17.96	8.57	8590	4099	Scatter of sub-rectangular features, adjacent to modern building and pond.								
25	37	6216	19.46	7.64	9307	3654	Line of sub-rectangular features.								
25	37	6216	19.82	5.93	9479	2836	Double row of spots.								
25	37	6216	22.79	8.30	10900	3970	Scatter of sub-rectangular feature.								
25	37	6216	21.51	11.70	10287	5596	Sub-rectangular feature.								
25	37	6216	15.62	11.37	7470	5438	Irregular feature. Probable pond.								
25	37	6216	11.55	15.78	5524	7547	Double row of spots.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	37	6216	20.77	18.43	9933	8814	Rectangular features.								
25	37	6216	6.76	18.06	3233	8637	Sub-rectangular feature.								
25	37	6214	16.25	15.20	7772	7270	Cemetery. Seems to be expanding to the N.		C	Y	8833/1	883320	444430	310	56
25	37	6214	22.01	13.34	10527	6380	Sub-rectangular features.			Y	8834/1	883445	444390	310	55
25	37	6214	11.50	2.77	5500	1325	Row of spots crosses width of picture. Extends on to 6216.								
25	37	6214	17.53	4.65	8384	2224	Row of spots. Extends on to 6212.								
25	37	6214	12.54	1.09	5997	521	Irregular feature. Probable pond.								
25	37	6214	7.84	6.66	3750	3185	Sub-rectangular features and pond.								
25	37	6214	5.16	9.26	2468	4429	Scatter of sub-rectangular features.								
25	37	6214	6.70	11.63	3204	5562	Scatter of sub-rectangular features with adjacent features, probably ponds.								
25	37	6214	7.77	12.03	3716	5753	Arc.								
25	37	6214	8.22	11.58	3931	5538	Sub-rectangular feature.								
25	37	6214	11.74	12.13	5615	5801	Group of irregular features. Probably ponds.								
25	37	6214	11.15	10.24	5333	4897	Irregular feature. Probable pond.								
25	37	6214	10.48	9.42	5012	4505	Rectangular features.								
25	37	6214	12.14	9.41	5806	4500	Group of rectangular and sub-rectangular features.								
25	37	6214	15.21	10.71	7274	5122	Scatter of sub-rectangular features.								
25	37	6214	16.38	11.58	7834	5538	Group of rectangular features.								
25	37	6214	18.68	10.83	8934	5180	Scatter of sub-rectangular features.								
25	37	6214	18.28	11.99	8743	5734	Irregular feature. Probable pond.								
25	37	6214	19.77	12.03	9455	5753	Irregular features. Probable ponds.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
25	37	6214	21.72	10.73	10388	5132	Scatter of sub-rectangular features.								
25	37	6214	16.68	12.90	7977	6170	Irregular features. Probable ponds.								
25	37	6214	6.41	14.01	3066	6700	Irregular feature. Probable pond.								
25	37	6212	22.13	5.85	10584	2798	Group of sub-rectangular features.			Y	8837/2	883799	444348	310	52
25	37	6212	21.85	6.90	10450	3300	Group of sub-rectangular features.			Y	8837/1	883772	444321	310	52
25	37	6212	8.79	11.45	4204	5476	Scatter of sub-rectangular features.			Y	8835/1	883525	444370	310	54
25	37	6212	5.14	0.67	2458	320	Row of spots. Extends on to 6214.								
25	37	6212	10.48	2.27	5012	1086	Trapezoid feature. Probable pond.								
25	37	6212	17.00	5.00	8130	2391	Large formerly enclosed area. Possibly old camp.								
25	37	6212	21.19	4.89	10134	2339	Sub-rectangular features.								
25	37	6212	16.05	6.81	7676	3257	Sub-rectangular features.								
25	37	6212	7.06	6.00	3377	2870	Linear features.								
25	37	6212	5.28	4.61	2525	2205	Linear features.								
25	37	6212	5.86	5.25	2803	2511	Linear features.								
25	37	6212	7.26	7.07	3472	3381	Linear features.								
25	37	6212	2.48	5.15	1186	2463	Double row of spots. Extends on to 6214.								
25	37	6212	10.90	11.91	5213	5696	Irregular features. Probable ponds.								
25	37	6212	4.07	10.69	1947	5113	Scatter of sub-rectangular features.								
25	37	6212	10.29	13.34	4921	6380	Linear features.								
25	37	6210	5.27	13.89	2522	6641	Cemetery.		C		8837/3	883734	444207	310	
25	37	6210	11.43	4.05	5467	1937	Row of spots.								
25	37	6210	11.16	6.28	5337	3003	Sub-rectangular features.								
25	37	6210	8.94	5.00	4276	2391	Sub-rectangular features.								
25	37	6210	7.03	5.06	3362	2420	Sub-rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
25	37	6210	3.57	5.19	1707	2482	Group of sub-rectangular features.								
25	37	6210	3.83	3.88	1832	1856	Group of sub-rectangular features.								
25	37	6210	5.07	7.76	2425	3711	Scatter of sub-rectangular features.								
25	37	6210	7.08	10.21	3386	4883	Sub-rectangular feature.								
25	37	6210	6.96	12.08	3329	5777	Square feature.								
25	37	6210	11.07	15.97	5294	7638	Group of rectangular and sub-rectangular features.								
25	37	6210	14.59	14.92	6978	7136	Square feature.								
25	37	6210	13.29	16.64	6356	7958	Square feature.								
25	37	6210	19.36	16.63	9259	7953	Sub-rectangular features next to the river.								
25	37	6210	20.67	14.69	9886	7026	Sub-rectangular features.								
25	37	6210	20.57	19.07	9838	9120	Scatter of sub-rectangular features.								
25	37	6210	14.11	19.70	6748	9422	Rectangular features.								
25	37	6210	14.93	19.39	7140	9273	Square and circular features.								
25	37	6210	15.46	22.15	7394	10593	Square features.								
33	38	6208	12.05	7.66	5763	3663	Group of sub-rectangular features.								
33	38	6208	16.34	8.24	7815	3941	Scatter of sub-rectangular features.								
33	38	6208	16.83	8.90	8049	4257	Rectangular features.								
33	38	6208	11.20	10.67	5357	5103	Scatter of sub-rectangular features.								
33	38	6208	8.95	14.83	4280	7093	Square feature.								
33	38	6208	9.71	12.70	4644	6074	Sub-rectangular feature.								
33	38	6208	10.46	13.70	5003	6552	Sub-rectangular feature.								
33	38	6208	16.07	14.44	7686	6906	Scatter of sub-rectangular features.								
33	38	6208	18.20	13.08	8704	6256	Row of spots.								
33	38	6208	12.79	16.64	6117	7958	Large rectangular enclosure.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	38	6206	7.13	13.44	3410	6428	Unknown.			Y	8840/1	884044	444336	309	49
33	38	6206	9.83	2.14	4701	1023	Sub-rectangular feature.								
33	38	6206	9.44	2.99	4515	1430	Sub-rectangular feature.								
33	38	6206	8.10	4.18	3874	1999	Circular feature.								
33	38	6206	12.16	2.27	5816	1086	Sub-rectangular features.								
33	38	6206	12.85	1.74	6146	832	Circular feature.								
33	38	6206	12.72	1.07	6083	512	Circular feature.								
33	38	6206	13.49	3.96	6452	1894	Sub-rectangular features.								
33	38	6206	19.13	7.00	9149	3348	Sub-rectangular feature.								
33	38	6206	21.88	7.03	10464	3362	Sub-rectangular features.								
33	38	6206	12.93	11.23	6184	5371	Sub-rectangular features.								
33	38	6206	12.44	12.05	5950	5763	Group of circular features.								
33	38	6206	7.14	15.28	3415	7308	Rectangular feature. Old building.								
33	38	6206	6.71	20.32	3209	9718	Sub-rectangular features adjacent to modern building.								
33	38	6204	5.87	13.53	2807	6471	Group of sub-rectangular features.			Y	8843/1	884342	444437	308	46
33	38	6204	7.22	13.74	3453	6571	Row of sub-rectangular features.			Y	8843/2	884370	444442	308	46
33	38	6204	6.88	14.65	3290	7007	Group of sub-rectangular features.			Y	8843/3	884372	444423	308	46
33	38	6204	8.84	14.96	4228	7155	Group of sub-rectangular features.			Y	8844/1	884403	444430	308	45
33	38	6204	7.20	15.49	3443	7408	Group of sub-rectangular features.			Y	8843/4	884375	444412	308	45
33	38	6204	10.23	13.22	4893	6323	Sub-rectangular feature.			Y	8844/2	884427	444465	308	45
33	38	6204	10.27	14.43	4912	6901	Sub-rectangular features.			Y	8844/3	884435	444427	308	45
33	38	6204	15.66	12.98	7490	6208	Sub-rectangular features.			Y	8845/1	884509	444507	308	44
33	38	6204	19.60	14.98	9374	7164	Area of many ponds with scatter of sub-rectangular features.			Y	8845/2	884590	444490	308	43
33	38	6204	3.46	2.20	1655	1052	Sub-rectangular features adjacent to modern building.								
33	38	6204	6.27	2.94	2999	1406	Group of sub-rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	38	6204	6.97	1.94	3333	928	Group of sub-rectangular features.								
33	38	6204	7.71	0.89	3687	426	Sub-rectangular features.								
33	38	6204	10.60	1.50	5070	717	Area of many ponds with groups of sub-rectangular features.								
33	38	6204	8.89	1.31	4252	627	Rectangular feature.								
33	38	6204	19.56	6.04	9355	2889	Sub-rectangular features.								
33	38	6204	6.79	8.22	3247	3931	Ponds with groups of sub-rectangular features.								
33	38	6204	17.12	6.95	8188	3324	Pond ringed by sub-rectangular features. Other ponds nearby.								
33	38	6204	20.78	7.18	9938	3434	Eroded rectangular and sub-rectangular feature.								
33	38	6204	18.27	9.69	8738	4634	Group of sub-rectangular features.								
33	38	6204	17.42	10.34	8331	4945	Sub-rectangular feature.								
33	38	6204	8.03	10.78	3840	5156	Group of sub-rectangular features.								
33	38	6204	20.02	19.30	9575	9230	Large segmented circle crossed by modern track and with superimposed pond.								
33	38	6204	7.96	21.25	3807	10163	Group of sub-rectangular features.								
33	38	6204	15.75	19.75	7533	9446	Sub-rectangular features.								
33	38	6196	18.02	5.09	8618	2434	Many sub-rectangular features following old water course.								
33	38	6196	19.74	5.57	9441	2664	Sub-rectangular features following old water course.								
33	38	6196	19.14	6.23	9154	2980	Sub-rectangular features.								
33	38	6196	20.26	12.82	9690	6131	Group of sub-rectangular features.								
33	38	6196	16.22	16.07	7757	7686	Rectangular feature overlaying track.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	39	6193	7.74	5.22	3702	2497	Group of sub-rectangular features.			Y	8856/1	885638	445130	306	30
33	39	6193	5.00	4.88	2391	2334	Rectangular enclosure with adjacent sub-rectangular features.			Y	8856/2	885609	445090	306	31
33	39	6193	2.74	2.00	1310	957	Sub-rectangular feature adjacent to stream.								
33	39	6193	1.37	3.32	655	1588	Rows of sub-rectangular features.								
33	39	6193	6.52	7.30	3118	3491	Double row of dark spots. Crosses frame from N to S.								
33	39	6193	14.79	2.34	7073	1119	Double row of dark spots.								
33	39	6193	9.27	5.78	4433	2764	Group of rectangular dark marks.								
33	39	6193	9.81	5.56	4692	2659	Irregular area, possibly cleaned.								
33	39	6193	9.40	6.62	4496	3166	Circular area, possibly cleaned.								
33	39	6193	8.73	7.27	4175	3477	Cleared circular area with central heap of stones.								
33	39	6193	11.46	5.98	5481	2860	Two cleared circular area.								
33	39	6193	8.34	18.81	3989	8996	Group of sub-rectangular features.								
33	39	6193	5.78	21.22	2764	10149	Sub-rectangular features.								
33	39	6191	20.90	10.13	9996	4845	Ponds.								
33	39	6191	17.76	14.90	8494	7126	Group of sub-rectangular features.								
33	39	6191	19.43	14.70	9293	7030	Possible pond.								
33	39	6191	11.89	16.07	5687	7686	Eroded sub-rectangular features.								
33	39	6191	16.77	18.19	8020	8700	Sub-rectangular features.								
33	39	6191	16.10	21.30	7700	10187	Old building.								
33	39	6189	19.90	11.67	9517	5581	Row of dark spots.			Y	8863/1	886310	445715	304	21
33	39	6189	8.13	1.79	3888	856	Group of sub-rectangular features.								
33	39	6189	10.61	1.75	5074	837	Straggle of eroded sub-rectangular features.								
33	39	6189	21.39	6.61	10230	3161	Scatter of sub-rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	39	6189	12.84	7.04	6141	3367	Group of sub-rectangular features.								
33	39	6189	11.84	6.51	5663	3113	Rectangular enclosure.								
33	39	6189	6.87	6.77	3286	3238	Sub-rectangular features adjacent to buildings.								
33	39	6189	9.26	7.95	4429	3802	Scatter of sub-rectangular features.								
33	39	6187	13.00	0.56	6217	268	Sub-square enclosures near source of stream.								
33	39	6187	12.71	3.17	6079	1516	Sub-square enclosures near source of stream.								
33	39	6187	14.55	2.29	6959	1095	Sub-square enclosures near source of stream.								
33	39	6187	16.28	2.56	7786	1224	Sub-square enclosures near source of stream.								
33	39	6187	17.52	1.19	8379	569	Sub-square enclosures.								
33	39	6187	18.80	2.28	8991	1090	Sub-square enclosures.								
33	39	6187	15.97	0.91	7638	435	Sub-square enclosure.								
33	39	6187	22.66	4.45	10837	2128	Tiny irregular features.								
33	39	6187	12.18	4.80	5825	2296	Sub-square enclosure in corner of large hill-top enclosure with internal features and 'dirty' soil.								
33	39	6187	7.54	4.93	3606	2358	Group of sub-rectangular features cut by stream. Surround large open area.								
33	39	6187	5.93	5.91	2836	2827	Group of rectangular and sub-rectangular features. Surround large open area.								
33	39	6187	3.84	5.80	1837	2774	Scattered rows of sub-rectangular features with larger enclosures. Surround large open area.								
33	39	6187	5.13	4.15	2453	1985	sub-rectangular features within large open area.								
33	39	6187	10.14	8.37	4850	4003	C-shaped feature and others.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	39	6187	14.19	5.96	6787	2850	Scatter of sub-rectangular features along stream.								
33	39	6187	14.82	7.82	7088	3740	Rectangular and sub-rectangular features.								
33	39	6187	19.73	10.66	9436	5098	Large scatter of sub-rectangular features close to streams.								
33	39	6187	17.62	9.92	8427	4744	Eroded rectangular features.								
33	39	6185	20.00	5.00	9565	2391	Individual sub-rectangular features scattered in this area.								
33	39	6185	7.28	8.31	3482	3974	Sub-rectangular features next to stream.								
33	39	6185	7.60	9.49	3635	4539	Sub-rectangular features next to stream.								
33	39	6185	8.19	9.14	3917	4371	Rectangular features.								
33	39	6185	16.58	11.90	7930	5691	Row of rectangular features with scatter of sub-rectangular features to NE.								
33	39	6185	15.00	10.15	7174	4854	Rectangular and sub-rectangular features. Some earlier, than modern road.								
33	39	6185	13.90	10.47	6648	5007	Rectangular and sub-rectangular features. Some earlier, than modern road.								
33	39	6185	13.03	10.77	6232	5151	Rectangular and sub-rectangular features. Some earlier, than modern road.								
33	39	6185	14.69	9.17	7026	4386	C-shaped feature and others.								
33	39	6185	4.36	12.73	2085	6088	Rows of sub-circular features.								
33	39	6185	2.98	13.06	1425	6246	Sub-circular enclosure in 'dirty' area.								
33	39	6185	4.17	13.87	1994	6633	Sub-square feature and other adjacent.								
33	39	6185	5.75	13.86	2750	6629	Sub-rectangular features next to 'piano keys'.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	39	6185	13.12	12.83	6275	6136	Sub-rectangular features.								
33	39	6185	16.73	13.21	8001	6318	Sub-rectangular features.								
33	39	6185	19.40	12.80	9278	6122	Sub-rectangular features.								
33	39	6185	20.66	13.79	9881	6595	Sub-rectangular features.								
33	39	6185	21.80	12.55	10426	6002	Row of sub-rectangular features.								
33	39	6185	21.00	16.00	10043	7652	Individual sub-rectangular features scattered in this area.								
33	39	6185	21.85	16.20	10450	7748	Row of spots.								
33	39	6185	16.19	19.15	7743	9159	Row of spots.								
33	39	6185	6.76	14.41	3233	6892	Row of sub-rectangular features.								
33	39	6185	6.42	14.75	3070	7054	Sub-rectangular features.								
33	39	6185	10.34	17.10	4945	8178	Sub-rectangular features next to stream.								
33	39	6185	19.00	17.65	9087	8441	Conjoined sub-rectangular enclosures cut by road with adjacent rectangular enclosures.								
33	39	6185	20.35	20.64	9733	9871	Rows of sub-rectangular features.								
33	39	6185	19.48	18.64	9317	8915	Row of spots.								
33	39	6185	17.96	21.80	8590	10426	Rectangular feature.								
33	39	6183	10.15	1.39	4854	665	Sub-rectangular features.								
33	39	6183	8.04	5.64	3845	2697	Line of spots that crosses frame 'N to S'								
33	39	6183	8.48	7.27	4056	3477	Line of spots that crosses frame 'N to S'								
33	39	6183	10.74	2.48	5137	1186	Row of spots crossing previous two.								
33	39	6183	22.27	4.92	10651	2353	Rectangular features.								
33	39	6183	20.30	4.35	9709	2080	Large enclosed hill-top area surrounded by group of sub-rectangular features.								
33	39	6183	16.33	4.56	7810	2181	Rows of sub-rectangular features.								
33	39	6183	16.47	3.14	7877	1502	Row of sub-rectangular features.								
33	39	6183	15.11	6.36	7227	3042	Sub-rectangular features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
33	39	6183	10.80	5.29	5165	2530	Scatter of sub-rectangular features.								
33	39	6183	19.31	6.47	9235	3094	Group of sub-rectangular features.								
33	39	6183	18.07	8.56	8642	4094	Sub-rectangular features.								
33	39	6183	6.87	9.62	3286	4601	Arc of spots.								
33	39	6183	4.49	11.69	2147	5591	Rows of sub-rectangular features.								
33	39	6183	6.71	14.69	3209	7026	Scatter of sub-rectangular features and rows of spots.								
33	39	6183	4.00	15.00	1913	7174	Individual sub-rectangular features scattered in this area.								
33	39	6183	2.74	19.33	1310	9245	Short row of 'triplets' of sub-rectangular features.								
33	39	6183	3.28	20.16	1569	9642	Short row of 'triplets' of sub-rectangular features.								
33	39	6183	4.06	21.85	1942	10450	Short row of 'triplets' of sub-rectangular features.								
33	39	6183	6.57	20.83	3142	9962	Short row of 'triplets' of sub-rectangular features.								
33	39	6181	10.05	3.50	4807	1674	Eroded sub-rectangular features.								
33	39	6181	6.24	6.53	2984	3123	Linear features. Probably modern.								
33	39	6181	3.59	10.62	1717	5079	Rectangular enclosures. Probably recent.								
33	39	6181	21.91	13.83	10479	6614	Row of 'triplets' of sub-rectangular features.								
33	39	6181	18.23	13.26	8719	6342	Curvilinear features.								
33	39	6181	7.02	11.60	3357	5548	Rectangular features cut by road.								
33	39	6181	6.23	13.85	2980	6624	Scatter of sub-rectangular features.								
33	39	6181	11.96	14.60	5720	6983	Linear features.								
33	39	6181	12.58	14.80	6017	7078	Linear features.								
33	39	6181	12.68	13.59	6064	6500	Linear features.								
33	39	6181	13.62	13.19	6514	6308	Linear features.								
33	39	6181	13.70	15.21	6552	7274	Sub-square feature.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
33	39	6181	19.84	14.45	9489	6911	Sub-rectangular features.								
33	39	6181	17.00	14.73	8130	7045	Eroded sub-rectangular features.								
33	39	6181	21.58	13.12	10321	6275	Rows of conjoined sub-rectangular features.								
33	39	6181	22.43	16.52	10727	7901	Scatter of sub-rectangular features.								
33	39	6181	21.37	17.34	10220	8293	Scatter of sub-rectangular features.								
33	39	6181	22.52	20.00	10770	9565	Row of spots.								
33	39	6181	13.22	19.43	6323	9293	Linear feature.								
32	60	6143	3.27	8.69	1564	4156	Eroded row of square features.								
32	60	6141	11.03	6.98	5275	3338	Eroded sub-rectangular features.								
32	60	6141	12.50	6.80	5978	3252	Eroded sub-rectangular features.								
32	60	6141	13.82	12.57	6610	6012	Rows of spots.								
32	60	6141	16.03	13.66	7667	6533	Sub-rectangular feature.								
32	60	6141	15.04	16.08	7193	7690	Spread of rectangular and sub-rectangular features.								
32	60	6141	14.25	15.12	6815	7231	Rectangular features within possible enclosed area. Maybe hill-top.								
32	60	6141	3.62	14.03	1731	6710	Rectangular feature.								
32	60	6141	7.37	19.91	3525	9522	Scatter of sub-rectangular features.								
32	60	6141	8.40	19.38	4017	9269	Scatter of sub-rectangular features.								
32	60	6141	7.79	19.47	3726	9312	Sub-rectangular features.								
32	60	6141	10.87	19.52	5199	9336	Row of sub-rectangular features.								
32	60	6141	11.77	17.75	5629	8489	Sub-rectangular features.								
32	60	6141	13.66	19.70	6533	9422	Group of sub-rectangular features.								
32	60	6141	13.11	22.19	6270	10613	Short row of spots.								
32	60	6141	11.79	22.10	5639	10570	Sub-rectangular features.								
32	60	6141	8.95	20.62	4280	9862	Rectangular features.								

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
32	60	6141	8.05	21.86	3850	10455	Rectangular features adjacent to modern road.								
32	60	6141	8.24	20.99	3941	10039	Curvilinear feature.								
32	60	6139	22.51	5.52	10766	2640	Row of sub-rectangular features.								
32	60	6139	19.03	8.34	9101	3989	Scatter of sub-rectangular features.								
32	60	6139	16.06	9.58	7681	4582	Square feature.								
32	60	6139	14.14	17.57	6763	8403	Group of sub-rectangular features.								
32	60	6139	14.40	19.29	6887	9226	Sub-rectangular features.								
32	60	6139	16.87	21.57	8068	10316	Sub-rectangular features next to stream.								
32	60	6137	4.52	5.52	2162	2640	Row of sub-rectangular features.								
32	60	6137	8.73	12.53	4175	5993	Short row of 'triplets' of sub-rectangular features.								
32	60	6137	9.76	13.76	4668	6581	Row of spots that cross most of photograph 'NW to SE'.								
32	60	6137	10.00	13.23	4783	6327	Curvilinear enclosure.								
32	60	6137	18.13	15.52	8671	7423	Sub-rectangular features.								
32	60	6137	7.35	18.38	3515	8790	Circular feature.								
32	40	6179	21.43	10.90	10249	5213	Rectangular feature.			Y	8868/1	886806	445960	303	15
32	40	6179	7.61	11.87	3640	5677	Sub-rectangular features.			Y	8865/1	886580	445920	304	17
32	40	6179	2.00	3.00	957	1435	Individual sub-rectangular features scattered in this area.								
32	40	6179	3.13	4.67	1497	2233	Line of small rectangular features, following or followed by track. Extends to S.								
32	40	6179	6.48	3.19	3099	1526	Short row of 'triplets' of sub-rectangular features.								
32	40	6179	7.24	2.43	3463	1162	Sub-rectangular features.								
32	40	6179	6.03	2.03	2884	971	Sub-rectangular features.								
32	40	6179	12.81	1.78	6127	851	Rectangular and sub-rectangular features. Some earlier, than modern road.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
32	40	6179	12.25	2.88	5859	1377	Rectangular and sub-rectangular features. Some earlier, than modern road.								
32	40	6179	14.99	0.92	7169	440	Sub-rectangular features.								
32	40	6179	15.09	2.13	7217	1019	Rectangular and sub-rectangular features.								
32	40	6179	16.11	2.88	7705	1377	Sub-rectangular features.								
32	40	6179	20.00	3.00	9565	1435	Individual sub-rectangular features scattered in this area.								
32	40	6179	19.45	5.13	9302	2453	Row of spots, which extends S.								
32	40	6179	21.79	5.13	10421	2453	Row of spots, which extends S.								
32	40	6179	13.39	5.14	6404	2458	Sub-rectangular features.								
32	40	6179	11.53	3.85	5514	1841	Sub-rectangular features.								
32	40	6179	9.87	3.72	4720	1779	Sub-rectangular features.								
32	40	6179	4.21	9.37	2013	4481	Large scatter of sub-rectangular features close to streams.								
32	40	6179	22.37	8.36	10699	3998	Rectangular features.								
32	40	6179	14.14	10.03	6763	4797	Sub-rectangular features.								
32	40	6179	6.12	11.07	2927	5294	Row of sub-rectangular features.								
32	40	6177	7.75	5.34	3707	2554	Row of spots, which extends N and S.			Y	8869/5	886910	446024	303	14
32	40	6177	8.67	9.76	4147	4668	Long rectangular features.			Y	8869/1	886907	445987	303	14
32	40	6177	9.90	7.95	4735	3802	Long rectangular feature with adjacent sub-rectangular feature.			Y	8869/2	886918	446034	303	14
32	40	6177	9.28	7.34	4438	3510	Curvilinear features.			Y	8869/3	886908	446040	303	14
32	40	6177	10.74	7.76	5137	3711	Eroded sub-rectangular features.			Y	8869/4	886940	446030	303	13
32	40	6177	12.81	8.53	6127	4080	Scatter of sub-rectangular features.			Y	8869/6	886990	446034	303	13
32	40	6177	9.53	2.44	4558	1167	Short row of 'triplets' of sub-rectangular features.								
32	40	6177	11.73	5.52	5610	2640	Group of sub-rectangular features.								
32	40	6177	8.42	5.95	4027	2846	Short row of 'triplets' of sub-rectangular features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
32	40	6177	6.75	5.27	3228	2520	Short row of 'triplets' of sub-rectangular features.								
32	40	6177	5.82	5.03	2783	2406	Short row of 'triplets' of sub-rectangular features.								
32	40	6177	15.66	10.00	7490	4783	Sub-rectangular features.								
32	40	6177	15.58	9.89	7451	4730	Sub-rectangular features.								
32	40	6177	13.69	11.51	6547	5505	Group of sub-rectangular features.								
32	40	6177	13.75	10.19	6576	4873	Sub-rectangular features.								
32	40	6177	10.95	12.13	5237	5801	Scatter of rectangular and sub-rectangular features.								
32	40	6177	6.64	11.69	3176	5591	Long rectangular features.								
32	40	6177	4.98	11.69	2382	5591	Long rectangular features.								
32	40	6177	5.31	12.98	2540	6208	Long rectangular features.								
32	40	6177	5.05	14.45	2415	6911	Sub-rectangular features.								
32	40	6177	5.61	15.82	2683	7566	Sub-circular features.								
32	40	6177	7.42	15.19	3549	7265	Rectangular features. Modern.								
32	40	6177	8.77	15.35	4194	7341	Scatter of sub-rectangular features.								
32	40	6177	11.87	14.18	5677	6782	Eroded sub-rectangular features.								
32	40	6177	10.81	14.12	5170	6753	Rectangular and curvilinear features.								
32	40	6177	14.11	14.36	6748	6868	Scatter of sub-rectangular features.								
32	40	6177	8.96	17.01	4285	8135	Exclamation' mark features.								
32	40	6177	7.91	17.22	3783	8236	Sub-rectangular features.								
32	40	6177	3.57	17.04	1707	8150	Sub-rectangular features.								
32	40	6177	7.75	17.71	3707	8470	Circle of circular enclosures.								
32	40	6177	9.74	17.83	4658	8527	Long rectangular feature.								
32	40	6177	15.07	18.46	7207	8829	Sub-rectangular features.								
32	40	6177	15.51	17.92	7418	8570	Sub-rectangular features.								
32	40	6175	17.80	15.26	8513	7298	Rectangular and sub-rectangular features.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
32	40	6175	19.65	20.00	9398	9565	Scatter of rectangular features near modern buildings.								
32	40	6175	18.25	7.36	8728	3520	Circular feature.								
32	40	6171	4.97	7.09	2377	3391	Rectangular features.			Y	8878/1	887825	446127	301	4
32	40	6171	16.00	1.20	7652	574	Possible building and rectangular features within fenced area.								
32	40	6171	20.78	3.85	9938	1841	Long row of spots.								
32	40	6171	6.62	8.70	3166	4161	Circular feature.								
32	40	6170	22.46	5.08	10742	2430	Row of spots.								
32	40	6170	18.38	17.77	8790	8499	Circular feature.								
35	53	6144	10.66	0.95	5098	454	Rectangular features.								
35	53	6144	22.55	4.84	10785	2315	Circular features within track-defined area.								
35	53	6144	5.85	7.47	2798	3573	Group of sub-rectangular features.								
35	53	6144	7.54	12.51	3606	5983	Rows of spots.								
35	53	6144	21.17	13.34	10125	6380	Sub-rectangular features.								
35	53	6144	16.69	16.25	7982	7772	Circular features.								
35	53	6144	2.49	17.61	1191	8422	Rows of spots.								
35	53	6146	4.50	5.21	2152	2492	Rectangular features in enclosed area. Recent.								
35	53	6146	12.25	5.11	5859	2444	Rectangular features. Recent.								
35	53	6146	16.53	6.50	7906	3109	Linear features.								
35	53	6146	17.60	5.24	8417	2506	Rectangular feature.								
35	53	6146	11.80	7.45	5643	3563	Double row of spots.								
35	53	6146	3.76	8.62	1798	4123	Row of spots.								
35	53	6146	22.14	13.28	10589	6351	Circular features.								
35	53	6146	21.52	12.86	10292	6150	Linear feature.								
35	53	6146	20.81	12.39	9953	5926	Linear and sub-rectangular features.								
35	53	6146	15.54	13.22	7432	6323	Row of spots.								
35	53	6146	11.96	13.13	5720	6280	Row of spots.								
35	53	6146	5.72	14.07	2736	6729	Row of rectangular features.								
35	53	6146	17.83	13.97	8527	6681	C-shaped feature.								

CD	Line	Frame	Coord x	Coord y	Scrn x	Scrn y	Comment	Arch	Cem	<200m	Site No	Pulkovo E	Pulkovo N	Map	KP
35	53	6146	21.26	16.34	10168	7815	Unknown.								
35	53	6146	12.68	16.89	6064	8078	Circular feature.								
35	53	6146	12.21	19.36	5840	9259	Row of spots.								
35	53	6146	21.81	19.69	10431	9417	Row of spots.								
35	53	6148	11.11	2.97	5313	1420	Linear feature.								
35	53	6148	17.86	3.81	8542	1822	Linear and sub-rectangular features.								
35	53	6148	13.54	6.74	6476	3223	Linear features.								
35	53	6148	16.30	6.91	7796	3305	System of linear features.								
35	53	6148	2.37	10.06	1133	4811	Group of sub-rectangular features.								
35	53	6148	2.42	12.48	1157	5969	Linear features.								
35	53	6148	3.54	13.63	1693	6519	Circular feature.								
35	53	6148	4.91	12.24	2348	5854	Linear feature.								
35	53	6148	4.53	13.93	2167	6662	Linear features.								
35	53	6150	9.70	3.65	4639	1746	Rectangular features.								
35	53	6150	14.15	17.70	6767	8465	Rectangular feature.								
35	53	6152	19.09	15.03	9130	7188	Rectangular enclosure and row of spots.								
35	54	6161	21.06	1.26	10072	603	Rectangular features.								
35	54	6163	13.42	7.85	6418	3754	Row of spots, that extends almost across photo 'N to S'.								
35	54	6163	21.73	16.86	10393	8063	Row of spots.								
35	54	6165	10.96	6.20	5242	2965	Rectangular features.								
35	54	6165	4.62	6.82	2210	3262	Double row of spots.								
35	54	6165	3.70	15.56	1770	7442	Row of spots.								
35	54	6167	12.69	16.80	6069	8035	Cemetery.								
35	55	6160	6.86	10.41	3281	4979	Rectangular features.								
35	55	6160	6.49	11.20	3104	5357	Sub-rectangular features.								
35	55	6160	3.46	22.41	1655	10718	Sub-rectangular features.								

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CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
26	18	6126	11.84	17.32	5663	8283	Walled small enclosures on local mound. Archaeological site 135.	A		Y	8543/1	854286	455886	370	400
16	20	6075	12.13	4.68	5800	2240	Isolated mound. Possible settlement site. Archaeological Site 112.	A		Y	8575/1	857541	453368	361	356
17	21	6056	3.18	11.54	1521	5519	Rectangular walled enclosure.	A		Y	8585/2	858575	452972	359	344
28	17	6020	19.01	7.43	9092	3553	Suggestion of structures on high ground surrounded by water courses.	A			8522/1	852210	458295	376	
28	17	6024	15.14	13.73	7241	6567	Curvilinear enclosure, possibly walled.	A			8525/1	852545	457939	375	
28	17	6024	15.68	13.32	7499	6371	Curvilinear enclosure, possibly walled.	A			8525/2	852549	457944	375	
28	17	6024	14.53	15.38	6949	7356	Small curvilinear enclosure	A			8525/3	852521	457922	375	
28	17	6026	21.50	10.27	10283	4912	Five or more small circles. Possible burial sites.	A			8528/1	852880	457775	375	
28	17	6028	14.86	1.79	7107	856	Suggestion of enclosures on high ground.	A			X1	not	on map		
28	17	6028	16.08	2.42	7690	1157	Suggestion of enclosure on high ground. Dubious.	A			8530/1	853005	457433	374	
28	17	6028	17.03	0.61	8145	292	Curvilinear walled enclosure with internal subdivisions.	A			X2	not	on map		
28	17	6030	21.08	15.11	10082	7227	Sub-rectangular enclosure damaged by modern vehicles. Rectangular structures on N side of road.	A			8532/1	853244	457397	374	
28	17	6030	8.58	20.89	4103	9991	Curvilinear walled structure.	A			8530/2	853029	457442	374	
28	17	6032	21.48	7.29	10273	3487	Row of three small circles, possibly burials.	A			8535/1	853530	457348	373	
28	17	6032	18.78	5.01	8982	2396	Small circle, possibly burial.	A			8535/2	853536	457402	373	
28	17	6032	11.26	11.19	5385	5352	Group of small circles.	A			8533/6	853366	457387	373	
28	17	6032	9.72	11.08	4649	5299	Single circle cut by track.	A			8533/5	853341	457411	373	

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28	17	6034	14.44	7.17	6906	3429	Two circles, possibly burials.	A			8536/1	853658	457251	373	
28	17	6034	12.81	9.19	6127	4395	Two, possibly three small circles (?burials). Adjacent features may be recent.	A			8536/2	853615	457254	373	
28	17	6034	13.60	10.19	6506	4874	Two circles, possibly burials.	A			8536/3	853621	457222	373	
26	18	6130	5.10	11.24	2441	5376	Oval area of ?bare soil, which includes mound with surface irregularities.	A			8540/4	854055	456495	371	
29	52	6108	5.63	2.43	2693	1162	Circular rampart enclosing uneven area. Some external features. Possible settlement.	A			X3	not	on map		
16	20	6091	18.65	8.99	8920	4300	Group of circular features. Adjacent rectangular features.	A			8560/1	856029	454705	366	
16	20	6091	18.59	7.94	8891	3797	Area of slight rectangular features. ?Possible settlement.	A			8560/2	856039	454725	366	
16	20	6085	4.92	3.29	2353	1573	Rectangular structures on high ground.	A			8565/1	856530	454388	364	
18	22	5569	17.58	4.45	8408	2128	Walled enclosure.	A			X4	not	on map		
19	23	6412	12.13	20.36	5801	9737	Walled rectangular features.	A			8618/4	861822	452121	353	
20	25	6384	13.46	10.49	6435	5015	Large area of possible cairns.	A			8640/2	864070	450150	347	272
20	25	6384	19.26	21.75	9211	10402	Large area of mostly curvilinear features on high ground. ?Ring cairns or natural.	A			8641/1	864150	449970	347	
24	33	6272	19.30	5.33	9230	2549	Embanked enclosure with internal structures. Located at junction of two extinct rivers.	A			8735/1	873559	448418	328	
24	34	6288	11.76	17.89	5622	8558	Small area of 'ridge and furrow'.	A			8775/1	877543	446599	321	
24	34	6288	12.41	18.33	5935	8766	Curvilinear enclosure.	A			8775/2	877556	446595	321	
24	34	6288	13.04	19.82	6235	9478	Sub-rectangular enclosure.	A			8775/6	877556	446570	321	
24	34	6288	13.16	20.23	6294	9674	Curvilinear enclosure.	A			8775/7	877555	446561	321	
24	34	6288	14.65	17.30	7006	8272	Possible curvilinear enclosure.	A			8775/3	877596	446611	321	
24	34	6288	13.92	20.07	6657	9600	Rectangular enclosure with internal subdivision.	A			8775/8	877570	446565	321	

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24	34	6288	11.10	21.20	5311	10140	Sub-rectangular enclosure.	A			8775/5	877521	446561	321	
24	34	6288	15.00	22.59	7175	10804	Multivallate curvilinear enclosure.	A			X5	not	on map		
24	34	6288	11.30	22.31	5404	10668	Curvilinear enclosure.	A			8775/4	877511	446537	321	
24	34	6289	18.88	20.85	9030	9972	Curvilinear enclosure.	A			8778/2	877813	446459	320	
24	34	6289	18.11	20.83	8661	9962	Curvilinear enclosure. Possibly superimposed on 'ridge and furrow'.	A			8778/1	877803	446465	320	
24	34	6289	17.50	20.82	8370	9957	Curvilinear enclosure.	A			8777/4	877793	446471	320	
24	34	6289	17.44	21.38	8341	10225	Curvilinear enclosure.	A			8777/5	877791	446459	320	
24	34	6289	18.81	21.78	8996	10417	Curvilinear enclosure.	A			8778/3	877812	446441	320	
24	34	6289	17.07	22.14	8164	10589	Curvilinear enclosure.	A			8777/7	877778	446449	320	
24	34	6289	17.63	22.00	8432	10522	Curvilinear enclosure.	A			8777/6	877793	446447	320	
24	34	6289	18.57	22.02	8881	10531	Sub-rectangular enclosure.	A			8778/4	877805	446441	320	
24	34	6289	19.09	22.82	9130	10914	Sub-rectangular enclosure.	A			8778/5	877808	446418	320	
24	34	6289	17.41	22.96	8327	10981	Sub-rectangular enclosure.	A			8777/8	877784	446432	320	
24	34	6289	10.65	20.70	5093	9900	Area of undated cultivation. Similar in appearance to ridge and furrow. Superimposed on or by enclosures (above).	A			X6	not	on map		
24	34	6289	9.82	21.37	4697	10220	Sub-rectangular enclosure.	A			X7	not	on map		
24	34	6289	11.55	20.76	5524	9929	Superimposed multivallate enclosures with adjacent enclosures.	A			X8	not	on map		
24	34	6289	12.72	21.86	6083	10455	Part of curvilinear enclosure.	A			X9	not	on map		
24	34	6289	13.07	22.16	6251	10598	Rectangular enclosure.	A				not	on map		
24	34	6289	10.80	21.60	5165	10330	Sub-rectangular enclosure.	A			X10	not	on map		
24	34	6289	10.89	22.51	5208	10766	Sub-rectangular enclosure.	A			X11	not	on map		
24	34	6289	9.88	22.15	4725	10593	Sub-rectangular enclosure.	A			X12	not	on map		
24	34	6289	10.36	21.76	4955	10407	Curvilinear enclosure.	A			X13	not	on map		
24	34	6289	10.09	22.89	4826	10947	Curvilinear enclosure.	A			X14	not	on map		

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CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
24	34	6289	10.76	21.25	5146	10163	Area of undated cultivation. Similar in appearance to ridge and furrow.	A			X15	not	on map		
25	36	6240	17.64	15.38	8437	7356	Conjoined circular enclosures with central spot. Possibly burials.	A			8799/1	879954	446039	317	
25	36	6240	16.67	15.21	7973	7274	Circular enclosure with central spot. Possibly a burial.	A			8799/2	879934	446046	317	
25	36	6240	15.50	15.40	7413	7365	Circular feature with internal spot. Possibly burial.	A			8799/3	879915	446010	317	
25	36	6240	15.64	16.10	7480	7700	Circular feature with internal spot. Possibly burial.	A			8799/4	879903	446031	317	
25	36	6240	15.87	15.97	7590	7638	Circular feature with internal spot. Possibly burial.	A			8799/5	879907	446037	317	
25	36	6228	16.23	6.26	7762	2994	Spread of curvilinear enclosures. Look more eroded, possibly older, than others.	A			8818/1	881850	445484	313	
25	36	6228	11.17	8.05	5342	3850	Rectangular enclosure with attached sub-rectangular feature.	A			8817/1	881732	445500	313	
17	21	6056	14.98	7.62	7162	3645	Cemetery. Archaeological Site.102.		C	Y	8587/1	858778	452959	359	342
17	21	6056	10.25	9.23	4901	4415	Probable cemetery.		C	Y	8586/2	858699	452960	359	343
17	21	6068	12.78	14.16	6110	6772	Cemetery.		C	Y	8602/1	860230	452370	356	326
19	24	6396	8.36	17.11	4000	8182	Cemetery.		C	Y	8635/1	863509	451227	349	286
19	24	6394	4.24	12.38	2030	5921	Probable cemetery.		C	Y	8636/2	863606	451025	349	283
19	24	6394	20.80	12.52	9949	5989	Cemetery.		C	Y	8636/1	863682	450782	348	281
25	37	6214	16.25	15.20	7772	7270	Cemetery. Seems to be expanding to the N.		C	Y	8833/1	883320	444430	310	56
28	17	6015	6.79	3.22	3247	1541	Cemetery		C			not	on map		
28	17	6017	10.08	10.38	4821	4964	Curvilinear area enclosed by hollow 'ditch' adjacent to modern cemetery.		C		8517/1	851760	458575	377	

AIR PHOTO INTERPRETATION: ARCHAEOLOGY, CEMETERIES, SITES WITHIN 200m

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
29	51	6040	21.41	8.97	10240	4290	Cemetery.		C			not	on map		385
29	51	6042	13.90	6.59	6650	3150	Cemetery.		C			not	on map		383
29	51	6044	9.81	20.57	4690	9840	Cemetery.		C			not	on map		
29	51	6045	18.63	20.08	8912	9604	Cemetery.		C			not	on map		
17	21	6056	22.35	12.66	10688	6054	Cemetery.		C		8588/1	858855	452850	359	341
17	21	6062	19.81	22.26	9476	10648	Cemetery.		C		8595/1	859543	452488	357	
17	21	6064	11.19	11.83	5350	5658	Cemetery.		C		8597/1	859717	452584	357	
17	21	6072	11.08	21.37	5300	10222	Cemetery.		C			not	on map		
19	23	6404	11.27	22.42	5390	10723	Possible cemetery.		C		8627/1	862730	451547	351	
19	24	6387	10.83	1.35	5181	646	Cemetery.		C		8640/1	864093	450027	347	
20	25	6372	14.03	23.00	6710	11000	Cemetery.		C		8657/1	865770	450100	344	
20	26	6361	19.24	0.61	9200	290	Cemetery.		C		8669/1	866907	450148	341	
20	26	6358	19.97	3.21	9550	1535	Possible cemetery.		C		8673/1	867311	450010	341	
21	27	6353	15.36	12.05	7348	5762	Cemetery.		C		8674/1	867458	449989	341	
21	27	6345	4.50	2.30	2150	1100	Cemetery, war memorial, Mig 17 (or 15)		C		8683/1	868350	449810	339	
22	29	6323	18.40	10.18	8800	4869	Cemetery.		C		8705/1	870520	449218	335	
22	30	6322	16.86	7.00	8065	3350	Cemetery.		C		8702/1	870200	449340	336	
23	31	6312	16.12	2.78	7708	1329	Cemetery.		C		8713/1	871303	448698	333	
23	31	6312	3.21	13.86	1534	6629	Cemetery.		C		8710/1	871099	448555	333	
23	31	6300	5.52	19.36	2640	9259	Hexagonal enclosure, which appears to overlay rectangular features in its SW corner. Dyke cuts off NE triangle of enclosure, which has been used as a modern cemetery. Cemetery extends outside E side of hexagonal enclosure and it is now within larger boundary.		C		8721/1	872160	448320	331	
24	33	6274	4.80	3.22	2294	1541	Cemetery.		C		8730/1	873000	448685	330	

AIR PHOTO INTERPRETATION: ARCHAEOLOGY, CEMETERIES, SITES WITHIN 200m

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
24	33	6268	19.59	17.76	9369	8494	Embanked enclosure with internal structures. Probably cemetery.		C		8741/1	874108	447930	327	
24	33	6264	8.93	11.51	4271	5505	Possible unenclosed cemetery. Probably recent.		C		8745/1	874578	447824	327	
24	33	6262	8.73	3.17	4175	1516	Probable enclosed cemetery.		C		8749/1	874941	447843	326	
24	34	6281	18.82	5.23	9000	2500	Cemetery.		C		8766/1	876655	447230	323	
24	34	6287	22.44	5.78	10733	2765	Cemetery.		C		8776/1	877643	446844	321	
24	35	6251	21.54	4.24	10303	2026	Cemetery.		C		8786/1	878603	446640	319	
25	36	6228	5.38	14.21	2573	6796	Cemetery with surrounding curvilinear features.		C		8815/2	881590	445435	314	
25	37	6210	5.27	13.89	2522	6641	Cemetery.		C		8837/3	883734	444207	310	
28	17	6034	14.00	21.54	6696	10302	Rectangular structures. Recent.			Y	8535/3	853527	457065	372	415
26	18	6130	15.43	17.48	7380	8360	Rectangular features. Probably recent. Next toArchaeological Site 138.			Y	8540/1	854052	456320	371	405
26	18	6128	12.23	19.13	5849	9149	Squareish features. Unknown origin.			Y	8541/3	854135	456104	370	403
26	18	6128	12.61	18.72	6031	8953	Linear spread of squareish features. Unknown origin.			Y	8541/2	854142	456102	370	403
26	18	6128	16.38	18.52	7834	8857	Area of scoops. Probably recent.			Y	8541/4	854168	456050	370	403
26	18	6122	18.70	12.95	8943	6193	Rectangular features. Probably recent.			Y	8546/1	854671	455334	368	393
26	18	6120	6.26	10.12	2994	4840	Group of rectangular features, which follow trench. Recent.			Y	8547/1	854729	455285	368	393
29	51	6038	14.18	16.90	6782	8083	Rectangular features. Unknown origin.			Y	8549/3	854940	455016	368	389
29	51	6038	10.72	19.29	5127	9226	Group of rectangular features.			Y	8548/1	854875	455058	368	390
29	52	6108	11.46	4.09	5481	1956	Rectangular features. Probably recent.			Y		not	on map		373
29	52	6108	9.14	4.59	4371	2195	Circular and other features on high ground.			Y		not	on map		374

AIR PHOTO INTERPRETATION: ARCHAEOLOGY, CEMETERIES, SITES WITHIN 200m

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29	52	6108	8.48	4.14	4056	1980	Walled small enclosures.			Y		not	on map		374
29	52	6110	21.81	10.17	10431	4864	Rectangular features adjacent to modern farm.			Y		not	on map		369
29	52	6112	16.65	13.81	7963	6605	Rectangular feature.			Y		not	located		368
29	52	6114	4.58	10.83	2190	5180	Linear and rectangular features.			Y	8566/1	856666	453867	363	366
29	52	6114	6.53	10.33	3123	4940	Linear features.			Y	8566/2	856697	453872	363	366
29	52	6114	6.69	13.19	3200	6308	Rectangular features.			Y	8566/3	856696	453828	363	366
29	52	6116	5.51	17.05	2635	8154	Rectangular feature.			Y		not	on map		363
29	52	6116	9.76	17.78	4668	8503	Rectangular features.			Y	8569/2	856981	453727	363	362
16	20	6079	4.02	13.51	1923	6461	Spread groups of rectangular features. Next to Archaeological Site 123.			Y	8569/1	856986	453701	363	362
16	20	6079	15.52	12.26	7423	5863	Probable quarries, separated by track.			Y	8571/1	857127	453606	362	361
16	20	6075	14.81	8.86	7083	4237	Small features, possibly with adjacent wall. Nearby sub-rectangular features.			Y	8575/2	857523	453293	361	355
17	21	6046	14.32	8.94	6849	4276	Rectangular features.			Y	8575/3	857324	453362	361	356
17	21	6054	15.96	8.92	7633	4266	Spread of rectangular features.			Y	8585/1	858537	453018	359	345
17	21	6054	21.38	9.76	10225	4668	Rectangular features.			Y	8586/1	858616	452990	359	344
17	21	6056	6.64	7.96	3176	3807	Rectangular feature.			Y	8586/3	858660	452986	359	344
17	21	6058	10.24	7.95	4897	3802	Embanked feature.			Y	8589/1	858958	452900	359	340
17	21	6058	15.46	11.45	7394	5476	Rectangular features.			Y	8590/1	859022	452828	359	339
17	21	6070	18.10	4.10	8657	1961	Unknown. Possibly erosion. Adjacent rectangular features.			Y	8606/2	860662	452432	356	321
17	21	6070	18.82	5.03	9001	2406	Unknown. Possibly erosion.			Y	8606/1	860645	452407	356	321
18	22	5567	17.39	11.59	8317	5543	Rectangular feature linked to track.			Y	8611/10	861102	452621	355	315
18	22	5567	17.61	11.74	8422	5615	Linear feature. Probably recent.			Y	8611/9	861150	452617	355	315
18	22	5567	15.53	11.89	7427	5687	Scoops and linear features.			Y	8611/8	861115	452612	355	316
18	22	5567	19.34	16.34	9250	7815	Rectangular feature.			Y	8611/5	861182	452570	354	315
18	22	5567	20.19	17.00	9656	8130	Rectangular feature.			Y	8612/1	861209	452557	354	316
18	22	5569	3.29	15.90	1573	7604	Rectangular and linear features.			Y	8611/6	861175	452573	354	315

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18	22	5569	9.92	22.45	4744	10737	Rectangular features.			Y	8613/1	861330	452512	354	313
19	23	6416	8.51	12.90	4070	6170	Rectangular features adjacent to modern building.			Y	8613/2	861345	452518	354	313
19	23	6416	13.31	17.66	6366	8446	Group of rectangular features, crossed by modern track.			Y	8613/3	861373	452429	354	312
19	23	6416	14.29	17.56	6834	8398	Rectangular feature.			Y	8613/4	861389	452431	354	312
19	23	6412	10.88	6.38	5203	3051	Rectangular features adjacent to area of different land use.			Y	8618/2	861875	452340	353	305
19	23	6412	14.95	10.99	7150	5256	Group of rectangular features.			Y	8619/3	861937	452230	353	304
19	23	6412	13.46	11.08	6437	5299	Unknown disturbance.			Y	8619/4	861905	452255	353	304
19	23	6412	18.20	9.63	8704	4606	Rectangular features.			Y	8619/7	861980	452226	353	304
19	23	6412	18.93	10.66	9053	5098	Rectangular features.			Y	8619/8	861991	452208	353	304
19	23	6398	8.71	11.20	4166	5357	Row of scoops.			Y	8630/1	863012	451455	351	292
19	23	6398	11.10	12.77	5309	6107	Unknown. Circular area, possibly enclosed.			Y	8630/3	863040	451533	351	292
19	24	6392	21.60	14.52	10330	6944	Rectangular feature.			Y	8636/3	863695	450505	348	278
19	24	6390	16.03	16.27	7667	7781	Unknown. Small area defined by tracks. Includes quarrying.			Y	8637/1	863732	450311	347	276
34	28	6339	10.00	5.05	4783	2415	Rectangular features adjacent to modern buildings.			Y	8687/1	868780	449794	338	220
22	29	6329	7.63	9.84	3649	4706	Rectangular feature.			Y	8696/1	869607	449597	337	211
22	30	6322	1.83	20.44	875	9776	Circular feature.			Y	8699/1	869928	449438	336	208
23	31	6312	10.08	10.26	4821	4907	Three sides of ditched feature, which is continued to the E as a hedged boundary. Recent.			Y	8706/1	870695	448652	334	195
23	31	6312	13.72	9.79	6562	4682	Rectangular cut holes. Recent.			Y	8707/1	870751	448659	334	195
23	31	6304	20.76	17.12	9929	8188	Square enclosure attached to boundary. Recent. Similar to 8717/1			Y	8718/1	871849	448419	332	183
24	34	6289	16.04	12.39	7671	5926	Curvilinear feature avoided by modern track.			Y	8777/1	877799	446620	321	118
24	34	6289	14.53	12.88	6949	6160	Scoops adjacent to modern track.			Y	8777/2	877780	446630	321	118

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24	34	6289	12.94	12.88	6189	6160	Group of scoops and rectangular features, some superimposed.			Y	8777/3	877752	446638	321	119
24	34	6289	7.28	11.12	3482	5318	Rectangular feature adjacent to modern building.			Y	8776/5	877648	446696	321	120
25	36	6234	17.82	10.65	8523	5093	Sub-rectangular features, partly superimposed by modern track.			Y	8809/1	880915	445758	315	84
25	36	6234	9.67	12.63	4625	6040	Possible circular and square features.			Y	8807/1	880750	445786	315	86
25	36	6234	7.60	12.56	3635	6007	Possible circular and square features.			Y	8807/2	880708	445804	315	86
25	36	6234	8.59	13.38	4108	6399	Group of sub-rectangular features, cut by modern railway.			Y	8807/3	880721	445784	315	86
25	36	6232	20.33	8.90	9723	4257	Sub-rectangular features.			Y	8812/2	881274	445678	314	81
25	36	6232	19.16	8.66	9163	4142	Sub-rectangular features.			Y	8812/1	881248	445687	314	81
25	36	6230	20.54	6.35	9823	3037	Extensive spread of groups of sub-rectangular features.			Y	8815/1	881590	445570	314	77
25	36	6230	12.97	6.33	6203	3027	Irregular enclosure.			Y	8814/1	881459	445630	314	79
25	36	6230	11.73	6.68	5610	3195	Rectangular enclosures.			Y	8814/2	881435	445635	314	79
25	36	6230	10.24	6.40	4897	3061	Sub-rectangular enclosures and ?stones.			Y	8814/3	881400	445645	314	79
25	36	6230	4.20	7.10	2009	3396	Sub-rectangular features.			Y	8813/1	881300	445679	314	80
25	36	6230	4.79	7.90	2291	3778	Group of sub-rectangular features.			Y	8813/2	881300	445663	314	80
25	36	6230	5.59	8.80	2673	4209	Group of sub-rectangular features with adjacent enclosure.			Y	8813/3	881310	445636	314	80
25	36	6230			4514	3760	Rectangular enclosure cut by WREP pipeline.			Y	8813/5	881384	445630	314	79
25	36	6230	9.58	8.57	4582	4099	Group of sub-rectangular features crossed by modern tracks.			Y	8813/4	881380	445620	314	79

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25	36	6228	6.69	10.78	3200	5156	Arc of conjoined rectangular features.			Y	8816/1	881638	445487	314	76
25	36	6228	7.17	11.08	3429	5299	Rectangular feature within circular enclosure.			Y	8816/2	881641	445480	314	76
25	36	6228	8.05	11.52	3850	5510	Rectangular feature within circular enclosure.			Y	8816/3	881656	445465	314	76
25	36	6228	9.70	10.07	4639	4816	Row of sub-circular features.			Y	8816/4	881699	445480	314	76
25	36	6228	8.32	9.09	3979	4347	Sub-rectangular features.			Y	8816/5	881672	445505	314	76
25	36	6226	8.37	12.43	4003	5945	Thin rectangular feature.			Y	8819/1	881946	445310	313	73
25	36	6226	7.89	12.51	3773	5983	Sub-rectangular feature.			Y	8819/2	881938	445310	313	73
25	36	6226	7.12	12.28	3405	5873	Curvilinear feature.			Y	8819/3	881925	445319	313	73
25	36	6226	13.63	13.96	6519	6677	Curvilinear feature.			Y	8820/1	882031	445249	313	73
25	37	6222	21.72	14.34	10388	6858	Linear feature with adjacent 'dashes' and 'dots'.			Y	8822/1	882295	445051	312	68
25	37	6220	14.74	14.01	7050	6700	Rectangular enclosure with adjacent features.			Y	8824/1	882442	444963	312	67
25	37	6218	12.72	16.56	6083	7920	Scatter of sub-rectangular features.			Y	8826/1	882641	444800	312	64
25	37	6218	12.06	15.93	5768	7619	Square enclosure.			Y	8826/2	882630	444804	312	64
25	37	6218	7.52	16.61	3597	7944	Square feature.			Y	8825/1	882577	444837	312	65
25	37	6216	14.85	12.47	7102	5964	Sub-rectangular feature.			Y	8830/1	883041	444613	311	60
25	37	6216	14.39	13.05	6882	6241	Sub-rectangular feature.			Y	8830/3	883022	444610	311	60
25	37	6216	14.27	12.51	6825	5983	Row of spots.			Y	8830/2	883030	444623	311	60
25	37	6216	18.13	13.33	8671	6375	Sub-rectangular feature.			Y	8830/4	883077	444595	311	59
25	37	6214	22.01	13.34	10527	6380	Sub-rectangular features.			Y	8834/1	883445	444390	310	55
25	37	6212	22.13	5.85	10584	2798	Group of sub-rectangular features.			Y	8837/2	883799	444348	310	52
25	37	6212	21.85	6.90	10450	3300	Group of sub-rectangular features.			Y	8837/1	883772	444321	310	52
25	37	6212	8.79	11.45	4204	5476	Scatter of sub-rectangular features.			Y	8835/1	883525	444370	310	54
33	38	6206	7.13	13.44	3410	6428	Unknown.			Y	8840/1	884044	444336	309	49

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33	38	6204	5.87	13.53	2807	6471	Group of sub-rectangular features.			Y	8843/1	884342	444437	308	46
33	38	6204	7.22	13.74	3453	6571	Row of sub-rectangular features.			Y	8843/2	884370	444442	308	46
33	38	6204	6.88	14.65	3290	7007	Group of sub-rectangular features.			Y	8843/3	884372	444423	308	46
33	38	6204	8.84	14.96	4228	7155	Group of sub-rectangular features.			Y	8844/1	884403	444430	308	45
33	38	6204	7.20	15.49	3443	7408	Group of sub-rectangular features.			Y	8843/4	884375	444412	308	45
33	38	6204	10.23	13.22	4893	6323	Sub-rectangular feature.			Y	8844/2	884427	444465	308	45
33	38	6204	10.27	14.43	4912	6901	Sub-rectangular features.			Y	8844/3	884435	444427	308	45
33	38	6204	15.66	12.98	7490	6208	Sub-rectangular features.			Y	8845/1	884509	444507	308	44
33	38	6204	19.60	14.98	9374	7164	Area of many ponds with scatter of sub-rectangular features.			Y	8845/2	884590	444490	308	43
33	39	6193	7.74	5.22	3702	2497	Group of sub-rectangular features.			Y	8856/1	885638	445130	306	30
33	39	6193	5.00	4.88	2391	2334	Rectangular enclosure with adjacent sub-rectangular features.			Y	8856/2	885609	445090	306	31
33	39	6189	19.90	11.67	9517	5581	Row of dark spots.			Y	8863/1	886310	445715	304	21
32	40	6179	21.43	10.90	10249	5213	Rectangular feature.			Y	8868/1	886806	445960	303	15
32	40	6179	7.61	11.87	3640	5677	Sub-rectangular features.			Y	8865/1	886580	445920	304	17
32	40	6177	7.75	5.34	3707	2554	Row of spots, which extends N and S.			Y	8869/5	886910	446024	303	14
32	40	6177	8.67	9.76	4147	4668	Long rectangular features.			Y	8869/1	886907	445987	303	14
32	40	6177	9.90	7.95	4735	3802	Long rectangular feature with adjacent sub-rectangular feature.			Y	8869/2	886918	446034	303	14
32	40	6177	9.28	7.34	4438	3510	Curvilinear features.			Y	8869/3	886908	446040	303	14
32	40	6177	10.74	7.76	5137	3711	Eroded sub-rectangular features.			Y	8869/4	886940	446030	303	13

AIR PHOTO INTERPRETATION: ARCHAEOLOGY, CEMETERIES, SITES WITHIN 200m

CD	*Line*	*Frame*	*Coord x*	*Coord y*	*Scrn x*	*Scrn y*	*Comment*	*Arch*	*Cem*	*<200m*	*Site No*	*Pulkovo E*	*Pulkovo N*	*Map*	*KP*
32	40	6177	12.81	8.53	6127	4080	Scatter of sub-rectangular features.			Y	8869/6	886990	446034	303	13
32	40	6171	4.97	7.09	2377	3391	Rectangular features.			Y	8878/1	887825	446127	301	4

ARCHAEOLOGICAL BASELINE DATA

Table 1 Immovable Historical and Cultural Monuments of National Importance (Architectural monuments)

INVENTORY NO.	NAME OF MONUMENT	DATE	LOCATION
1.	“Ateshgah” praying house complex	XVIII century	Surakhani District, Baku
2.	“Inner City” architectural- town planning complex	VI-XIX centuries	Sabail District, Baku
2.1.	Mahammad Mosque	1078-1079	42 M. Mansur Street
2.2.	Maiden Tower	VI-XII centuries	A. Zeynalli Street
	Shirvanshahs’ Palace Complex	XIII-XV centuries	76 Gala Side Street, Baku
2.3.	Shirvanshahs’ dwelling building	XV century	
2.4.	Court-room	XV century	
2.5.	Shah’s mosque	1441-1442	
2.6.	Seyid Yahya Bakuvi’s sepulchre	XV century	
2.7.	Shirvanshahs’ sepulchre	1435-1436	
2.8.	Gate of Murad	1585	
2.9.	Bath-house	XV century	
2.10.	Relics of Key Gubad Mosque	XV century	
	Caspian Coastal Defence Facilities. Towers, Caravanserais and Water Reservoir Complexes	The Initial Middle Ages XVIII century	Western shore of the Caspian Sea
3.1.	Great Mardakan Castle	XIII-XIV centuries	Mardakan Township
3.2.	Small Mardakan Castle	XIII-XIV centuries	Mardakan Township
3.3.	Ramana Castle	XII-XIV centuries	Ramana Township
3.4.	Nardaran Castle	XIV century	Nardaran Village
3.5.	Bayil Castle	1234-1235	Baku Bay
3.6.	Beshbarmag Wall	The Middle Ages	Davachi District
3.7.	Chiraggala	V-VI centuries	Davachi District
4.	Gulu Musa oglu’s tomb	1314	Khachin Turbatli Village, Agdam District
5.	“Allah-Allah” sepulchre and Nushaba Tower	1322	Barda City

INVENTORY NO.	NAME OF MONUMENT	DATE	LOCATION
6.	Synig korpu (broken bridge)	XII century	Gazakh District
7.	Ili-su Village	XVIII-XIX centuries	Gakh District
8.	Temple	V century	Lakit Village, Gakh District
9.	Khynalig Village	XVII-XIX centuries	Khynalig Village, Guba District
10.	Ganjasar Friary	1238	Vangli Village, Kalbajar District
11	Khudavang Friary	XIII-XVII centuries	On the Tartar River, Kalbajar District
12.	Khudaferin Bridge with 11 portals	XI-XII centuries	Jabrayil District
13.	Khudaferin Bridge with 15 portals	XIII century	Jabrayil District
14.	Lahij State Historical and Cultural Reserve	XV-XIX centuries	Lahij Township, Ismayilli District
15.	Yusif Kuseyir oglu’s tomb	1161-1162	Nakhchivan City
16.	Momina Khatun Sepulchre	1186-1187	Nakhchivan City
17.	Garabaglar Historical and Architectural Complex	XII-XIV centuries	Garabaglar Village Sharur District
18.	Gulustan Sepulchre	XIII century	Juga Village, Julfa District
19.	Ordubad Historical and Cultural Reserve	XV-XIX centuries	Ordubad City
20.	“Yukhari Bash” Historical and Architectural Reserve	XVIII-XIX centuries	Shaki City
20.1.	Shaki Palace of Khan	1796	Shaki City
21.	Shusha Historical and Architectural Reserve	XVIII-XIX centuries	Shusha City

Table 2 Immovable Historical and Cultural Monuments of National Importance (Archaeological monuments)

Inventory No.	Name of Monument	Date	Location
22.1-22.1060	Gobustan State Historical and Literary Reserve (ancient residential area and drawings on cliffs	Mesolithic – Middle Ages	Garadagh District, Baku
23.	Old Ganja	Middle Ages	Near the city of Ganja
24.	Chalagantapa Residential Area	Neolithic Age	Afatli Village, Agdam District
25.	Leylantapa Residential Area	Neolithic Age	Guzanli Village, Agdam District
26.	Uzarliktapa Residential Area	Bronze Age	Agdam City
27.	Ancient Residential Area and Cemetery (Choban Dashi)	Bronze-Initial Iron Age	Dag Kasaman Village, Agstafa District
28.	Toyratapa Residential Area	Neolithic-Bronze Age	Ashagi Goyjali Village, Agstafa District
29.	Ancient cemetery, temple and residential area	Antique Age	Nuydu Village, Agsu District
30.	Beylagan Residential Area (Orangala)	Middle Ages	South of Kabirli Village, Beylagan District
31.	Old Barda	Middle Ages	Barda District
32.	Niftali Burial Mounds	Bronze Age	Khubyarli Village, Jabrayil District
33.	Alikopaktapa Residential Area	Neolithic Age	Uchtapa Village, Jalilabad District
34.	Khoshbulag Burial Mounds	Latest Bronze-Initial Iron Age	Khoshbulag Village, Dashkasan District
35.	Shabran	Middle Ages	Shahnazarli Village, Davachi District
36.	Gilgilchay Fortifications Complex	Middle Ages	The bank of Gilgilchay River, Davachi District
37.1.-37.3.	I-III Misharchay Residential Area	Neolithic-Initial Iron Age	In the south of Jalilabad City
38.	Azigh Cave Camp	Palaeolithic Age	Fuzuli District
39.	Taglar Cave Camp	Palaeolithic Age	Fuzuli District
40.	Big Castle	Bronze-Initial Iron Age	Soyudlu Village, Gadabay District
41.1-41.2	Sarija Minbarak Necropolis; Minbarak Residential Area and Burial Mounds	Neolithic, Bronze, Iron Ages	Minbarak Plain, Gakh District
42.	Damjili Cave Camp	Palaeolithic Age	Dashsalahli Village, Gazakh District
43.	Baba Darvish Residential Area	Bronze Age	Damirchilar Village, Gazakh District
44.	Ancient Gabaka City, Salbir Gala	Antique Age – Middle Ages	Gabala District
45.	Sargartapa Residential Area	Bronze Age	Sargartapa, Khachmaz District

Inventory No.	Name of Monument	Date	Location
46.	Chanakhir Hills	Antique Age – Middle Ages	Chanakhir Village, Khachmaz District
47.	Khojali Burial Mounds	Bronze-Initial Iron Age	Khojali District
48.	Temple	Latest Bronze – Initial Iron Age	In the west of Zazali Village, Khanlar District
49.1-49.2	Borsunlu Burial Mounds and Temple	The Bronze-Initial Iron Age	Borsunlu Village, Tartar District
50.	Ancient Shamakhi City	Antique Age – Middle Ages	Shamakhi City
51.	Kish Residential Area; Kish Temple	Antique Age – Middle Ages	Kish Village, Shaki District
52.	Ancient Shamkir City	Middle Ages	Near Shamkir City
53.	Ruins of the ancient Nakhchivan City	II millennium BC – Middle Ages	Nakhchivan City
54.1.-54.3.	Gyzilbulag Residential Area; I-II Gyzilbular Praying Houses	Bronze Age	Gyzilbulag Village Babek District
55.1.-55.2.	Aznaburd Tower; Aznaburd Burial Mounds	Bronze Age	Aznaburd Village, Babek District
56.	I Kultapa Residential Area	Neolithic-Bronze Age	Kultapa Village, Babek District
57.	II Kultapa Residential Area	Neolithic-Bronze Age	Ashagi Uzunoba Village, Babek District
58.	Alinja Fortress	VII-XII centuries	Khanegah Village, Julfa District
59.	Relics of Kharabagilan City	Latest Bronze-Initial Iron Age	Yukhari Aza Village, Ordubad District
60.	Damjili Cave Camp	Palaeolithic Age	Tananam Village, Sharur District
61.	Batatapa Residential Area	Antique Age	Yurdchu Village, Sharur District
62.1.-62.3.	Kultapa Residential Area; Garabulag Necropolis; Second Makhta Kultapa	Bronze Age	Makhta Village, Sharur District
63.1.-63.2.	First Shahtakhti Temple; Second Shahtakhti Temple	III-I millennium BC	Shahtakhti Village, Sharur District
64.	Oglangala Residential Area	Bronze Age – Initial Iron Age	Oglangala Village, Sharur District

Table 3 List of Historical and Cultural Reserves

Yukhary-Bash Reserve of History and Culture in Sheki Town
Gobustan State Reserve of History and Art
Gabala State Reserve of History and Culture
Ordubad State Reserve of History and Architecture
Icheri Shekher State Reserve of History and Architecture
Shusha State Reserve of History and Architecture
State Reserve of History and Culture in Lagich Village
State Reserve of History and Ethnography in Kala Village
Zakatal Reserve of History and Culture
Ganja Reserve of History and Culture
Avey State Reserve of History and Culture in Gazakh Region
State Reserve of History and Culture in Baskal Village
Gulistan State Reserve of History and Architecture
Nardaran State Reserve of History and Architecture.

HYDROGEOLOGY BASELINE

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1 INTRODUCTION

1.1 SCOPE OF REPORT

The purpose of this report is to provide a description of groundwater conditions along the proposed pipeline route in Azerbaijan,

The report considers specifically the hydrogeological characteristics of the proposed pipeline corridor (using Route 09 as the baseline case), and is based on existing reports, expert opinion and recent geotechnical investigations.

1.2 SOURCES OF INFORMATION

The following sources of information have been used when compiling this report:

- Excursions to the field in April and October 2001, focussing on the area of the Karayazi wetland and the Ganja-Kazakh Piedmont Plain
- Results of analysis of sediment samples collected during field trips, performed by Caspian Environmental Labs of Baku
- Discussions with Azerbaijani specialists, in particular, Dr F Aliyev, Dr A Alekperov, Dr I Tagiev (State Committee for Geology, Ministry of Environment and Natural Resources), Dr R Israfilov (Institute for Geology) and Dr N Katz
- Results of Shah Deniz midstream geotechnical investigations (Gibb 2001)
- Relevant portions of the Environmental Impact Assessment for the Western Route Export Pipeline
- Reports compiled for BP by Dr F Aliyev (2001) and Dr Tagiev and Dr Alekperov (2001)
- Published geological (Nalivkin et al. 1976) and hydrogeological (Aliyev et al. 1992) maps
- Records of exploration boreholes (pumping test results, geological logs), maps and sections provided by the State Committee for Geology
- Published scientific literature (see Section 4, References), and international guidance documents available via the Internet
- Findings of other RSK employees, communicated in written form to the author

2 HYDROGEOLOGICAL CONDITIONS ALONG THE PIPELINE ROUTE

2.1 CLIMATE, TOPOGRAPHY AND HYDROLOGY

The main climatic, topographic and hydrological factors relevant to the hydrogeology of the study area are summarised below, from the reports by Kashkay and Aliyev (*undated*) and Ali-Zadeh et al (*undated*).

As the proposed pipeline corridor traverses Azerbaijan from the semi-desert areas in the east to the more temperate west the following changes are noted:

- Climate becomes somewhat cooler and potential evapotranspiration declines. Typical potential evapotranspiration rates are generally high along the whole route at some 600-800mm/annum
- Average annual precipitation increases from 150mm in the east to some 400mm at the Karayazi wetland area
- River flow seasonality becomes more pronounced, with peak flows in May, related to snowmelt in the Lesser Caucasus
- Soils and waters become less saline

A major source of river flow generation and groundwater recharge is precipitation falling as rain or snow in the Lesser Caucasus, with annual precipitation rates of some 800mm/annum. According to Musaev and Panakhov (1971), some 45-51% of the discharge of these rivers derived from groundwater, some 35-38% snowmelt and some 14-18% rainfall.

In the area containing the major fresh groundwater reserves (west of Yevlakh), the following right-bank tributaries of the Kura are crossed, draining from the Lesser Caucasus (from E to W):

- Indjachay
- Goranchay (mean discharge 2.4m^3/s)
- Kurekchay
- Karasuchay (mean discharge 4.2m^3/s)
- Ganjachay (mean discharge 4.61m^3/s)
- Shamkirchay (mean discharge 8.56m^3/s)
- Dzhegamchay (Zayamchay) (mean discharge 5.66m^3/s)
- Tovuzchay (Tauzchay) (mean discharge 0.91m^3/s)
- Hasansuchay

The flow in the above rivers is highly seasonal. For example, the maximum flow in the Shamkirchay is estimated as 127m^3/s, the minimum as 0.95m^3/s. Low flows are typical in December-February with peak flows between April and June.

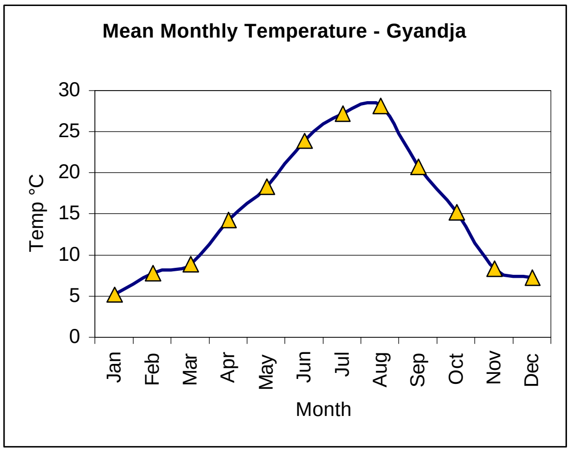
The rivers typically have a relatively high pH of around 8 and an electrical conductivity in excess of 600µS/cm. According to Musaev and Panakhov (1971), the waters are mostly of Ca-HCO_3 type.

These rivers are associated with thick alluvial fan outwash deposits, which contain a high proportion of pebbly/gravelly material and which contain significant fresh groundwater resources.

Table 2-1 shows monthly average near-surface temperatures from a meteorological station in Ganja. Assuming that subsurface/groundwater temperatures reflect annual average air temperature, a subsurface temperature in Ganja of some 15-16°C might be expected.

Table 2-1 Average near-surface monthly temperatures, Ganja, for the year 1999

Month	Temp. °C
Jan	5.1
Feb	7.8
Mar	8.8
Apr	14.3
May	18.4
Jun	23.8
Jul	27.3
Aug	28.2
Sep	20.7
Oct	15.2
Nov	8.4
Dec	7.3



2.2 OVERVIEW OF GEOLOGY

In the following description, a brief overview of the setting of the Caucasus area is given, based on descriptions by Nalivkin (1960), followed by a more detailed description of strata in the Ganja-Kazakh area (the focus of most hydrogeological interest), based on descriptions by Musaev and Panakhov (1971). The following specific Azerbaijani terms should be noted:

- Maikop Suite - a series dominated by alternating sands and clays originating from the late Palaeogene (Oligocene) to early Neogene (Miocene)
- Sarmat - a time corresponding to Late Miocene
- Akchagil Suite - a dominantly argillaceous series, comprising clays with sands, silts, conglomerates and volcanogenic strata, of Pliocene age
- Apsheron Suite - similar to Akchagil sediments, but more dominated by arenaceous (sandy) facies. Of late Pliocene age

2.2.1 Mesozoic

The geological and hydrogeological context of the proposed pipeline route is defined by the Alpine-Caucasus orogenic (mountain building) event. The mountains of the Caucasus are largely characterised by metasediments and metavolcanics of Palaeogene and Mesozoic ages.

The Jurassic rocks of the Lesser Caucasus in the Ganja-Kazakh area occur in the Mrovdag and Shakhdag Ranges and comprise porphyrites, tuffaceous sandstones, quartzic plagioporphyries, limestones, dolomites, conglomerates and clays/argillites. The Cretaceous of the area comprises a basal conglomerate, limestones (sometimes marly or sandy), sandstones, argillaceous shales, volcanogenic formations (porphyrites, tuffaceous conglomerates and sandstones).

2.2.2 Palaeogene

The Lower Palaeogene is characterised by flysch deposits and marine shales with some limestones and volcanics. In the Upper Palaeogene in the Lesser Caucasus, molasse-type deposits comprising mudstones, sandstones and conglomerates, with thick volcanic sequences, become dominant (Nalivkin 1960).

In the Ganja-Kazakh area, Palaeocene deposits occur extensively in the Ganjachay-Indjachay interfluve area and comprise marly limestones, marls, marly clays, sandy marls and sandstones. Eocene deposits are well developed in the foothills of the Lesser Caucasus and comprise marls and marly clays with layers of sandstone and, in some places, volcanogenic deposits. Beneath the Ganja-Kazakh Piedmont Plain, Palaeocene and Eocene deposits are encountered in boreholes, at depths of some 300-350m depth near Akstafa, and at 1050-1210m depth at the River Kurekchay (Musaev and Panakhov 1971).

Oligocene deposits (the lower part of the Maikop Suite) are widely distributed in the Ganja-Kazakh area and comprise sandy/clayey deposits of some 2000m thickness (Musaev and Panakhov 1971).

2.2.3 Neogene

In the Neogene, the latest phases of orogenic activity reached maximum intensity and a transition from dominantly marine to dominantly continental environment occurred. On the Kura Plain, for example, Neogene sediments of terrigenous "molasse" type, resulting from the erosional denudation of the Caucasus, reach 6000-7000m thickness (Nalivkin 1960).

In the Ganja-Kazakh area, the Lower Miocene (the upper part of the Maikop Suite) is expressed as alternating clays and sandstones with layered sands and marls. Thickness varies from 500 to 1500m. In many locations, the full Lower Miocene sequence has been removed by subsequent erosion. Middle and Upper Miocene deposits are only found locally in the foothills of the Lesser Caucasus and are believed to have been eliminated beneath the Ganja-Kazakh Piedmont Plain by subsequent erosion during the prevailing continental regime of Sarmat-Akchagil time (Musaev and Panakhov 1971).

In the Ganja-Kazakh area, the Pliocene Akchagil deposits are dominated by clayey sediments. Commencing with a basal conglomerate, they transgressively overlie older strata. Towards the Lesser Caucasus, the clayey marine facies of the Akchagil becomes progressively more interbedded with a continental facies (clays, sands, sandstones, conglomerates, marl, volcanogenic ash), sometimes to the extent that the marine facies disappears (Musaev and Panakhov 1971).

Similarly, the Pliocene Apsheron deposits are also represented by marine (clays with layers of sand/sandstone) and continental (more arenaceous and conglomeratic) facies in the Ganja-Kazakh area. The Apsheron is transitional from marine to continental, both in time (becoming more continental with time) and geographically (becoming more continental towards the foothills of the Lesser Caucasus, where the Apsheron comprises thick conglomerate sequences). Beneath the Quaternary deposits of the Ganja-Kazakh Piedmont Plain, only the Lower Apsheron is marine. The overlying continental analogue of the Apsheron is transitional into the continental, alluvial and proluvial deposits of the Quaternary (Musaev and Panakhov 1971).

2.2.4 Quaternary

During the Quaternary, the Caucasus (especially the Greater Caucasus) experienced valley and mountain glaciation, resulting in moraines and fluvioglacial deposits. Thick alluvial/proluvial plains developed at the foot of the mountains, forming (for example) the inclined Ganja-Kazakh Piedmont Plain (Nalivkin 1960).

Most of the important groundwater reserves are contained within the Quaternary, and the detailed structure of these deposits will be dealt with in the following sections.

2.3 OVERVIEW OF HYDROGEOLOGY

Despite the importance of groundwater in Azerbaijan, only limited hydrogeological information is readily available for the proposed pipeline route, although a number of hydrogeological cross-sections and maps are held by the State Committee for Geology. Few hydrogeological analyses for Azerbaijan have been published in the accessible international literature. This contrasts strikingly with the wealth of publications on the petroleum geology of Azerbaijan and the hydrogeology of neighbouring Caucasus Republics, including aquifer modelling and the relationships of groundwater levels and spring discharges to precipitation receipts and seismic activity.

The essential elements of the hydrogeological conditions along the proposed pipeline corridor are summarised below, from the hydrogeological map of Aliyev et al. (1992), discussions with the State Committee for Geology and the reports of Tagiev and Alekperov (2001) and Banks (2001):

The proposed pipeline corridor largely lies within a fault-bounded intermontane trough between the Lesser Caucasus and the Greater Caucasus. The Lesser Caucasus south of the Ganja-Kazakh area is composed of Jurassic and Cretaceous "bedrock", comprising sandstones, tuffs, limestones, shales, breccias, porphyries etc., and contains some fresh groundwater resources. These are not of immediate relevance to the proposed pipeline.

The intermontane trough between the Lesser and Greater Caucasus is filled by a succession of Neogene and Quaternary sediments. The sediments in the immediate subsurface are of three main types:

- Outwash/alluvial fan sedimentation generated by erosion of the Lesser and Greater Caucasus mountain chains, comprising thick layers of rather poorly sorted sands, gravels and cobbles, with finer-grained silty/clayey interlayers. This type of sedimentation becomes more dominant towards the west and in the proximity of the mountains. These sediments are often called *proluvial* in Soviet terminology
- Marine sedimentation, becoming more dominant towards the east
- Modern, Kura-river alluvial deposits

In the western end of the intermontane trough (near the Georgian border) and along the foothills of the Greater and Lesser Caucasus, the proluvial/alluvial sediments would be expected to be generally more dominated by coarser-grained horizons, with a greater degree of interconnection between potential aquifer horizons. Towards the centre of the trough and away from the Caucasus foothills, coarse-grained sediments would be expected to become less dominant and aquifer horizons would be expected to have a lesser degree of connectivity. The map of Aliyev et al. (1992) confirms that alluvial fan sediments in the foothills of the

Lesser Caucasus are 90% comprised of pebble-sized clasts. In the upper Kura valley, this proportion is somewhat lower at 75-90%, and in the lower Kura valley <25% (Figure 2-2).

Figure 2-1 Hydrogeological map for the western Azerbaijan

INSERT A3 MAP

Figure 2-2 Proportion of pebbles in Quaternary aquifer horizons

INSERT A3 MAP

The distribution of coarse-grained sediments in the alluvial fan deposits is likely to be governed by the complex interplay of several factors:

- The development and lateral migration of rivers flowing out of the Caucasus ranges
- Episodes of fault motion and orogenic uplift increasing hydraulic gradients and producing higher energy erosional environments
- Climatic fluctuations (eg melting of ice caps following Quaternary glacial periods) would also produce high-energy environments for erosion and transport of coarse-grained material. In fact, the extremely poor sorting of the proluvial sediments and the large range of clast types suggest that the sediments may be *fluvioglacial* (ie derived from reworking of glacial deposits) rather than purely fluvial (K Richardson, BP, *pers. comm. 16/10/01*)

As a result, any attempt to systematise the sediments into laterally extensive, separate, strata-bound aquifer horizons is very problematic. Tagiev and Alekperov (2001) indicate this and therefore divide the sediments into aquifer complexes. The Quaternary aquifer sediments of the intermontane trough can be divided (Aliyev et. al. 1992) into:

- Upper Continental Quaternary Aquifer Complex $K(Q_{II\text{-}IV})$ of Upper and Middle Quaternary age
- Lower Continental Aquifer Complex $K(N_2^3\text{-}Q_{I,IV})$ of Upper Pliocene and largely lower Quaternary age

These may in turn be underlain by Neogene sediments of the Apsheron (continental) and Akchagil (continental and marine) complexes. These Neogene sediments also outcrop at the surface, especially in the core of the intermontane trough between the Greater and Lesser Caucasus, forming linear ranges of hills, for example, around Lake Mingechaur and on the northern bank of the Kura west of Lake Mingechaur.

In the western end of the intermontane trough (near the Georgian border) and along the foothills of the Greater and Lesser Caucasus, recharge would be expected to occur largely from infiltration of water in rivers flowing off the Caucasus ranges onto the Quaternary alluvial fan sediments. In these regions, downward head gradients would be expected to be predominant. The ultimate source of recharge is probably thus precipitation and snow melt-water on the Caucasus ranges and foothills. Irrigation water and direct infiltration of precipitation to the proluvial sediments will also be sources of recharge.

In the central and eastern part of the intermontane trough, upward head gradients are likely to be predominant (with artesian heads in deeper aquifer horizons). Direct recharge from precipitation in these areas is likely to be of little importance to the water balance of the aquifer complexes, owing to these upwards head gradients and to high evapotranspiration.

One would expect a greater thickness of unsaturated zone in the foothills of the Caucasus and a lesser thickness below the plains in the centre of the trough.

Groundwater flow in the intermontane sedimentary aquifer complexes is generally from the Caucasus foothills towards the Kura and from the west to the east. This is shown by the contours on Figure 2-1.

Groundwater quality is freshest in the coarse sediments of the recharge areas at the foothills of the Caucasus. It becomes more progressively more saline towards the lowlands and towards the east. Its hydrochemical type changes from HCO_3^- to $SO_4^=$ or even to Cl^- (Musaev and Panakhov 1971). This is shown on Figures 2-1, 2-3 and 2-4b. This salinisation process is probably related to two main factors:

- Progressive salinisation along flow pathways owing to water-sediment interaction (gypsum dissolution, interaction with residual salts in marine sediments)
- Lower rainfall and higher evaporation in the central plains. Evapotranspiration of water during recharge and from shallow groundwaters increases contents of dissolved solids

Fresh groundwaters are dominantly of bicarbonate, bicarbonate-sulphate or bicarbonate-chloride type. Brackish waters in the central part of the intermontane trough (Shirvan Plain) may be of bicarbonate, sulphate or chloride-dominated. Saline waters in the eastern part of the country are typically chloride type.

2.4 HYDROGEOLOGY OF PIPELINE SECTIONS, BASED ON EXISTING DATA

2.4.1 Sangachal-Kazi Magomed Section

Morphologically, this section comprises (Gibb 2001):

- KP0-6: a coastal plain, with shallow wadi courses, until a scarp feature at KP6
- KP7-13: raised plateau feature comprising clays and silts underlain by shallowly dipping mudstones
- KP13-23.5: a flat piedmont plain at the base of the Touragai mud volcano
- KP23.5-28.5: steep rugged topography of the Gotur mud volcano ridge
- KP28.5-41: flat alluvial plain with saline silt and clay soils
- KP41-50.5: low hilly area with dominantly silty and clayey soils, ending with a low scarp at Kazi-Magomed

In this section of the route, exposed lithologies comprise Quaternary sediments of continental, mud-volcanic and "diluvial"/marine facies, overlapping Tertiary sedimentary rocks of the Apsheron and Akchagil formations (Aliyev 2001).

The sub-soils in this section are generally of low permeability (silts, clays), while borehole and trial pit logs from the Shah Deniz geotechnical investigations give no indication of significant laterally continuous aquifer horizons. The section is characterised by varied elevation, ravine and gully systems and the occurrence of mud volcanoes. Some borehole logs (BH-A1b, BH-A4) provide evidence of volcanic mudflow-derived horizons.

According to Aliyev (2001), the route does not traverse any significant groundwater reserves in this section, and such limited groundwater reserves as do occur are highly mineralised. Average annual precipitation is approximately 100 - 250mm/annum. Yearly precipitation is usually considerably less than potential evapotranspiration, the latter being extremely high because of strong solar radiation receipts, high temperatures, low atmospheric humidity (average 12.4 - 14.6%) and high wind speeds in the region. Very little recharge of groundwater resources, therefore, is thought to be taking place under present climatic regimes.

Limited reserves of low-mineralisation groundwater may occur and are typically found in association with the narrow alluvial deposits of rivers (eg the Pirsagat River). Occasionally hand-dug wells or springs based on small pockets of fresh groundwater may be used by nomadic or local peoples (although generally, in the arid east of Azerbaijan, water is often tankered in and sold by the bucket - Wolfson and Daniell 1995). Other scarce fresh groundwater sources are mainly related to outcrops of limestone which are occasionally confined by low permeability clay layers. Such resources are clustered mainly in an arc to the north-east of the Pirsagat river, which includes the Dagni nomad camp. These are not thought to conflict with the proposed pipeline corridor.

In summary, groundwater vulnerability is regarded as low in this region.

2.4.2 Kazi Magomed -Yevlakh section (Shirvan Plain)

This section of the proposed pipeline route crosses the flat, semi-arid Shirvan Plain, underlain dominantly by Pliocene-Quaternary proluvial, "diluvial" deposits and alluvial deposits of the Kura river system (Aliyev 2001). In general, sediments tend to be dominated by fine grain sizes, as evidenced by geotechnical borehole and trial-pit logs. Coarse-grained sediments are typically associated with river outwash systems, such as that of the Alazan-Agrichay.

Between KP146-150, the route runs north of the West Karasu Bog. From KP156 westwards, the Plain becomes more barren and saline and halophilic plants become evident. This area was, however, extensively farmed in the Soviet era. The Plain is dissected by many irrigation channels of 2 to 5m depth, which are especially dense between KP153-158, KP191-200 and KP203-206. The Geokchay and Turianchay canals cross the route at KP171 and KP193, which subsequently revert to natural meandering river systems. The soils become more fertile once again and are being farmed towards the River Kura, whose floodplain, with abandoned channels and oxbow lakes, occurs between KP 216-226 (Gibb 2001).

Aliyev (2001, undated) argues that the vulnerability of groundwater resources in this section to potential pollution by oil products is low, simply because extensive fresh groundwater resources are not perceived to exist. Along the proposed pipeline route, groundwater mineralisation is typically in the range 5-100g/l. The water table is generally within 3m of the ground surface over 90% of the area of the Shirvan Plain, partially owing to protracted infiltration of irrigation water from canal systems. On the proposed pipeline route, only in the regions of Kurdamir and Shakyar-Kobu is the groundwater level expected to be deeper, approximately 5-10m bgl (Aliyev 2001).

According to Aliyev (2001), horizontal groundwater head gradients on the Shirvan Plain are low (0.03 to 0.0007) and decrease in the direction of the Kura River. The thickness of significantly transmissive strata also decreases towards the Kura and is believed to be of the order of 10-20m in the proposed pipeline corridor. Hydraulic conductivities are believed to be 0.1 to 3m day^{-1} in the water-bearing strata.

Below only around 5% of the area of the Shirvan Plain can groundwater resources be classified as "fresh" (<1g/l mineralisation, Aliyev 2001) and these lie topographically above the level of the proposed pipeline corridor and are not vulnerable to contamination.

Specifically, the route across the Shirvan Plain can be divided into two hydrogeological sections, according to Aliyev (2001):

1. Kazi-Magomed to Karasu/Padar/Sigirly railway stations which are underlain by alluvial-diluvial and proluvial-diluvial deposits of clays, silts and silty sands. Groundwater levels are typically at 2-3m depth and the groundwater mineralisation is 40-85g/l, being dominated by sodium chloride, with high sulphate concentrations.

2. Sigirly to Kura crossing and Yevlakh where silts, silty sands and sands predominate. Here the landscape is characterised by irrigated farming. In some sections, the water table is very close to the surface and conditions are swampy and saline, especially between Udzhari and the Kura River. On the River Kura floodplain itself, sandy strata occur, often below clayey surficial strata (Gibb 2001).

According to Aliyev (2001), three artesian aquifer complexes are recognised below the shallow, "quasi-unconfined" aquifer complex of the Shirvan Plain. Water in these is typically highly mineralised (5-10g/l). In these, generally upward vertical head gradients prevail, providing protection from contamination.

In general, therefore, there is not perceived to be any risk to significant groundwater resources in this zone of the proposed pipeline route, owing to (a) the poor aquifer characteristics of the sediments and (b) the saline nature of the groundwaters. However, there may be the possibility of small areas of fresh groundwater being present along the courses of major rivers (eg the Kura alluvium) and adjacent to freshwater irrigation canals. Also, there is the possibility that small pockets of fresh groundwater or seepage areas may exist which are too small to have been flagged up by the State Committee for Geology. These may, however, be very important as watering places for local herdsmen (e.g. a seepage area, near the main road, some 3-4 km west of the Goranchay River crossing at N40°38’46.7” E46°45’35.0”).

In general, the vulnerability of groundwater reserves in this area is regarded as low.

2.4.3 Yevlakh

In the western part of Yevlakh, unconfined and confined groundwaters occur in the alluvial deposits of the Kura River (whose alluvial plain extends to around KP244.5, according to Gibb 2001) and in marine deposits. Shallow groundwaters are encountered at depths of only 1-2m below ground level (bgl), typically in sands and loamy sands with hydraulic conductivities of 0.1 to 3m day^{-1}, and are usually highly mineralised (10-15g/l mineralisation of sodium chloride/sulphate type). Confined aquifers of sands and loamy sands are encountered at 50-200m bgl, and contain brackish waters (1.2-1.5g/l) that are widely used for a variety of purposes including potable supply. The confined aquifers are typically isolated from the surface by at least 10m of clay (Aliyev 2001).

2.4.4 Yevlakh-Poylu Section (Ganja - Kazakh Piedmont Plain)

The section, on the southern side of the Kura, between Yevlakh/Geranboi and the Kura river crossing at Poylu, traverses a small part of the *Karabakh Plain* (between Yevlakh and Mingechaur Station) and the Ganja-Kazakh Piedmont Plain. The latter region is essentially underlain by alluvial fan (*proluvial*) deposits with a high proportion of coarse-grained permeable sediment, containing fresh groundwater resources. Recharge to these is believed to be derived from precipitation (41%) and by infiltrating river waters (32%), although irrigation waters (22%) and inflow from mountain zones (5%) are also significant (Tagiev and Alekperov, 2001).

On the Ganja-Kazakh Piedmont Plain, the aquifer horizons here are conventionally divided (Tagiev and Alekperov 2001) into one upper, partially unconfined aquifer complex (Russian *gruntovaya voda*) and four confined aquifer complexes (Russian *napornii vodonosnii gorizont*), largely on the basis of stratigraphic proximity of aquifer horizons with similar water chemistry. These subdivisions are largely symbolic and arbitrary as the real structure of the aquifer is complex with many alternating coarse and fine layers that vary laterally. Ultimately, the sedimentary succession must be viewed as a single unit. Recharge occurs in the foothills of the Lesser Caucasus, where deposits are coarse and aquifer levels are to a greater or lesser degree interconnected. Further north, towards the Kura, aquifers become more confined and separate in nature and deeper confined aquifers may even develop artesian heads. Indeed, uncontrolled artesian overflowing boreholes in such aquifers are used for irrigation.

2.4.4.1 Upper, unconfined aquifer

The uppermost, largely unconfined aquifer complex (according to the conventional subdivision) is the most potentially vulnerable to pollution incidents (Tagiev and Alekperov 2001). It comprises gravels, cobbles and pebbles, with sandy, silty interlayers, in its proximal facies in the foothills of the Lesser Caucasus, becoming finer grained towards the River Kura. Figure 2-4a shows typical depths to the shallow water table. It will be noted that depths to groundwater are greatest (often >25 m) in the interfluves between the rivers draining from the NE slope of the Lesser Caucasus, especially:

- Each side of the Ganjachay
- Between the Kurekchay and Goranchay
- The interfluves between the Shamkirchay and Akstafachay Rivers

The shallowest depths to groundwater (<5 m) occur:

- Immediately north of Geranboi, possibly partly owing to infiltration from the Upper Karabakh Canal
- In the valleys of the rivers draining the NE slope of the Lesser Caucasus, especially the Kurekchay, Tovuzchay, Hasansuchay and Akstafachay
- In the Kura valley where, in places, the water table intersects the surface, swamping the land

Groundwater level hydrographs (Annex 2) suggest that water level fluctuations are low in magnitude. Where seasonal trends can be identified (wells 57/4 and 81/2, Annex 2), groundwater level maxima are seen around April-May.

Recent groundwater level data independently collected from geotechnical boreholes (Gibb 2001) broadly supports the groundwater level interpretation given in Figure 2-4a. Groundwater flow is generally from the SW to NE (ie, toward the Kura, Figure 2-1), except in the east where groundwater flow tends to be towards the east, owing to obstruction of flow by the low-permeability Bozdag hills.

The upper aquifer complex sediments are exposed in gravel pits and erosional ravines containing the major rivers flowing from the NE slopes of the Lesser Caucasus. The coarsest deposits comprise sub-angular to moderately well-rounded cobbles and pebbles set in a matrix of silt, fine sand and medium sand (in some cases up to coarse sand). Deposits as a whole are generally poorly sorted and this may lead to a somewhat lower hydraulic conductivity than would otherwise be expected from deposits of this clast size. A thin layer (1-2m thick) of brown clayey silty material (fine sand according to the State Committee for Geology) typically overlies coarser transmissive aquifer deposits in interfluve areas, but is breached in river valleys. Silty/fine sand interbeds are noted within the aquifer succession. Exploration boreholes drilled in connection with the Shah Deniz midstream geotechnical program suggest that in interfluve areas, good thick coarse sand, gravel or pebble sequences are not especially common in the upper c. 20m of the succession. In the valleys of rivers such

as the Koshkarchay, Karasuchay, Shamkirchay, Dzegamchay and Tovuzchay, sand/gravel units are found in the immediate subsurface, implying greater connectivity, vulnerability and transmissivity in the main river valleys. The hydraulic conductivity of aquifer facies typically ranges from 0.1 to 13.4m day^{-1} and the transmissivity from 3 to 1600 m^2/d (see Table 2-2). The highest values of transmissivity are observed in the central part of the alluvial fans of the Dzegamchay and Shamkirchay rivers (Tagiev and Alekperov 2001). Records of test pumping of exploration boreholes No. 47 to 64 (provided from the archives of the State Committee for Geology) suggest typical values of hydraulic conductivity of around 10m day^{-1}. However, it should be noted that A. Alekperov and F. Aliyev (State Committee of Geology, Azerbaijan Ministry of Environment, pers. comm. minutes of meeting, 3/9/01) cite hydraulic conductivities of 20-100m day^{-1}ay (average 20-40m day^{-1}ay) as being typical of coarse proluvial aquifer sediments in this area.
Figure 2-4b shows the total mineralisation of groundwaters of the upper aquifer unit. As regards water quality, fresh (<1g/l mineralisation) groundwater is present in the upper aquifer horizon beneath almost the entire area. Areas of brackish water occur just north of Akstafa and some distance NE and NW of Ganja. To the north and east of Geranboi, salinity increases rapidly. As regards contamination, the quality of groundwaters in the aquifer complex is generally good. Limited nitrogen contamination is stated to occur near livestock farms and other contamination near the Ganja aluminium factory (Tagiev and Alekperov 2001).

2.4.4.2 Confined aquifers

Deeper confined aquifer complexes in this area generally have favourable hydraulic characteristics for groundwater abstraction and contain good-quality water over the majority of the area. These units are not believed to be especially vulnerable to oil contamination from the proposed pipeline owing to their depth and the presence of aquitard horizons separating them from the upper, unconfined aquifer complex.

While dominantly remaining fresh and $Ca\text{-}HCO_3$ dominated, there is some tendency with increasing depth and increasing distance along flow pathways, to acquire $Na\text{-}SO_4^{=}$ or even Na-Cl character. Some of the deeper artesian boreholes yield saline Na-Cl waters with a salinity of several thousand mg/l. Some of these boreholes also contain dissolved H_2S at concentrations exceeding 20 mg/l and significant concentrations of dissolved methane (Musaev and Panakhov 1971).

2.4.4.3 Abstractions

There are reported to be more than 2000 abstraction wells in the Ganja-Kazakh Piedmont Plain, with typical depths of 100-150m. They generally abstract from the first confined and, to a lesser extent, the unconfined aquifers (and, less commonly, the second confined aquifer). In the south-eastern part of the Plain, they also abstract from the fourth confined aquifer. In recent years, the total rate of production of subsurface waters for the entire Piedmont Plain was between 820,000 and 1,130,000 m^3/d (9,500 to 13,100 l/s). In the early 1980s the annual production exceeded 1,600,000 m3/d (18,500 l/s). Besides production wells, groundwaters are also abstracted by springs, karizes (qanats) and horizontal drains that are constructed in stream valleys. The abstracted waters are mainly used for irrigation purposes by farms and private persons, although groundwater also provides drinking water supply to Ganja, Tovuz and Shamkir towns and the majority of rural settlements (Tagiev and Alekperov 2001, see Table 2-3). Locally approved reserves of exploited groundwater exist in this complex (see Figure 2-3), namely:

- Alluvial fan of the Ganjachay river, for water supply to Ganja

- In the valley of the Akstafachay river, for water supply to the settlements of Kazakh and Akstafa regions
- In the valley of the Dzegamchay alluvial fan, for water supply to settlements of Tovuz Region
- The Dzegamchay-Djagirchay interfluve, for water supply to settlements of Shamkir Region
- The fan of the Ganjachay river, for water supply to settlements of Samukh and Khanlar regions
- The fan of the Kurekchay river, for water supply to settlements of Geranboi region

In the Ganja-Kazakh Piedmont Plain, more than 300 karizes were known in the unconfined aquifer by Musaev and Panakhov (1971), with a total flow of >6000 l/s. These typically yield fresh water of mineralisation < 1g/l and of $Ca\text{-}HCO_3^-$ type (occasionally $Ca\text{-}SO_4^{=}$).

Figure 2-3 Hydrogeological map of confined aquifers of Azerbaijan

INSERT A3 MAP

Figure 2-4a Depth to groundwater (g/l) in the 1st aquifer horizon (unconfined aquifer) of the Gyandja-Kazakh Piedmont Plain and Karayazi Plain

INSERT A3 MAP

Figure 2-4b Mineralisation of groundwater in 1st aquifer horizon (unconfined aquifer of the Gyandja-Kazakh piedmont plain and Karayazi plain

INSERT A3 MAP

2.4.4.4 Yevlakh - Geran Station

As far as local details are concerned, between Yevlakh and Geran Railway Station, shallow and confined aquifer horizons are ubiquitous, although the latter are too deep to be of practical importance. Shallow groundwaters occur at depths of 0.4-12m bgl, however, typically in silts, silty sands and sands, with hydraulic conductivities in the range 0.1 to 0.7m day^{-1}. Mineralisation is high, ranging from 3 to 25g/l. Flow is towards the east, owing to the Bozdag Hills obstructing northwards flow to the Kura (Aliyev 2001).

Goranchay - Ganjachay

Further west, towards the Ganjachay, confined and shallow aquifers become valuable sources of water, occurring in gravels/pebbles and sands, with hydraulic conductivities of 3 - 20m day^{-1}. The depth to shallow groundwater ranges up to 25-30m (see Figure 2-4a), while the mineralisation increases downgradient from fresh up to 10g/l. In the proposed pipeline corridor, however, waters are generally fresh and used for potable supply, e.g. from "subartesian" aquifers near the villages of Safikud, Dalimamedly and Geranboi. In this region, aquitard strata between unconfined and "confined" strata do not possess as low hydraulic conductivity as elsewhere, potentially rendering the aquifer sequence vulnerable to contamination (Aliyev 2001).

2.4.4.5 West of Ganja

Still further west, along the route north of Ganja, between Ganjachay and Shamkirchay, a surficial layer of silty sands some 2 to 5m thick occurs, with a depth to groundwater of up to 5-10m bgl in the foothills of the Bozdag range. Here mineralisation may be as high as 1-3g/l (Aliyev 2001).

Continuing west, fresh groundwater in shallow and confined aquifer horizons is ubiquitous. Shallow groundwater often occurs in alternating sands and silt strata, although aquifers of pebble and gravel are associated with the main river valleys: Ganjachay, Goshgarchay, Shamkirchay, Dzegamchay, Tovuzchay, Akstafachay and Kura (Aliyev 2001).

Table 2-2 Characteristics the shallow "quasi-unconfined" and the upper two confined aquifer complexes of the Ganja-Kazakh Piedmont Plain (after Tagiev and Alekperov 2001)

	Unit	Aquifer Complex			
		Shallow, "quasi-unconfined"		1st Confined	2nd Confined
Depth to top of complex	m bgl	-		9.0-138.00	38.5-218.0
Water level	m	54.2-0.3		(-)77-(+)15.5	(-)70-(+)10.6
Absolute level of piezometric surface	m OD	-		441.4-33.8	400.0-40.0
Hydraulic gradient		Akstafachay-Hasansu interfluve	0.03 to 0.007	0.03-0.003	0.01-0.003
		Hasansu-Tovuzchay interfluve	0.05 to 0.007		
		Tovuzchay-Dzegamchay interfluve	0.01 to 0.011		
		Dzegamchay-Ganjachay	0.03 to 0.008		

	Unit	Aquifer Complex			
		Shallow, "quasi-unconfined"		1st Confined	2nd Confined
		Remaining part of the plain	0.1 to 0.004		
Yields of (exploration) wells	l/s	0.1-33.3		0.2-39.7	0.05-28.3
Specific yields of wells	l/s.m.	0.02-10.8		0.02-3.38	0.03-2.7
Thickness of aquifer	m	4.0-138.0		4.0-134.0	6.5-129.5
Hydraulic conductivity	m/d	0.1-13.4		0.25-50.6	0.7-21.4
Transmissivity	m^2/d	3-1600		14-1675	8-990

Table 2-3 Production of groundwater by administrative regions from the aquifers of the Ganja-Kazakh Piedmont Plain (after Tagiev and Alekperov 2001)

Administrative Regions	Abstraction of groundwater, various years $10^3 \times m^3/d$	Usage of subsurface waters, %		
		For public and drinking purposes	For production and technical purposes	For irrigation
Akstafa Region	20 - 48	14	3	83
Kazakh Region	24 - 59	43	17	40
Tovuz Region	70 - 75	17	12	40
Shamkir Region	190 - 290	10	12	78
Samukh Region	206 - 255	10	8	82
Geranboi Region	238 - 312	3	4	93
Yevlakh Region	20 - 41	25	19	56
Ganja City	48 - 52	57	30	13

2.4.5 Poylu - Georgian Border (Karayazi aquifer complex)

The topography of the north bank of the Kura in this area appears to be related to underlying geology and comprises successive ridges of hills trending ESE-WNW. These ridges correspond with successively older terraces of the River Kura.

2.4.5.1 Kura alluvial floodplain

Firstly, the current Kura alluvial flood plain appears, in the Poylu area, to comprise moderately-to-well-rounded pebbles and cobbles in a matrix of silt to medium sand. In places this is overlain by 10-20 cm of silty material, assumed to represent the current flood plain deposits. The current River Kura alluvial deposits must this be assumed to represent a good aquifer unit. Groundwaters are fresh and shallow (Figure 2-4a).

2.4.5.2 Quaternary alluvial-proluvial aquifer complex

To the north-east of the modern Kura flood plain, there is a flat area/”terrace” stretching from Salakhli, through Karayazi to Sadikhli and Boyuk Kasik, and hosting the Karayazi wetland. It is this feature which the proposed corridor traverses for much of its length between Poylu and the Georgian border. The geological map designates it as "Modern" alluvial deposits of the Kura River.

This area appears to be underlain by a complex of sedimentary deposits (gravel/pebbles/cobbles in a silt/sand matrix, with interlayers of silty/clayey material) of alluvial and probably (at depth) also proluvial derivation. In many places, a surficial layer of silt or clay is observed.

The complex contains fresh groundwater. According to Aliyev (2001), the depth to water table in the unconfined aquifer ranges from near zero up to 37m in the hills of the NE. Figures 2-4a and 2-5a illustrate depth to groundwater in the Karayazi Plain, although it will be noted that there are considerable inconsistencies between the two maps in places. This is likely to be because the map in Figure 2-5a utilises, at least in part, data from very deep boreholes whose water level may not represent the unconfined water table. Both maps do, however, indicate that the water table in the upper unconfined part of the aquifer is shallow (<5 m) over large areas, and is, in places, shallow enough to support wetland areas of ecological value. Fieldwork undertaken in December 1996 at the Karayazi wetland indicated that pool water was clear (turbidity 2.36 NTU), alkaline (pH 7.82) and not highly mineralised (electrical conductivity: 665$\mu S.cm^{-1}$).

When groundwater level contours are reduced to metres above sea level, it appears that the general direction of groundwater flow in the unconfined aquifer is parallel with the Kura, from WNW to ESE. In the western part of the Karayazi plain, a hydraulic gradient of some 0.002 appears to be typical.

Deeper (>100 m) parts of the Karayazi aquifer complex are often characterised by artesian heads.

Shallow (3 to 8 m) dug wells in the unconfined aquifer are commonly used by villagers for irrigation and (in Sadikhli) drinking water supply.

There also exist public supply abstraction boreholes at Soyukbulakh. One of these is located at (085-22-783/045-76-264) just south of the railway, and is 120m deep, and operates under artesian pressure. A second public supply borehole of similar depth is reported to be sited in the military compound north of the railway, immediately adjacent to the proposed route at KP 429.5.

Deeper boreholes in the lower part of the complex also support public water supply abstractions: two artesian boreholes of depth 360-380m at (085-16-546E/045-84-384N) supply several thousand villagers at Muganli and Boyuk Kasik with drinking water. These deep boreholes, presumably tapping confined aquifers, are likely to be well-protected in the event of a spill from an oil pipeline (both the WREP and the proposed pipeline route run within a few hundred m of the boreholes).

To the north-east of the railway the land rises in a series of “quasi-scarps” which are likely to correspond, in part, to successively older terraces of the Kura. These are composed of alluvial and proluvial deposits. For example, those immediately north of Boyuk Kasik and Soyukbulakh are observed to comprise large thicknesses of moderately well-rounded pebbles and cobbles in a silt to medium sand matrix, with some silty/fine sand interbeds, and occasional thin beds of cemented pebbles and cobbles. Around Salakhli, a significantly higher proportion of finer-grained sediment appears to be present, especially in the lower “terraces”. In the area to the north of the railway, between Kechveli and Poylu water quality becomes slightly brackish (1-3g/l).

Figure 2-5a Depth to groundwater (m) in the Quaternary aquifer complex of Karayazi plain

INSERT A3 FIGURE

Figure 2-5b Mineralisation of groundwater (g/l) in the Quaternary aquifer complex of the Karayazi plain

INSERT A3 FIGURE

2.4.5.3 Neogene sediments

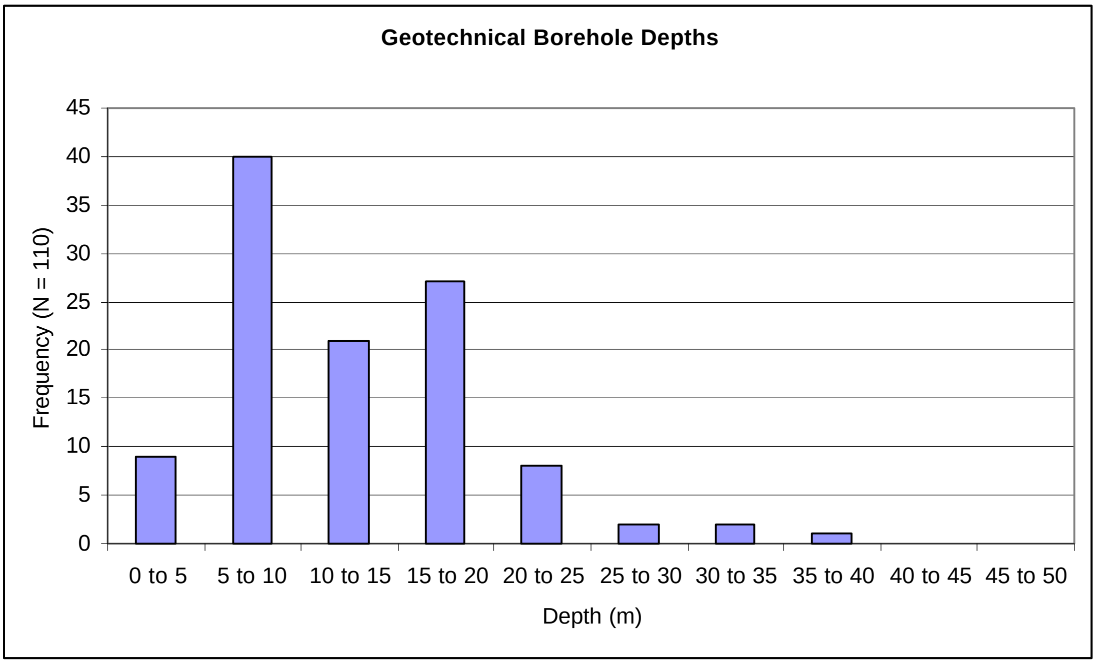
Further to the NE, geological maps indicate that Neogene sediments outcrop. Access restrictions to these areas, owing to presence of military ordnance, did not permit examination of these sediments. These are believed to be dominantly fine-grained. It is noted that the various maps (those of Aliyev et al. (1992) and Nalivkin et al. (1976)) do not wholly agree on the areas of outcrop of the Neogene sediments, or on their hydrogeological significance. The current proposed pipeline corridor (as at Route 09), however, avoids these areas of controversy.

2.4.6 Determinations of aquifer characteristics from geotechnical site investigations

Results from the Shah Deniz midstream geotechnical investigations (Gibb 2001) have been examined, based on a digital preliminary version of all trial pit and borehole logs (provided by K. Richardson, geotechnical consultant to BP, 16/10/01). These comprise:

- c. 112 trial pits, typically to c. 3m depth
- c. 110 investigation borehole logs. The boreholes are generally rather shallow, being less than 40m and, in most cases, less than 20m deep (Figure 2-6)

Figure 2-6 Distribution of depths of investigation boreholes forming the Shah Deniz midstream geotechnical investigations



In general, the geotechnical results support the information gleaned from existing sources in section 2.4 above, with generally fine-grained sands and silts east of Yevlakh (with the exception of coarser-grained alluvial materials in the Kura valley), and coarser sands and gravels becoming more prevalent west of the Goranchay River. It is, however, noteworthy that the investigation boreholes encounter good gravelly/sandy massive aquifer units rather seldom in interfluve areas west of Yevlakh. It may be that the "unconfined" aquifer complex, discussed by local hydrogeologists (Section 2.4.4), over much of this interfluve area comprises, in its upper part, alternating sands, silts and clays rather than a massive gravelly aquifer unit. It may alternatively be that any thick aquifer sequence commences beneath the base of the rather shallow geotechnical boreholes (in which case such an aquifer would be well protected, and may possibly even be partially confined).

In certain locations, however, exploration borehole logs indicate that sands and gravels stretch almost from the surface to the full depth of the borehole. Such boreholes are typically located in major river valleys (eg the Koshkarchay, Shamkirchay, Dzegamchay, Tovuzchay and Hasansuchay). Here, it is believed that coarse, transmissive deposits form the "core" of alluvial fans, and *may* provide a recharge pathway to deeper aquifer horizons.

Section 2.5.1 discusses the uppermost portion of the borehole and trial pits logs (down to 4m depth). Sections 2.5.3 to 2.5.5 use the samples collected from trial pits and entire borehole sections to statistically assess the distribution of hydraulic parameters west of the River Goranchay.

2.4.7 Distribution of sub-soil permeability (to 4m depth) along the pipeline route

Borehole and trial pit logs from the Shah Deniz midstream geotechnical investigations have been examined. The assessment is based on the zone from 1 to 4m depth, as this is believed to be the zone most relevant to possible leakages from a buried pipeline (at 1 to 2m depth). The classification used is based on the following scale:

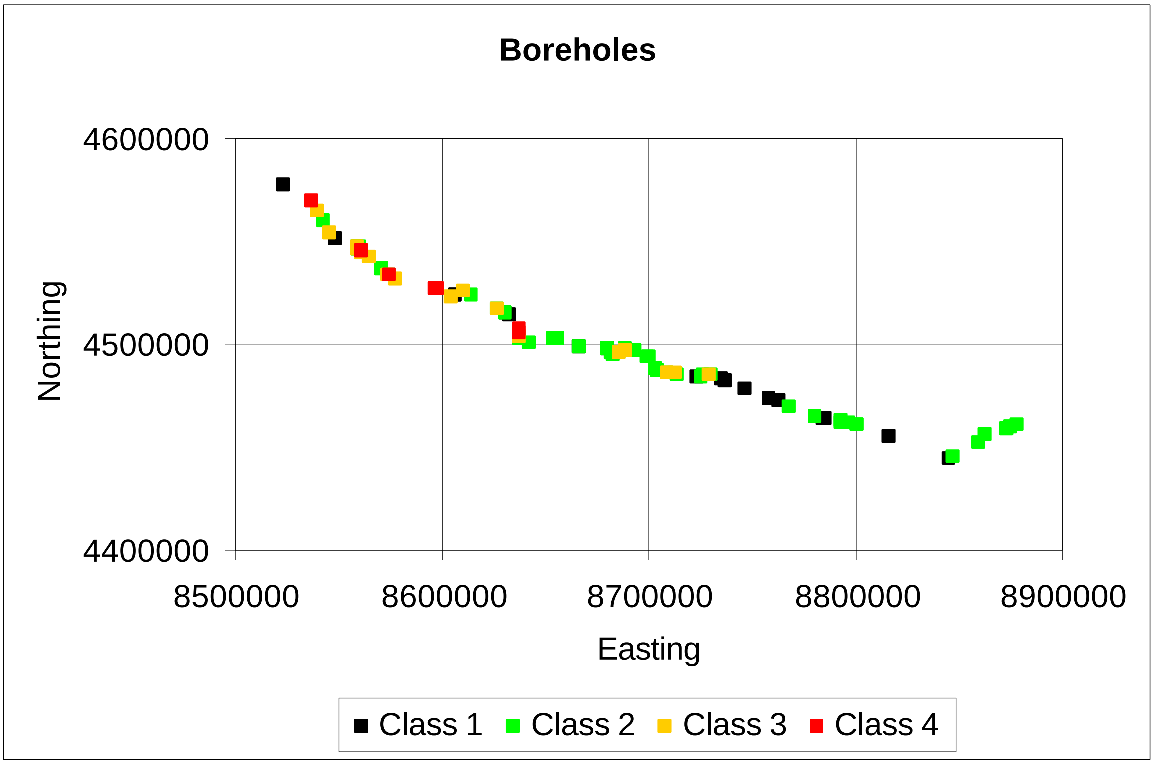
- 1 = very low permeability (clay)
- 2 = low permeability (silt and fine sand)
- 3 = medium permeability (medium to coarse sand)
- 4 = high permeability (gravels/cobbles)
- 5 = very high permeability (fissure flow)

There is clearly a degree of subjectivity in the classification for the following reasons:

- Based on logs, it is difficult to ascertain the degree of sorting (which will have a large effect on permeability)
- Trial pit logs do not reach to 4m, therefore the assessment is made of only a partial profile. Classifications based on borehole data are thus more representative than those based on trial pits
- The relevant section of the logs may contain different lithologies. In most cases, it was decided to err on the side of caution. For example, if the 3m section (1-4m) contains 1.5m silt and 1.5m gravel, the location would receive a rating "4". If, however, the gravel was only a thin bed within silts, a compromise designation of "3" may be chosen

Results are plotted in Figures 2-7a,b to 2-8a,b.

Figure 2-7a,b Classification of subsoil permeability at 1 to 4m depth in Shah Deniz geotechnical boreholes.



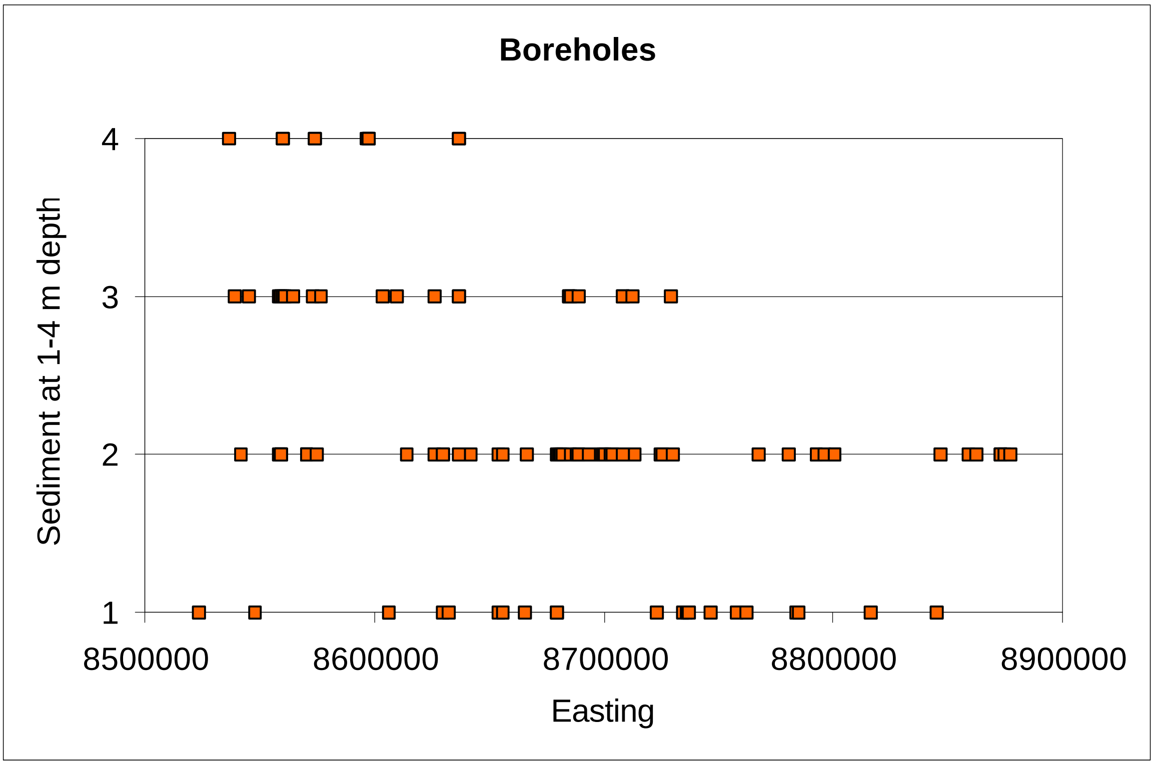
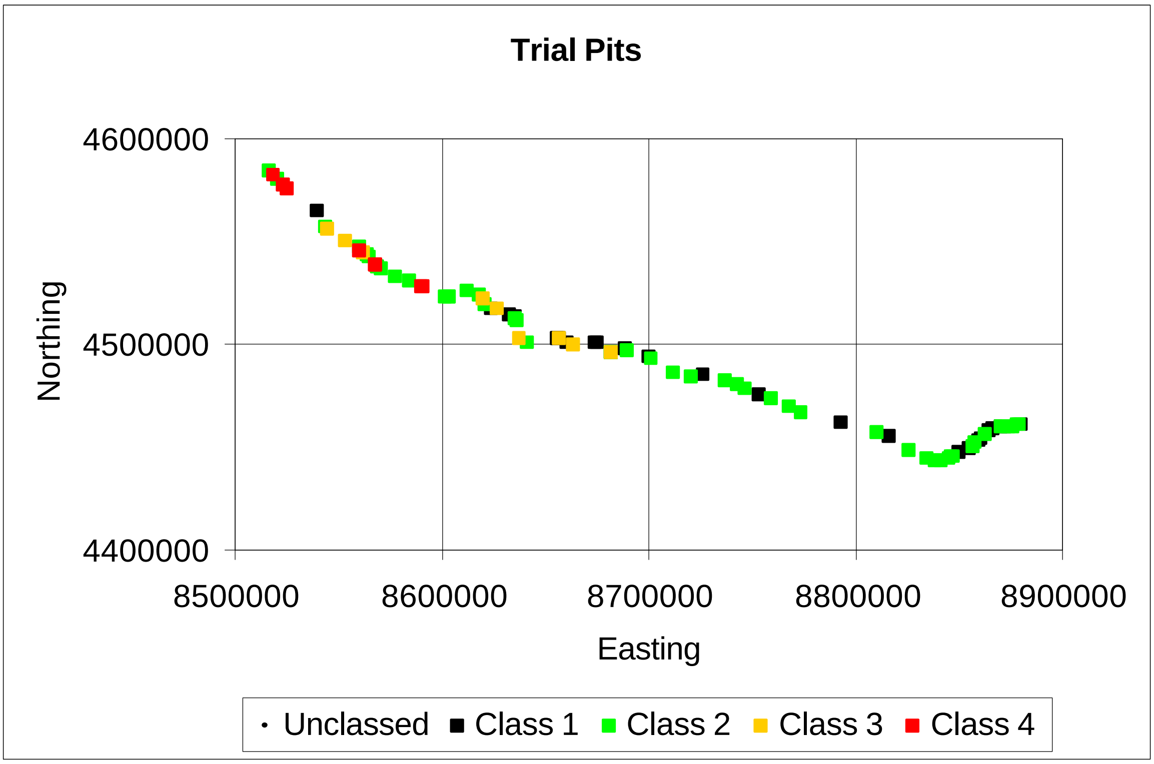
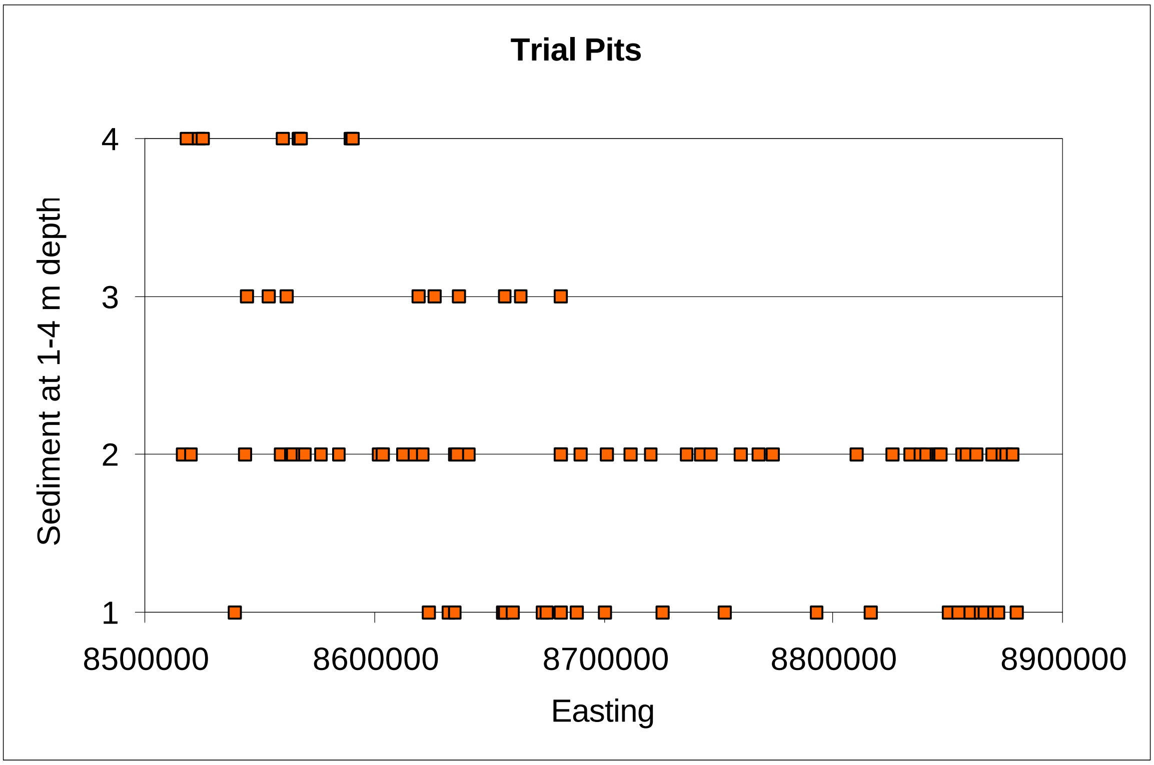


Figure 2-8a,b Classification of subsoil permeability at 1 to 4m depth in Shah Deniz geotechnical trial pits



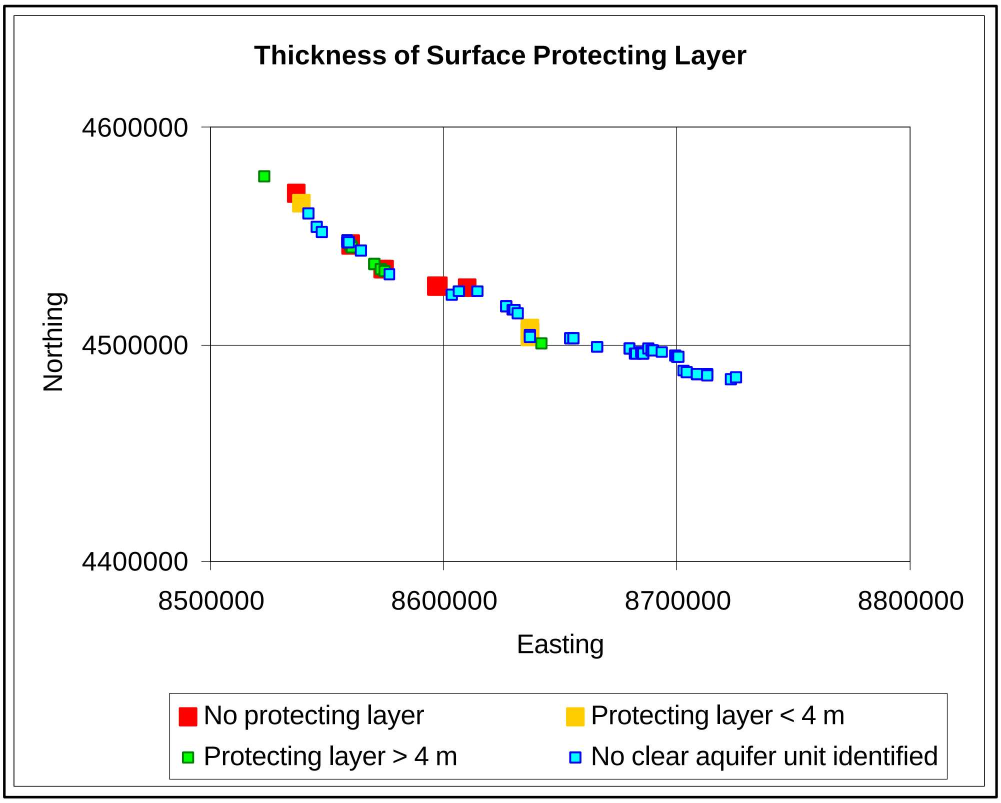


It is clear from Figures 2-7 and 2-8 that the subsoil to the east of the Kura crossing near Yevlakh is largely comprised of fine-grained silts and clays with subordinate sands. West of

Yevlakh, and especially west of Shamkir, the subsoil becomes more frequently sandy/gravelly/cobbly (Gibb 2001), offering less protection to the groundwater environment in the event of a leakage or spill. It will be noted, however, that, in the Ganja-Kazakh Piedmont Plain and the Karayazi section, there are locations where a superficial layer of silty or clayey material several metres thick appears to afford a degree of protection. It is, however, not consistently present. Thus, borehole logs west of the River Kura crossing have been examined to identify the thickness of any silty/clayey protecting layer overlying a major sand/gravel aquifer (Figure 2-9). Boreholes have been ranked in 4 ways:

- 1 = no protective layer. Sand/gravel aquifer exposed at surface
- 2 = protective layer <4m thick above sand/gravel aquifer
- 3 = protective layer >4m thick above sand/gravel aquifer
- 4 = no clear aquifer unit identified in borehole (this could mean that the aquifer unit does not commence until below the borehole base, or that the aquifer here comprises relatively thin interlayers of finer and coarser material, rather than a single unit).

Figure 2-9 Nature of any superficial protective layer overlying sandy/gravelly aquifer material in geotechnical exploration boreholes west of the River Kura.



It is notable that, east of Ganja, it was typically not possible to identify a clear massive sand/gravel aquifer unit within the depth of the borehole. West of Ganja, an "unconfined" sand/gravel aquifer unit becomes more readily identifiable (especially in major river valleys), either with or without any protective superficial layer. However, even here, in a significant number of localities, a clearly identifiable aquifer unit was not identified within the depth of the borehole.

2.4.8 Gypsum and organic carbon content

Gypsum spots, streaks or, occasionally, crystals are present in the soils along the route, with determined gypsum contents in samples ranging from 0.07 to 4 %, with some high values of up to around 9% (Gibb 2001).

Content of organic material was determined on a very limited number of samples along the proposed pipeline route by Gibb (2001), and summarised in Table 2-4. It is assumed (though not specifically stated by Gibb) that these samples are generally clays and silts, rather than gravels.

Table 2-4 Organic content of sediment samples taken along proposed pipeline route by Gibb (2001), expressed as % organic matter.

Chainage KP	Range %	Median %	Location
129	0.62	(0.62)	BVA5
153	0.43	(0.43)	BVA6
90-216	0.43-0.90	0.48	
216-226	0.28-0.62	0.45	
226-244.5	0.22-0.32	0.27	
281-322.5	0.14	(0.14)	

2.4.9 Grain size distribution

Grain size analyses from samples from the boreholes and trial pits of the Shah Deniz midstream geotechnical investigations (Gibb 2001) have been examined (digital preliminary version of trial pit and borehole log data, provided by K. Richardson, geotechnical consultant to BP, 16/10/01). The Beyer method, cited in Langguth and Voigt (1980) and Misund and Banks (1993) has been used to estimate hydraulic conductivity (K), porosity and effective porosity from grain size distributions.

The grain size analyses suggest that such gravelly deposits as are encountered in boreholes and trial pits in the Yevlakh/Akstafa and Karayazi areas are generally rather poorly sorted, with d_{60}/d_{10} ratios in the range 10 to >100. Occasionally, better-sorted coarse-grained gravels occur, with d_{60}/d_{10} ratios in the range 2-10 and very high calculated values of hydraulic conductivity, especially within the valleys of the Rivers Tovuzchay and Shamkirchay,

Figures 2-10 and 2-11 show grain size analyses for samples of gravels and silts/clays with rather typical estimated values of hydraulic conductivity (with the exception of BH-A61/B4, which comprises very coarse gravels in the Tovuzchay valley, yielding an extremely high value of conductivity).

Figure 2-10 Grain size distribution curves for five selected samples of gravel: (i) Borehole BH-A70, sample B2 (4-5m depth), Karayazi, nr. Kechveli, estimated K = 70m day^{-1}, (ii) Borehole BH-A61, sample B4 (6.5-8m depth), River Tovuzchay, estimated K > 1000m day^{-1}, (iii) Borehole BH-A56, sample B1 (0-0.75m depth), near River Dzegamchay, estimated K = 190m day^{-1}, (iv) Trial pit TP-A67, sample B1 (0.2-1m depth), near Hasansuchay, estimated K = 290m day^{-1}, (v) Trial pit TP-A59, sample B3 (1.1-3.1m depth), between Dzegamchay and Tovuzchay, estimated K = 390m day^{-1}.

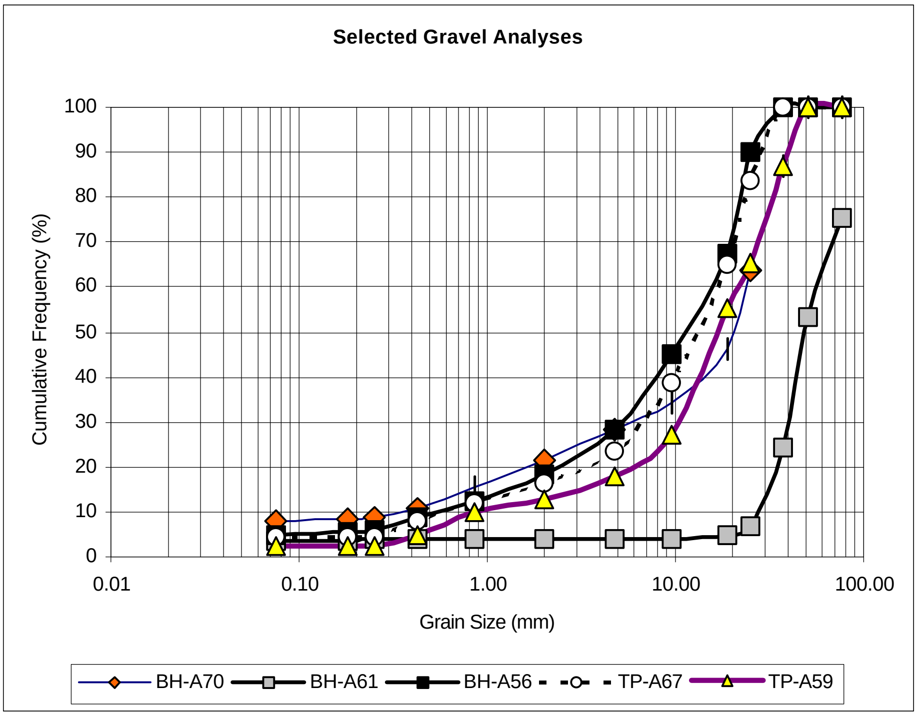
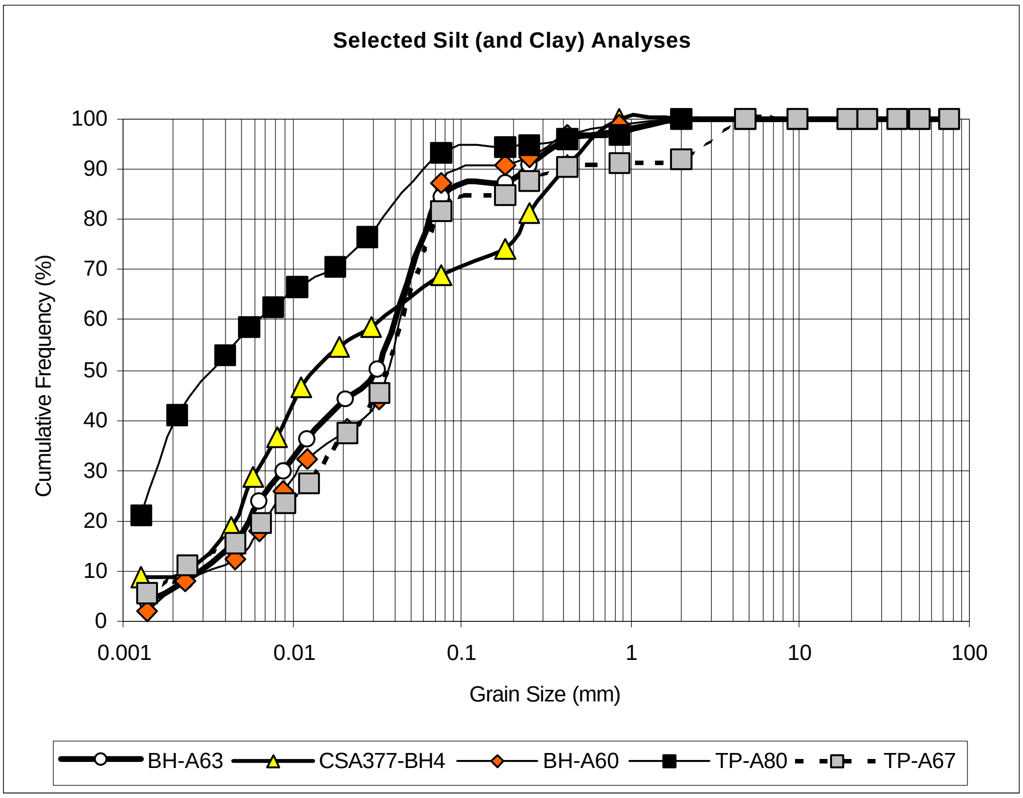


Figure 2-11 Grain size distribution curves for five selected samples of silt/clay: (i) Borehole BH-A63, sample UD3 (silt, 4-4.5m depth), SW of River Hasansuchay, estimated K = 5x10^{-8} m/s, (ii) Borehole CSA377-BH4, sample B1-2 (silt, 2.5-3m depth), NW of River Tovuzchay, estimated K = 4x10^{-8} m/s, (iii) Borehole BH-A60, sample UD1 (silt, 2.5-3m depth), near River Tovuzchay, estimated K = 7x10^{-8} m/s, (iv) Trial pit TP-A80, sample B1 (clay, 0.15-1.05m depth), near Boyuk Kasik, Karayazi, near Georgian border, estimated K = 8x10^{-9} m/s, (v) Trial pit TP-A67, sample B2 (silt, 1.3-2.2m depth), near Hasansuchay, estimated K = 3x10^{-8} m/s.



2.4.10 Saturated hydraulic conductivity

The estimation of hydraulic conductivity is essentially based on the following algorithm:

$K = C.d_{10}^2$

where C is a coefficient depending on the degree of sorting (d_{60}/d_{10}), and d_{10} and d_{60} are the 10th and 60th percentiles of the cumulative grain size distribution curve. The following diagrams (figures 2-12a-c and 2-13) illustrate the distribution of calculated hydraulic conductivities in samples west of borehole BH-A36 and trial pit TP-42a (ie west of River Goranchay).

Figure 2-12a Distribution of hydraulic conductivity (estimated from grain size distributions for samples where d_{10} > detection limit) of samples from boreholes west of the River Goranchay)

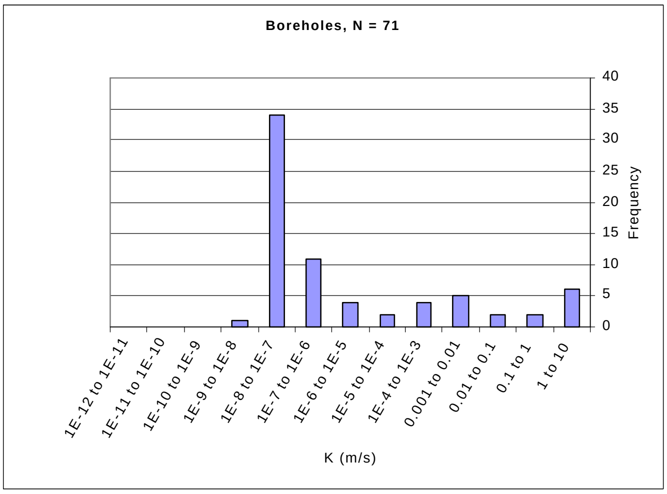


Figure 2-12b Distribution of hydraulic conductivity (estimated from grain size distributions for samples where d_{10} > detection limit) of samples from trial pits west of the River Goranchay)

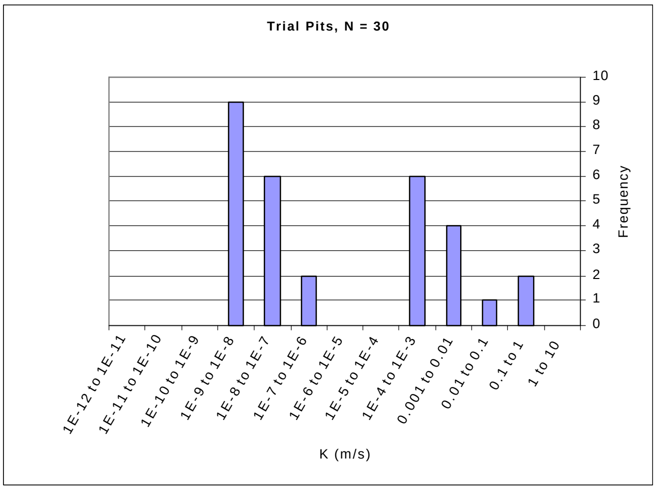


Figure 2-12c Distribution of hydraulic conductivity (estimated from grain size distributions for samples where d_{10} > detection limit) of samples from trial pits and boreholes west of the River Goranchay).

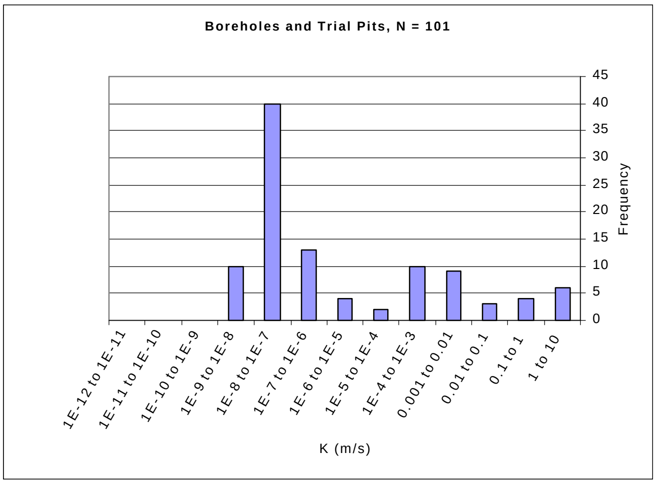
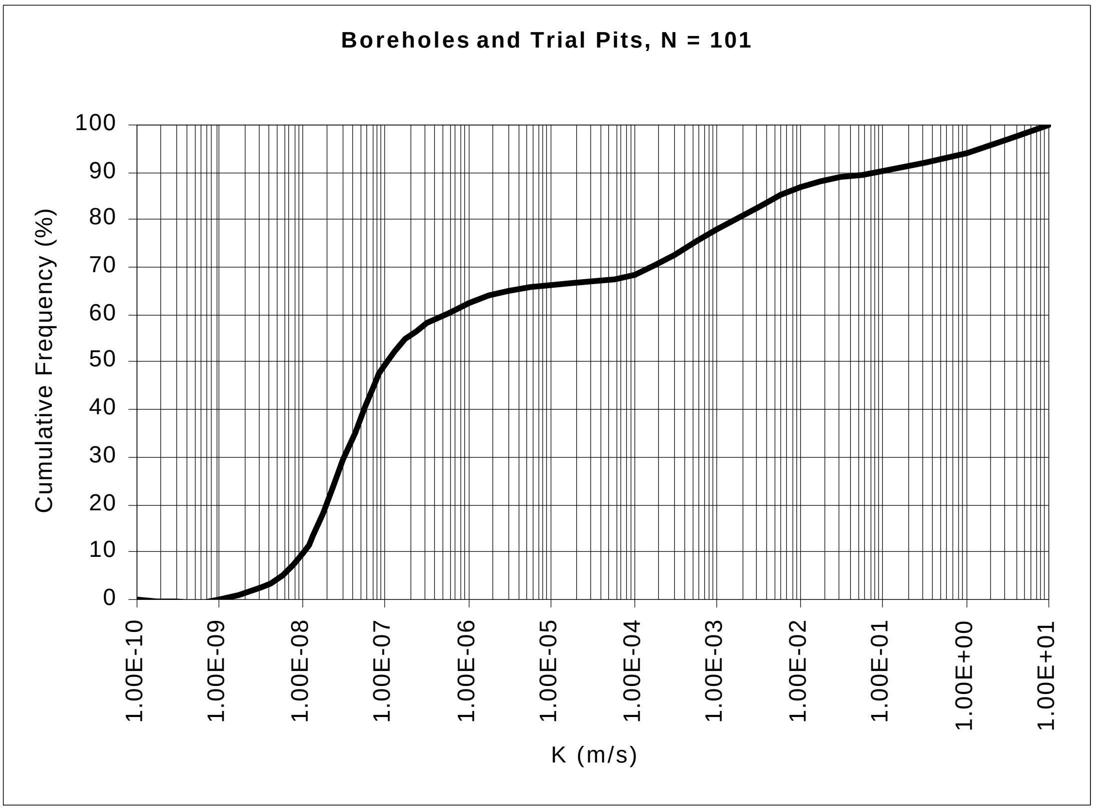


Figure 2-13 Distribution of hydraulic conductivity (estimated from grain size distributions for samples where d_{10} > detection limit) of samples from trial pits and boreholes west of the River Goranchay



The diagrams suggest a bimodal distribution of hydraulic conductivities, with modal values:

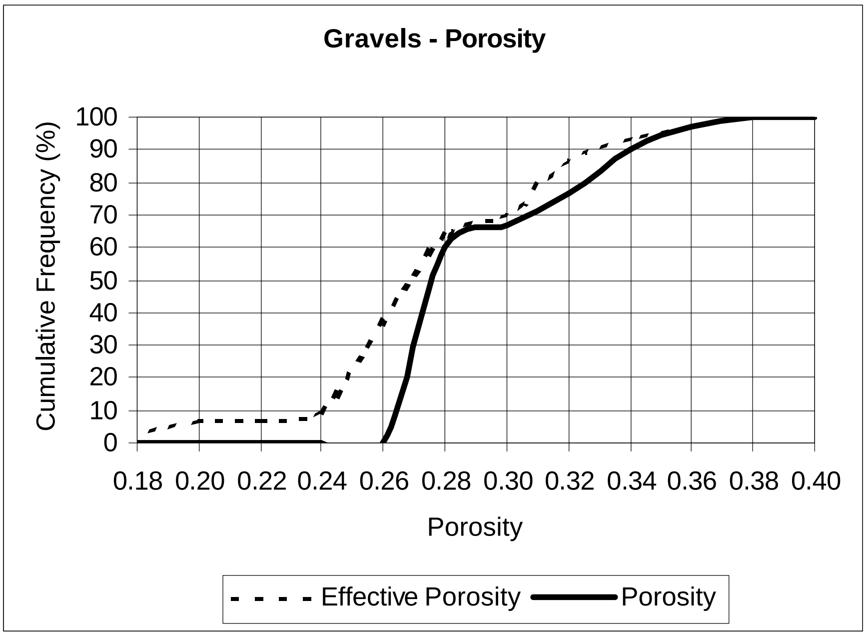
Silt: mode = 3 to 4 x 10^{-8} m/s (3 x 10^{-3}m day^{-1})
Gravel and sandy gravel: mode = c. 1 to 2 x 10^{-3} m/s (86 - 170m day^{-1}), median = 5x10^{-3} m/s (430m day^{-1})

This situation is almost certainly not a true representation of the distribution of conductivities in the ground. Fine-grained samples were determined for particle size by wet sieving and hydrometer, coarse sediments by wet sieving. There are a substantial number of clayey samples with a d_{10} grain size <0.001mm (the lowest category determined by hydrometer measurements), for which it has not been possible to quantitatively estimate hydraulic conductivity. There are also a number of coarser samples where the d_{10} value lies below the smallest sieve size of 0.075mm. Thus, the apparent bimodal distribution, may simply be an artefact of clayey and finer sandy deposits not having d_{10} quantified by the available analytical techniques. Additionally, the very highest gravel hydraulic conductivities are likely to be significantly overestimated, as the Beyer method is not appropriate to such large grain sizes.

2.4.11 Porosity

Porosity and (hydraulically) effective porosity can also be estimated by Beyer's nomograms (Langguth and Voigt 1980, Misund and Banks 1993), although these are only likely to be valid for rather sandy/gravelly sediments. Taking only the gravel strata in samples west of borehole BH-A36 and trial pit TP-42a (ie west of River Goranchay), the distribution of these parameters is shown in figure 2-14.

Figure 2-14 Distribution of porosity and effective porosity (estimated from grain size distributions) of gravel samples from trial pits and boreholes west of the River Goranchay (N=30).



It will be seen that the median gravel porosity is estimated as some 28%, with a median effective porosity of 27%.

2.5 AQUIFER PROPERTIES DETERMINED BY ADDITIONAL ANALYSES (OCT. 2001)

2.5.1 Introduction

In October 2001, fifteen samples of sediment (numbered Az10 to Az24) were collected from the area between Geranboi and the Georgian border at Boyuk Kasik. The samples were collected from the erosional bank cliff of river channels (eg Tauzchay, Shamkirchay, Hasansuchay etc.) or from gravel pits. The samples are typically either of gravels/cobbles or of silty strata, and are typically also collected within three vertical metres of the ground surface. The sample descriptions are given in Annex 1. The quantity of sample collected was typically some 6-7l (c. 15kg) in a sealed bucket, using a stainless steel trowel. The samples were submitted to Caspian Environmental Laboratories (CEL) of Baku, where they were subject to the following analyses:

- Grain size analysis using a combination of dry sieving, wet sieving and pipette determination. This resulted in grain size classes ranging from >4mm to <3.6µm. The method is described in CEL (2001a)
- Determination of carbonate content (by weight loss on hydrochloric acid digestion) and organic matter content (by additional weight loss on ignition at 600°C). The method is descibed in CEL (2001b)
- Sediment-water partition coefficients for benzene were determined at three aqueous concentrations of benzene (100, 500 and 1000µg/l) using a batch method.

Samples Az17 and Az19 were field duplicates.

2.5.2 Grain size distributions

Raw data for the grain size analyses may be found in Annex 1. Figures 2-15a, b, c illustrate graphically the results as diagrams showing cumulative percentage passing each individual sieve size.

Figure 2-15a Cumulative grain size distribution curves (percentage finer than a given dimension) for gravel/cobble samples Az11, 12, 13 and 14, analysed at CEL.

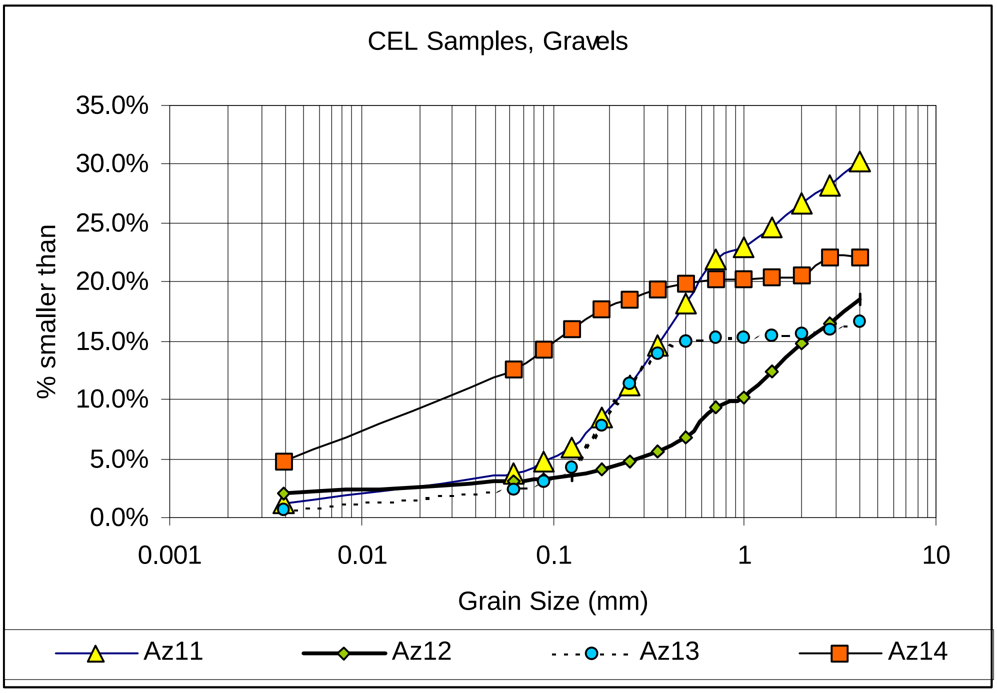


Figure 2-15b Cumulative grain size distribution curves (percentage finer than a given dimension) for gravel/cobble samples Az15, 16, 20, 21 and 23, analysed at CEL

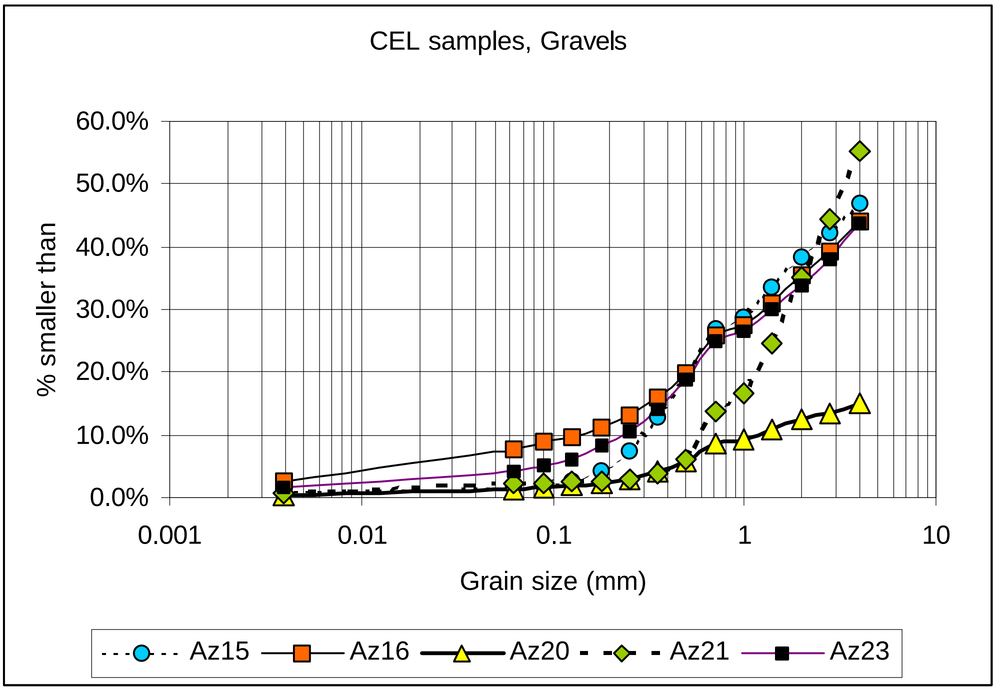
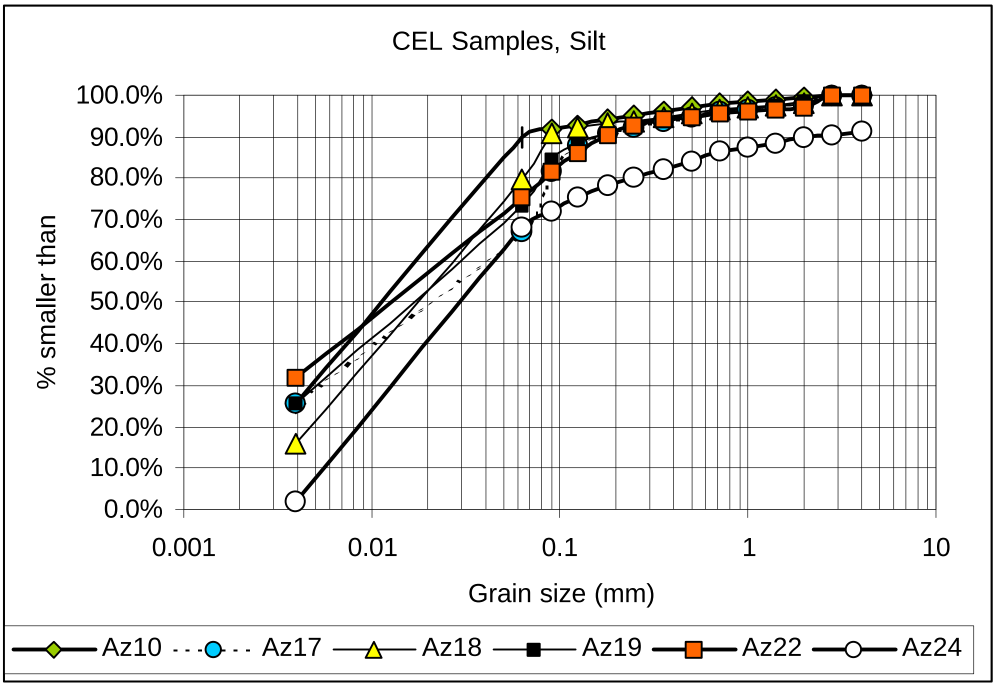


Figure 2-15c Cumulative grain size distribution curves (percentage finer than a given dimension) for silt samples Az10, 17, 18, 19, 22 and 24, analysed at CEL. Az17 and Az19 are field duplicates



2.5.3 Determinations of organic matter and carbonate content

Raw data from these determinations are shown in Annex 1. Table 2-5 summarises the statistical distribution of organic and carbonate content in the silt samples (Az10, 17, 18, 19, 22 and 24) and gravel/cobble samples (Az11, 12, 13, 14, 15, 16, 20, 21 and 23).

Table 2-5 Arithmetic mean (average), median, maximum and minimum values for organic matter (OM) and carbonate contents in silt (N=6) and gravel/cobble (N=9) samples, analysed at Caspian Environmental Laboratory. Organic carbon (OC) is estimated by OC=0.5.OM.

Silts	OM	OC	Carbonate
Average	4.5%	2.3%	22.9%
Median	4.3%	2.2%	22.9%
Max	6.1%	3.1%	28.0%
Min	2.8%	1.4%	18.4%
Gravels	**OM**	**OC**	**Carbonate**
Average	1.1%	0.6%	5.9%
Median	0.9%	0.4%	5.6%
Max	2.3%	1.1%	11.1%
Min	0.4%	0.2%	2.2%

It will be noted that the determinations of organic matter do not tally well with those performed by Gibb (2001) and documented in Table 2-4. It may be that the CEL samples were sampled in a more open environment than the Gibb (2001) samples (which were taken from trial pits/boreholes) and so may have had more opportunity to be contaminated by surficial humic soils. The discrepancy may also be ascribed to analytical error. While the grain size curves and carbonate contents are very similar for the field duplicate samples Az17 and Az19, the organic matter determinations deviate significantly (Annex 1).

2.5.4 Sediment-water benzene partition coefficient

Sediment-water partition coefficients for benzene were determined at three aqueous concentrations of benzene (100, 500 and 1000µg/l) using a batch method. A sediment-water mass ratio of approximately 2:1 was used. The benzene solution-sediment mixture was agitated in sealed vessels for 14 hours, following which the sediment was allowed to settle for 1 hour before the aqueous phase was filtered. The filtrate was analysed by GC-FID. Process blanks were included to determine benzene losses and recovery, and the data in Table 2-6 have been corrected accordingly.

Table 2-6 Soil/water partition coefficients for benzene (ml/g) for four different sediment samples

Sample	Type	Benzene conc. µg/l	Kd ml/g	Average Kd ml/g	Soil characteristics
Az13	Gravel/cobbles	100	0.52	0.36	83.5% >4mm 2.0% organic matter
		500	0.20		
		1000	0.35		
Az18	Silt	100	1.13	1.16	80% <63ìm 0% >4mm 2.8% organic matter
		500	1.71		
		1000	0.63		
Az20	Gravel/cobbles	100	0.27	0.25	85%>4mm 0.4%organic matter
		500	0.15		
		1000	0.33		
Az21	Gravel/cobbles	100	0.61	0.63	44.8% > 4mm 1.4% organic matter
		500	0.53		
		1000	0.76		

Note that the US Environmental Protection Agency cite K_d values of 0.14 to 0.83 ml/g for soils containing 0.1-1% organic carbon. Golder (2000) recommend a value of 0.57 ml/g for sediments with 1% organic carbon. Given that it is generally accepted that K_{oc} lies in the range of several tens of ml/g, the determined values in table 6, suggest that organic carbon contents of around 0.4 - 1.1% are realistic for gravels, and 2.0% for silt. These tally with the organic carbon determinations provided by CEL (section 2.6.3).

3 CONCLUSIONS

3.1 PIPELINE ROUTE

3.1.1 Hydrogeological classification of the pipeline route

The proposed pipeline route has been assessed according to two measures:

1. Soil/subsoil permeability from depth 1m to depth 4m, according to the following scale, using data from the Shah Deniz midstream geotechnical investigations (Gibb 2001):
   Class 1 = very low permeability (clay)
   Class 2 = low permeability (silt and fine sand)
   Class 3 = medium permeability (medium to coarse sand)
   Class 4 = high permeability (gravels/cobbles)
   Class 5 = very high permeability (fissure flow)

2. Groundwater vulnerability, based on type and importance of aquifer, using the following scale:
   Class 1 = Non-aquifer
   Class 2 = Confined aquifer - local importance
   Class 3 = Confined aquifer - regional importance
   Class 4 = Unconfined aquifer - local importance
   Class 5 = Unconfined aquifer - regional importance

In terms of subsoil permeability, it should be noted that there is a degree of subjectivity in the classification for the following reasons:

- Trial pit logs do not reach to 4m; therefore the assessment is made of only a partial profile. Classifications based on borehole data are thus more representative than those based on trial pits
- The relevant section of the logs may contain different lithologies. In most cases, we have chosen to err on the side of caution. For example, if the 3m section (1-4m) contains 1.5m silt and 1.5m gravel, the location would receive a rating "4". If, however, the gravel was only a thin bed within silts, a compromise designation of "3" may be chosen
- The trial pits and boreholes are not evenly distributed along the borehole route, and do not reach a density of one per kilometre. Thus, a significant amount of interpolation between investigation points has been necessary. For example, between KP 414 and KP 426 there is no available geological information
- The route of geotechnical investigation deviates significantly from the latest pipeline route (Route 09) between KP 365 and KP 390

As regards groundwater vulnerability, it should be noted that the applied classification is not ideally suited to the situation along the proposed pipeline route for several reasons:

- It takes no explicit account of water quality (ie whether water is potable or not)
- Along parts of the proposed pipeline route, there may exist a vertical sequence comprising an unconfined aquifer complex and several confined aquifer complexes

- It does not recognise that a deep unconfined aquifer may be overlain by a substantial protective (though not confining) layer of silt and clay, whereas a confined aquifer may be very shallow and confined by only a relatively thin layer of clay

In general, groundwater can be regarded as vulnerable to contamination from pipeline construction or operation where the subsoil permeability is high, and where there exists an unconfined aquifer of local or regional importance.

3.1.2 East of Yevlakh

From KP0 (Sangachal) to the Kura at KP216, there is likely to be little conflict between potential contamination from the pipeline and potable groundwater interests. This is because the subsurface sediments are generally fine-grained, groundwater recharge is very low and groundwaters are saline and not suitable for exploitation as potable water resources. Regional head gradients are also likely to be dominantly upwards. Aliyev (2001) and the published hydrogeological map (Aliyev et al. 1992) support this viewpoint.

Between Sangachal and Kazi Magomed, terrain varies in elevation and is, in places, steep. Sediments are dominantly argillaceous and groundwaters saline. The main exception is in the alluvial deposits of the River Pirsagat, where limited fresh groundwater resources are stated to occur (Aliyev 2001).

On the Shirvan Plain, head gradients are low (0.03 to 0.0007) and decrease in the direction of the Kura River. The thickness of significantly transmissive strata also decreases towards the Kura and is believed to be of the order of 10-20m in the proposed pipeline corridor. Hydraulic conductivities are believed to be 0.1 to 3m day^{-1} in the water-bearing strata. On the proposed pipeline route across the Shirvan Plain, groundwater mineralisation is typically in the range 5-100g/l. The water table is generally within 3m of the ground surface over 90% of the area of the Shirvan Plain, partially owing to protracted infiltration of irrigation water from canal systems. On the proposed pipeline route, only in the regions of Kurdamir and Shakyar-Kobu is the groundwater level expected to be deeper, approximately 5-10m bgl (Aliyev 2001).

Three caveats to the general designation of low groundwater vulnerability in this section should be noted, however:

1. There may exist small (unmapped) pockets or lenses of fresh groundwater along the route. These, if they exist, are likely to be extremely important to local herdsmen, nomads and even villagers in this arid region because fresh groundwater reserves are so scarce.
2. Where permeable strata exist, groundwater resources are likely to be brackish or saline, and thus of little use as a drinking water resource. They may, however, have a potential use as irrigation water (under some circumstances) or as a water resource for industrial use. Such uses of water are obviously less sensitive to contamination than potable usage. However, even such low sensitivity usages will be susceptible to gross contamination by hydrocarbons.
3. Even where usable groundwater resources do not exist, permeable strata in the subsurface may be efficient at transporting spilled or leaked contaminants to surface water receptors such as streams or irrigation canals, where the presence of contamination could have an adverse impact.

In the immediate vicinity of the Kura, high permeability alluvial sediments occur, which are assumed to have potential value as aquifers (KP217-225). Such deposits are also likely to be efficient at transporting spilled or leaked contaminants via the subsurface to the River Kura.

3.1.3 Yevlakh and west

West of the Kura, through Yevlakh and in the western outskirts of Yevlakh, confined aquifers exist which are exploited for reserves of fresh groundwater. This confined groundwater is not believed to be vulnerable to contamination from construction or operation of the proposed pipeline, as it is confined typically by at least 10m of clay. In this area, shallow "unconfined" groundwater is encountered at depths of only 1-2m bgl, typically in sands and loamy sands with hydraulic conductivities of 0.1 to 3m day^{-1}. It is usually highly mineralised (10 - 15g/l) and generally unsuited to potable supply, but may conceivably have applications for industrial usage. The subsurface may also permit spilled hydrocarbons to migrate to surface water recipients, or permit vapours to migrate into dwellings. In general, the sensitivity of groundwater to contamination is regarded as low, however.

Further west, especially west of the River Goranchay, on the Ganja-Kazakh Piedmont Plain, unconfined groundwater becomes progressively fresher and regarded as an exploitable resource. Its vulnerability to contamination thus increases. The aquifer complex here comprises proluvial and alluvial deposits of sands, gravels and cobbles, alternating with silty/clayey interlayers. The complex generally becoming finer grained away from the Lesser Caucasus towards the River Kura. The aquifer horizons here are conventionally divided into one upper, partially unconfined aquifer complex (Russian *gruntovaya voda*) and four confined aquifer complexes (Russian *napornii vodonosnii gorizont*), largely on the basis of stratigraphic proximity of aquifer horizons with similar water chemistry. These subdivisions are largely symbolic and arbitrary as the real structure of the aquifer is complex with many alternating coarse and fine layers that vary laterally. Ultimately, the sedimentary succession must be viewed as a single unit.

On the Piedmont Plain, depths to groundwater are low (<5m) in the Geranboi/Goranchay area and in the valleys of the main rivers. Depths to water table can exceed 25m in interfluve areas. Groundwater is generally fresh (<1g/l mineralisation) except in the area immediately north and north-east of Geranboi. The hydraulic conductivity of the sediments comprising the upper aquifer complex is stated by Tagiev and Alekperov (2001) to be in the range 0.1-13.4m day^{-1}, although discussions with the State Committee for Geology suggest that values of 20-100m day^{-1} may be more typical for the gravelly/cobbly strata.

In the immediate subsurface of interfluve areas of the Ganja-Kazakh Piedmont Plain, there are often layers of silt or clay which will hinder (although not necessarily prevent) the downward migration of hydrocarbons to the water table. Several confined aquifer horizons, with fresh groundwater reserves, also exist beneath most of the area. These are generally not regarded as being vulnerable to potential contamination from pipeline-related activities.

Throughout the Ganja-Kazakh Piedmont Plain, both unconfined and confined aquifers are exploited by wells, boreholes, springs and karizes for potable, irrigation and industrial uses. In recent years, the total rate of production of subsurface waters for the entire Piedmont Plain was between 820,000 and 1,130,000 m^3/d (9,500 to 13,100 l/s). Musaev and Panakhov (1971) reported more than300 karizes in the unconfined aquifer of the Piedmont Plain, with a total flow of >6,000 l/s.

In the valleys of the major rivers (Tovuzchay etc.) draining the north-eastern slope of the Lesser Caucasus, vulnerability of groundwater is regarded as extremely high, for the following reasons:

- The immediate subsurface is generally sandy/gravelly/cobbly, with a high degree of interconnectivity

- The water table is relatively shallow
- The gravels of the immediate subsurface may have been "winnowed" of fine material by fluvial reworking; these deposits may thus be especially permeable

A spill in such valleys may have particularly severe implications because contaminants may migrate rapidly vertically downwards to groundwater resources, down-valley through fluvial sediments or laterally to the surface watercourse through fluvial sediments.

For similar reasons (shallow water table, gravelly/cobbly subsurface strata, highly permeable aquifer strata), large portions of the Karayazi Plain section of the proposed pipeline route are regarded as rather sensitive as regards groundwater contamination. In this area, inhabitants are known to use shallow groundwater for drinking water supply. Shallow groundwater also supports wetland interests of considerable ecological value.

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ANNEX 1 Results of analyses of sediment samples collected in October 2001 and performed by Caspian Environmental Laboratories.

Annex 1, Table 1 Sample locations for samples analysed at CEL

Sample	Pulkova E	Pulkova N	Elevation m asl	Location	Description
Az10	085-86-394	045-27-672	319	Smallish river near Dallar	Sample of bed (c. 1 m thick) of occasionally sandy, pale brown, unbedded silt/clay in 4 m high erosional river bank, c. 20 m south of main road
Az11	085-86-394	045-27-672	319	Smallish river near Dallar	Sample of bed of gravel/pebbles in medium-coarse sandy matrix (with relatively low silt/clay content) in 4 m high erosional river bank, c. 20 m south of main road
Az12	085-93-541	045-20-099	365	River Shamkirchay	Sample of gravel/pebble/cobble strata in rather poorly sorted medium-coarse sandy matrix, with some individual coarse sand layers. From the base of c. 8 m high erosional cliff comprising similar sediments, in west bank of Shamkirchay River c. 100 m south of main road bridge.
Az13	085-16-916	045-85-772	292	Gravel pit north of Boyuk Kasik	Sample of subangular to subrounded gravel/pebbles/cobbles in poorly sorted matrix of fine-medium sand in quarry.
Az14	085-23-988	045-77-845	312	Stream channel N of Kechveli	Moderately well-rounded gravel/pebbles/cobbles in poorly sorted silty/fine sand matrix in eastern erosional cliff of dry valley.
Az15	085-29-649	045-73-956	277	River Kurudere	Subangular to subrounded gravel/pebbles/cobbles in poorly sorted matrix of fine-medium sand in erosional cliff (c. 2-3 m high) in east bank of river, c. 200 m south of road bridge.
Az16	085-42-241	045-52-156	340	River Hasansuchay	Subangular to subrounded gravel/pebbles/cobbles in very poorly sorted matrix of silt-medium sand in erosional cliff (c. 8m high) in west bank of river, c. 20-30 m south of road bridge.
Az17	085-46-378	045-48-098	364	Small stream east of Hasansuchay	Compact, homogeneous clayey light brown silt, c 1.5 m below surface in west cliff of stream, c. 20 m north of road bridge.
Az18	085-54-328	045-39-243	375	River Tauzchay	Sample of c. 2 m thick clayey silt layer at top of 12-15 m high cliffs of west bank of river, c. 20 m north of main road bridge. Sample from c. 2 m below top of cliff.
Az19	085-46-378	045-48-098	364	Field duplicate of Az17	

Annex 1, Table 1 Sample locations for samples analysed at CEL

Sample	Pulkova E	Pulkova N	Elevation m asl	Location	Description
Az20	085-54-328	045-39-243	375	River Tauzchay	Sample of subangular to subrounded gravel/pebbles/cobbles in poorly sorted silt-coarse sand matrix. From c. 3 m below top of 12-15 m high cliffs of west bank of river, c. 20 m north of main road bridge.
Az21	086-07-739	045-10-565	398	Gravel pit just west of Ganja	Subangular gravels (some pebbles) in largely sandy matrix, c. 2 m below original surface.
Az22	086-14-451	045-21-332	212	Excavation for water pipe, Ganja-Yenikend road	Brown fine sandy, clayey silt from c. 2 m below surface
Az23	086-30-388	045-07-327	261	Gravel pit east of Ganja	Pebbles/cobbles in poorly sorted dominantly medium sand matrix with silt/clay. From 5 m below surface in south face of gravel pit.
Az24	086-30-388	045-07-327	261	Gravel pit east of Ganja	Fine sandy silt from surficial silt layer. Sample from c. 1 m below surface in east face of pit.

Annex 1, Table 2. Results of grain size analysis and determinations of organic matter and carbonate content

Size class	Az10	Az11	Az12	Az13	Az14	Az15	Az16	Az17	Az18
>4mm	0.0%	69.6%	81.5%	83.5%	77.8%	53.1%	56.0%	0.0%	0.0%
4 - 2.8mm	0.0%	2.0%	2.1%	0.7%	0.0%	4.7%	4.8%	0.0%	0.0%
2.8 – 2mm	0.5%	1.5%	1.7%	0.3%	1.6%	3.8%	3.7%	2.2%	2.2%
2 - 1.4mm	0.5%	2.1%	2.4%	0.2%	0.1%	4.8%	4.4%	0.7%	0.5%
1.4 – 1.0mm	0.5%	1.7%	2.2%	0.1%	0.1%	4.7%	3.7%	0.6%	0.5%
1.0mm - 710µm	0.3%	0.9%	0.8%	0.0%	0.1%	2.1%	1.6%	0.4%	0.2%
710 - 500µm	1.1%	3.9%	2.6%	0.3%	0.3%	7.1%	5.9%	1.3%	1.0%
500 - 355µm	1.0%	3.5%	1.2%	1.0%	0.5%	6.8%	4.0%	1.0%	1.0%
355 - 250µm	1.0%	3.4%	0.9%	2.6%	0.8%	5.4%	2.9%	1.3%	1.0%
250 - 180µm	1.0%	2.7%	0.6%	3.5%	1.0%	3.1%	1.7%	1.6%	0.7%
180 - 125µm	1.4%	2.6%	0.6%	3.6%	1.7%	1.9%	1.6%	3.1%	0.9%
125 - 90µm	1.0%	1.2%	0.3%	1.2%	1.6%	0.6%	0.9%	6.1%	1.2%
90 – 63µm	1.9%	1.0%	0.2%	0.7%	1.8%	0.3%	1.0%	14.5%	11.0%
3.9-63µm(Silt)	64.4%	2.5%	0.9%	1.7%	7.7%	0.5%	5.1%	41.5%	64.1%
<3.9µm(Clay)	25.5%	1.2%	2.1%	0.7%	4.8%	1.0%	2.7%	25.7%	15.8%
Carbonate %	24.5%	3.2%	3.7%	7.9%	3.4%	7.2%	8.9%	18.4%	21.3%
Organic matter %	4.0%	0.6%	0.5%	2.0%	0.7%	0.9%	2.3%	3.9%	2.8%

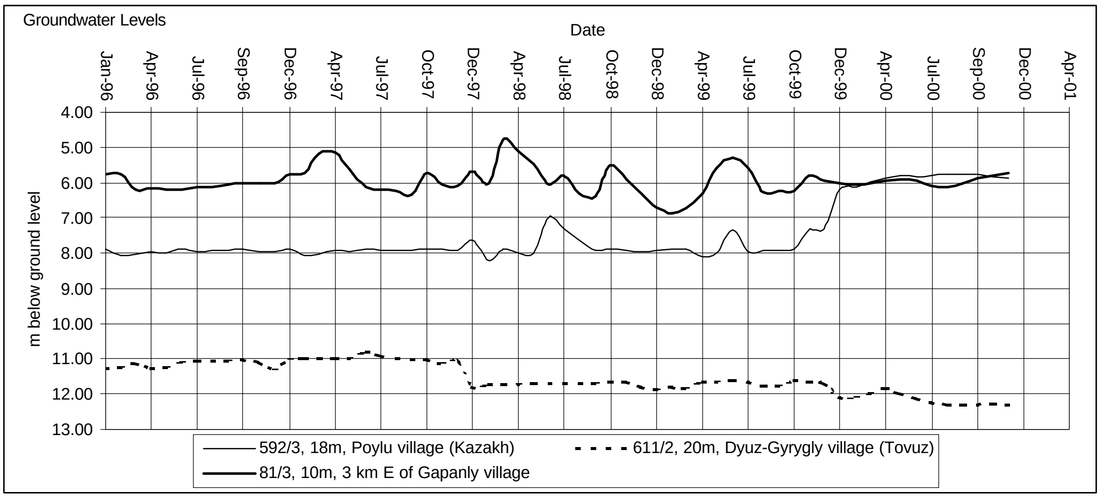
Size class	Az19	Az20	Az21	Az22	Az23	Az24
>4mm	0.0%	85.0%	44.8%	0.0%	56.3%	8.7%
4 - 2.8mm	0.0%	1.4%	10.7%	0.0%	5.6%	1.1%
2.8 - 2mm	1.7%	1.2%	9.4%	3.0%	4.1%	0.5%
2 - 1.4mm	1.0%	1.5%	10.5%	0.5%	3.8%	1.2%
1.4 - 1.0mm	0.9%	1.5%	8.0%	0.5%	3.6%	1.2%
1.0mm - 710µm	0.4%	0.7%	2.9%	0.2%	1.7%	0.6%

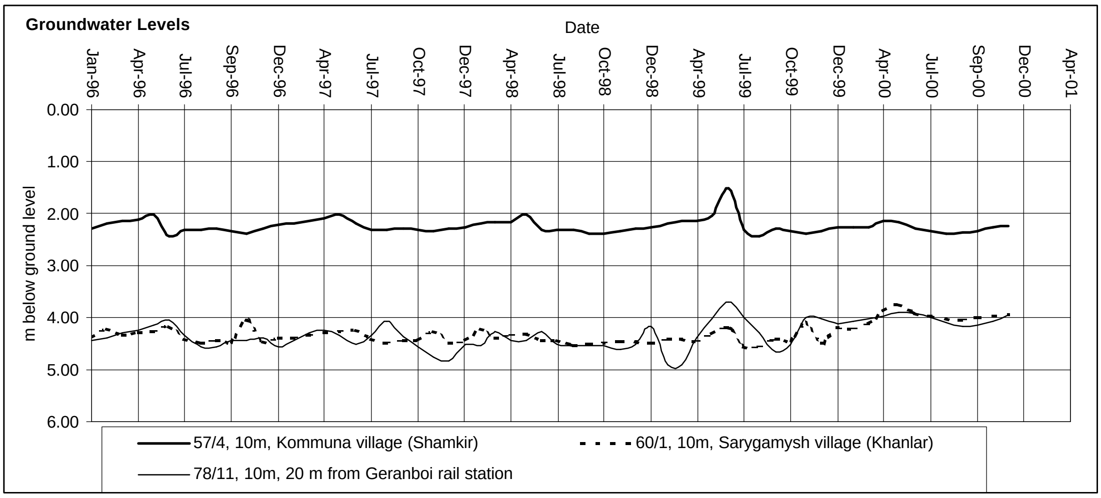
Annex 1, Table 2. Results of grain size analysis and determinations of organic matter and carbonate content

710 - 500µm	1.6%	2.8%	7.6%	0.8%	6.1%	2.4%
500 - 355µm	1.1%	1.7%	2.3%	0.8%	4.7%	1.9%
355 - 250µm	1.2%	1.1%	0.8%	1.4%	3.5%	1.9%
250 - 180µm	1.5%	0.7%	0.4%	2.4%	2.3%	1.9%
180 - 125µm	2.6%	0.5%	0.2%	4.5%	2.1%	3.3%
125 - 90µm	3.5%	0.3%	0.1%	4.1%	1.0%	3.0%
90 - 63µm	11.4%	0.3%	0.1%	6.2%	0.8%	3.9%
3.9-63µm(Silt)	47.9%	0.8%	1.7%	43.4%	2.6%	66.2%
<3.9µm(Clay)	25.4%	0.4%	0.5%	32.1%	1.7%	2.1%
Carbonate %	19.9%	2.2%	5.6%	28.0%	11.1%	25.2%
Organic matter %	6.1%	0.4%	1.4%	4.6%	1.3%	5.7%

ANNEX 2: Groundwater hydrographs from the Goranboy-Kazakh piedmont plain

Well number, depth, location (region)





TRAFFIC ASSESSMENT

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1 TRAFFIC ASSESSMENT

1.1 INTRODUCTION

A traffic census has been carried out and an outline mitigation measures have been developed as part of the ESIA. The purpose of the traffic census is to establish an accurate baseline so that a project specific Transport Management Plan can be developed by the contractor constructing the pipeline. This plan will indicate measures to avoid excessive inconvenience to local traffic.

The objectives of the traffic census are to:

- Define the number of vehicle movements along the key access routes at different times of day.
- Identify if there are any seasonal differences in the level of traffic on certain routes.
- Provide a breakdown of total vehicles on key access routes by type
- Identify key pinch points or restrictions along these access routes (these may physical, cultural or schedule driven)
- Identify key sensitivities along these access routes (e.g. schools, hospitals etc.)

The survey was carried out between 20th November 2001 and 8th December 2001. Supervision of the survey teams was done jointly by Adam Andreski of WSP and Frances Waters of RSK. Surveyors and an additional supervisor were provided by Baku Engineering Contractors (BEC).

1.2 METHODOLOGY

1.2.1 Route Identification

Prior to undertaking the surveys it was necessary to determine appropriate survey points to ensure that the data collected was representative of the likely access routes between the main road network, the pipe dumps and the rail line. Likely access roads from the potential pipe yards and construction camps were identified along the whole of the route through Azerbaijan.
The routes selected were considered to be likely routes. Whilst the pipeline construction contractor will be responsible for the identification of the routes to be used it was considered that the survey points would identify the levels of traffic likely to be experienced and so would be appropriate for identifying the basic nature of the Transport Management Plan.

1.2.2 Baseline Traffic

In order to identify the current levels of traffic on the roads likely to be directly affected by the construction and operation of the pipeline base line surveys to identify the volume and nature of existing traffic were required. Different types of vehicle using the road have different impacts in terms of noise, vibration, speed and amount of highway capacity (and space) required. In order to determine both the volume and type of vehicle using the roads manual classified vehicle counts were required.
Census points were chosen at critical sections where construction traffic would be likely to travel. These included main roads in towns, river crossings, and access roads between pipe dumps, camps and the pipeline. A total of ten traffic surveyors were employed over a two-week period at the end of November and beginning of December 2001. The forms used for the counting are contained in **Appendix A**.
BP’s safety and overseas working regulations do not allow travelling during the hours of darkness, nor the use of non-approved accommodation. This restricted the ability to keep survey staff on site for the 12 hour period and, in general, an 8 hour survey period was completed.
In order to assess the variation in traffic flows throughout the week two survey sites (sites 6 and 61) were surveyed over a seven day period.

1.2.3 Analysis

Following this data collection the following analysis was undertaken:

A Modifying all observations to a common base
B Summarising data for analysis
C Assessment of additional flows generated by the construction and operation phases
D Analysis of total traffic flows
E Determination of highway capacity
F Identifying pinch-points
G Development of management measures

Items a and b are covered in some detail in section 3, whilst section 4 covers the forecasting of additional traffic and the resulting total traffic flows. Items e to g are covered in section 5.

1.3 ANALYSIS OF TRAFFIC DATA

The traffic flow information has been processed so that the data can be compared consistently across all sites and against well-defined capacity standards. The surveys were undertaken on average weekdays and covered an 8 hour period (0900-1700) which represents the busiest times of the day. During the period of the surveys the survey staff had to take comfort breaks on a regular basis. Hourly counts were corrected to allow for no observation of traffic during these periods. For example if 10 minutes were lost in an hour then a correction factor of 60/50 was applied.

Traffic on the roads of Azerbaijan is of a very wide mix. Whilst motorised traffic is extremely common there is still considerable reliance on the vehicles drawn by animals, walking and cycling. These various sorts of traffic have very different impacts on the local environment, the highway pavement and the road capacity. These different users are also differentially sensitive to the impacts of the heavy lorry traffic that will be generated by the construction of the pipeline.

In order to gain a sense of the nature of these problems the traffic observations have been further aggregated as identified in Table 3.1 below.

The “slow” category do not generally take up a considerable amount of the highways capacity but can reduce vehicle speeds and will be very sensitive to increases in heavy goods traffic. Light vehicles will generally move more quickly, take up more road space and could well be disadvantaged by increases in slow moving heavily laden vehicles. Heavy vehicles will be less affected by construction traffic but the existing volumes will have implications in terms of net increases in noise and vibration and impact on pavements.

Table 1.1 - Vehicle classification

Vehicle type	Category
Pedestrians	Slow
Animal Flocks	Slow
Bicycles	Slow
Animal Drawn Carts	Slow
Motorcycles	Light vehicle
Agricultural Vehicles	Light vehicle
Cars/Taxis	Light vehicle
Minibuses	Light vehicle
Buses	Heavy vehicle
Trucks	Heavy vehicle

1.3.1 Average weekday traffic flows

Each of the surveys has been analysed to provide the following information:

- total number of vehicle movements during the survey period
- proportion of each category of vehicle during the day
- level and time of peak traffic flows and composition of that traffic

A table summarising the data is contained in **Appendix B**.

Flows on almost all roads surveyed are very low over the survey period. Minimum two-way flows of less than 100 per day are observed and the maximum flow over the 8-hour period of just over 6000 vehicles. Only two roads (the main and access roads at survey site 50) exceed 4000 vehicles during the survey period.

Vehicle compositions vary greatly between sites. However, almost universally the proportion of slow mode vehicles (pedestrians, cycles, animal drawn carts and flocks of animals) represent less than 15% of roads users on the main routes. This relates to the use of these lesser roads as thorough-fares for local agricultural and industrial activities.

The proportion of heavy vehicles on the most of the roads high with many of the main roads vary from 15-25% of vehicles falling into this category. Many of the proposed access routes also form parts of the local road network feeding villages and towns from the main route from Geogia to Baku. Many of these also have substantial proportions of goods vehicle traffic.

On a general basis therefore the main road network is characterised by low traffic flows but serves a large volume of goods vehicle traffic. The access roads have lower volumes of traffic, this generally being due to a reduction in the proportion of light vehicles. On these roads the predominance of slow moving vehicles and heavy vehicles will result in very slow travel speeds.

1.3.2 Road Capacity

The nature of the road network along the route has a considerable bearing on the ability of the roads to handle volumes of traffic. In general the following observations can be made that affect the capacity of the local road system:

- a large proportion of roads are not metalled
- lack of street lighting in most areas, limited in urban areas
- poor signage
- lack of road markings
- extensive use of single track roads
- poorly maintained road surfaces
- lack of crash barriers and other safety infrastructure
- direct frontage of commercial activities onto the frontages
- fixed infrastructure (bridges, underpasses and level crossings)

All of these have an impact on the capacity of the road and only direct observation could identify the maximum volumes of traffic using the roads. However, as a rough approximation the following hourly two-way traffic flows can be used:

- For the main route, which has a reasonably well maintained road surface and is of adequate width - 1500 vehicles per hour
- For access routes unmetalled, but allowing for two-way operation of traffic – 1000 vehicles per hour
- For access roads with passing spaces at least every 100m - 500 vehicles per hour

- For access roads with passing spaces less frequently - 250 vehicles per hour

Clearly the capacity of the single direction of operation is dependent on directional split of traffic, if flows are evenly balanced then considerable conflicts will occur and the capacity will be reduced further. If the flow is in one direction only then capacity would be of the order of 600 vehicles per hour in that direction.

Analysis of the peak flows identified in the Table 3.1 shows that only four sites exceed 500 vehicles per hour at any time during the day. Site 50 is in the middle of the urban area of Gyandzha. The road has ample pedestrian facilities, a well-maintained metalled road surface and is of considerable width. This road has ample capacity and a flow of 500 vehicles per hour will not pose a problem. Similarly, site 7 is located on the main east-west highway. The pavement is fully constructed and well-maintained, has gravel hard shoulders and very limited access. A flow of 500 vehicles per hour is again well within the capacity of the road.

1.3.3 Conclusion

It may therefore be concluded that the existing levels of traffic are catered for adequately by the existing road network. Consideration must therefore be given to the level of traffic likely to be generated by the construction and operation of the pipeline. This is covered in the next section.

1.4 FORECAST TRAFFIC LOADS AND DESIGN CRITERIA

1.4.1 Construction Process

1.4.1.1 Method of transport of pipeline

The pipe itself will be transported to pipe dumps by rail. Onward movements will then be conducted using pipe trucks, which will be capable of carrying 3 sections of pipe, each some 12 metre long pipes. The pipes will be transported to the pipe dump locations during a 3 month pre-stocking period, and will then be transported to the pipeline itself as construction progresses.

1.4.1.2 Types of Vehicles.

Whilst no information is available on the type of vehicles used for the transporting of the pipe sections they will are likely to be either 16.5m standard articulated vehicles or logging style trucks with a separate rear axle using the load, in this case the pipe, as the rigid structure. In either event these vehicles have a large minimum turning circle and poor acceleration/braking characteristics. Such vehicles will take up a considerable proportion of the highway capacity, are likely to experience problems on narrow roads when encountering oncoming traffic and will need to be considered carefully when choosing routes through urban areas and particularly on routes where there is significant amounts of street furniture such as street lighting.
In addition, all materials and equipment will need to be delivered to the pipeline along these same roads. Heavy digging and lifting equipment, generators etc may require vehicles with even more substantial dimensions and axle loadings.

1.4.1.3 Duration of Operations.

Initial operations are scheduled for commencement in October 2002, with construction continuing for 2 years. The contractor will develop the final plan for construction procedure, but the oil pipeline (BTC) will be laid in the first year (Oct 2002-Oct 2003), with the gas pipeline (SCP) following from Oct 2003-

Oct 2004. During this period the temporary and permanent camps will need to be maintained and serviced, resulting in considerable volumes of traffic delivering food, water and construction supplies.

1.4.1.4 Traffic GenerationThe following criteria have been set as the minimum assumption in the ITT documents.

Table 1.2 - Traffic generation assumptions

ROAD CLASSIFICATION	NO. OF COMMERCIAL VEHICLES PER DAY IN BOTH DIRECTIONS	CUMULATIVE NO. OF STD. AXLES PER 20 YEARS (MILLION)
Main plant access road	80	0.61
Primary road	40	0.30
Secondary road	20	0.15
Service road	6	0.046

With each section of pipeline being some 12m long, and each lorry being able to carry three sections of pipeline per trip this equates to the delivery of 2.8km of pipeline per day. Over a two year period, assuming a 6 day working week this would result in 1700km of pipeline delivered. This seems to be in the right order, allowing for slack periods, the need to deliver other equipment and materials etc which will reduce the number of deliveries from the 80 proposed above. This figure will be used as worst case estimate.

1.4.2 Design Criteria

The following sets out some of the key design criteria that may have impacts on the local road network and other road users.

1.4.2.1 Speed limitations

Geometric design shall be based on the following design speeds:

- Main plant access road - 80km/h
- Primary road - 50km/h
- Secondary road - 30km/h
- Service road - 25km/h

1.4.2.2 Radii

Minimum radii of edge of paving or surfacing for 90 degrees intersection shall be:

- Main plant access road - 15m
- Primary road - 10m
- Secondary road - 8m
- Service road - 6m

1.4.2.3 Horizontal and vertical clearance

At roads without raised kerbs a horizontal clearance of 1.0m shall be maintained between the edge of the shoulder and any structure projecting above shoulder level. However, for safety barriers and traffic signs the minimum horizontal clearance shall be 0.6m.
At roads with raised kerbs the minimum horizontal clearance shall be 0.6m from the face of the kerb.

Horizontal clearances shall be maintained for the full required vertical clearance for the road classification.
For vertical clearances over roads refer to piping design and plant layout requirements.

1.4.2.4 Road Widths

Minimum lane and shoulder widths shall be as listed below. Shoulder widths shall be added to the carriageway widths to obtain minimum roadway widths.

Table 1.3 - Road widths

Classification	Carriageway Width (m)	Each Shoulder (m)
Main plant access road	8.0	2.0
Primary road	8.0	1.5
Secondary road	6.0	1.5
Service road	4.0	0.0

1.5 IMPACT ON THE ROAD NETWORK

The volumes of traffic being proposed in the ITT are unlikely to have any significant operational impacts on the existing road network. Whilst on some roads the volumes will represent more than a doubling of existing traffic flows the volumes are universally low enough that this should not be a concern. There are no locations where the additional volumes will create delays, queues and generally disadvantage other road users.
However, there are a number of problems that will result from the increased level of heavy vehicle traffic on the roads:

- Conflict with slow road users on most of the access roads where the road is too narrow to allow convenient passing
- Physical constraints in urban areas
- “Anti-social” aspects of goods vehicles near sensitive receptors
- Accidental impacts

Each of these items is discussed in detail in the remainder of this section.

1.5.1 Conflict with slow road users

Slow road users will be disadvantaged in a number of ways by the general increased level of traffic along the roads being used. The vast majority of “slow” road users are pedestrian. The most significant potential impact for pedestrians is in terms of safety. In many cases pedestrian activity is a significant proportion of the total level of traffic on the road. As such conflicts with large vehicles being used to transport the pipes and any other construction materials are very likely and any incidents will probably be of a serious nature.

In the more rural areas the potential to mitigate these impacts will be less. The highway infrastructure in Azerbaijan does not appear to include for specific provision of footways for pedestrians, nor any form of protected crossing points. Despite the volumes of pedestrian movements any provision could not be justified. Consideration may need to be given to the speed at which the vehicles are permitted to travel on the public road network and especially in non-urban areas.

In urban areas the conflicts may be more readily managed. The routes pass through relatively few urban areas so any management will be relatively easy to undertake. Again, the key issue will be the speed at which vehicles may travel in urban areas. A maximum speed of 50km/h in any built up area will ensure that braking distances are not too great. Unless there is no other option routes should be chosen to avoid locations that attract considerable volumes of pedestrian traffic, namely:

- Hospitals
- Schools
- Shops and markets
- Major employment centres

In this schools are of particular concerns as young children have not developed the same level of traffic and road awareness and so are at a greater risk. Where urban areas cannot be avoided the operation of the deliveries should be controlled to avoid the busy periods, particularly the start and end of the school and working day.

If this is not possible from an operational perspective then consideration should be given to local safety improvements outside schools and hospitals. Any investment should be low cost and not require subsequent maintenance. Railings immediately outside the school entrance and possibly a central refuge for those crossing the road would be a maximum level of provision.

There are some areas where the movement of animal flocks are also of a reasonable level. Such movements will most likely take up the whole road and will take some time to dissipate. It is unlikely that conflict with animal flocks can be avoided and careful consideration will need to be given to the nature of any mitigation measures. The provision of crossing facilities in rural areas for occasional conflicts would not present an economic solution unless these conflicts were extremely frequent and impacted upon the construction programme. This is highly unlikely given the number of such observations. It is most likely that the only reasonable mitigation is through ensuring driver behaviour by reducing speeds in areas where conflicts occur and providing guidelines on how to deal with situations, e.g.:

- Stop at least 10m from the herd
- Do not sound the horn
- Switch off engine if the wait is likely to be for more than 1 minute
- Allow the flock and herder to clear the road before continuing

1.5.2 Physical constraints in urban areas

Clearly the size of the vehicles used in transporting the pipeline and other materials will be substantial, often in excess of 16.5m. In the more rural areas such vehicles are unlikely to have any problems but in urban areas, where there are constraints on all sides, junctions and street furniture this is likely to be a more substantial problem.

Observations identify that there are likely to be few restrictions in terms of vertical constraints, although a thorough audit of all underpasses will need to be undertaken in identifying routes. Problems are most likely to result at junctions where the vehicles are required to make a turn. The length of the vehicles means that there is a considerable over-run area where the vehicle turns. Some of the existing routes identified include a number of sharp right or left turns in urban areas. These should be avoided wherever possible. Where no practical alternative can be found then the junctions will need to be assessed to ensure that the vehicle is capable of making the turn without physically damaging any existing infrastructure.

In urban areas there were a number of observations of shops and stalls immediately to the side of the road. Such activities create pinch points either physically or through parking of other vehicles in close proximity. Where such locations cannot be avoided it may be necessary to assist the owner in moving the stall further from the edge of the road or providing parking facilities off the road.
On-street parking is also a very common issue that may need to be addressed in urban areas. The level of parking on roads reduces the effective operating width of the carriageway and may mean that larger vehicles cannot safely negotiate a section of the road. The solution to this problem will be dependent on the duration over which the road will be used. Over a long period (more than 2 months say) a semi-permanent solution may need to be found, identifying an alternative local site where the vehicles may park. However, this is likely to be problematic in terms of identifying the location, obtaining permission to use the land and making the ground ready for use.

If the problem is for a shorter period of time then may be sufficient to obtain the assistance of the local police. Temporary restrictions on parking along any particularly constrained part of the route would need to be enforced diligently by local police but would be a simpler solution to the problem for short periods of time.

1.5.3 "Anti-social" aspects of goods vehicles near sensitive receptors

In this regard anti-social aspects of goods vehicles are considered to be noise, vibration and emissions. Issues in this regard will be related to both time and location. It is not clear whether nighttime operations would be considered during the construction programme, but these should not be allowed in urban areas where the noise and vibration caused by heavy vehicles will affect considerable numbers of local residents. It is recommended that work at night be avoided for safety reasons. Traffic accidents related to construction and camp service vehicles would be much more likely at night.
As already identified earlier in this section, where possible routes should avoid schools, and hospitals. Where this is not the case, and in all areas where the vehicles are in close proximity to people the following general principals should be adhered to:

- Do not leave engines idling either when is queues or parked unless absolutely necessary
- Avoid unnecessary revving of engines
- Radios not to be played loudly in quiet locations

Considerable benefits can be generated through ensuring the vehicles used are in a reasonable state of repair. Clearly emissions testing is not a viable option in this regard but the operators of the vehicles should be encouraged to ensure that vehicles do not produce significant emissions because of poor maintenance and financial incentives (or penalties) should be put in place to ensure that this does not occur.
This maintenance regime should also be designed to ensure the braking systems and tyres are of a sufficient quality that the vehicles will not represent and undue safety hazard during normal operations or when a hazardous situation occurs.

1.5.4 Accidental impacts

The greatest impacts are most likely to be experienced as a result of some accidental actions. In particular consideration should be given to ensuring only routes identified for use are followed. With a considerable volume of vehicles being used, some following circuitous routes, there is the potential for vehicles to follow the wrong routes. This could lead to a wide range of issues including:

- Bridge strikes and grounding
- Bogging down on roads unprepared for the loads
- Damage to pavements
- Damage to other infrastructure

- Accidents involving injury
- Lost operating time

The most appropriate way to take this forward is through the development of a signing and routing system that is easily understood by all. Care should be taken that this not map based, because of the quality of any mapping is questionable and also because drivers will not necessarily be experienced in reading maps.
Following the contractors detailed assessment detailed access plans should be produced. These plans will involve:

- Identifying routes from pipe storage area to site
- Identifying weight/height restrictions and alternative routes
- A signing strategy for the routes
- Mechanisms for vehicle control

1.5.5 Route identification

The route identification process will need to take account of all the issues described earlier in this section. In addition audits of clearances, restrictions and limits along the route, along with pavement conditions will inform the process. Developing detailed route plans will allow the further problems to be identified as below.

1.5.6 Weight/height restrictions and alternative routes

These restrictions are the absolute drivers of any route requirements. Maximum vehicle dimensions and axle loadings will determine the main constraints and allow the optimum route to be defined. Where there are alternative routes for different vehicle types this will need to be identified for information and control purposes.

1.5.7 Signing Strategy

The signing strategy will probably be the most important element of the process. All routes must be clearly signed from the main highway, and always through urban areas. The signing strategy must allow unique identification of each route, along with speed and other restrictions. All drivers should have access to a schedule of the routes and a delivery control mechanism put in place to ensure all goods and material deliveries are clearly routed.
The strategy may also include further restrictions such as restriction upon the time during which vehicles may operate and the hazard warnings.
Signs must clearly indicate that they relate to vehicles serving the pipeline construction so that they are not misunderstood by other road users.

1.5.8 Mechanisms for vehicle control

Despite the efforts to provide information the operator must guard against pipeline vehicles using inappropriate roads and other road users venturing down pipeline access roads.
For the former, where there is a danger that this will result in a serious accident or other safety risk then some form of physical restriction to access may need to be considered. For the latter additional signing along the road and potentially gating may be required to ensure drivers are aware that they have no right of access. Turning points may be required in some locations.

1.6 KEY OBSERVATIONS

Within the time available for in-country surveys it was neither possible nor practical to visit all access roads along the route. In any event, as the final decision for the routes to be used will be by the pipeline construction contractor, the value of detailed route surveys was limited. However, a number of observations can be made that have relevance to the route selection.

1.6.1 Railway Crossings

The pipeline follows a similar route as the river and railway line to the Georgian border from Baku. There are many instances along the route where it will be necessary for the access routes to cross the railway line. Most of the crossings observed were by level crossing or underpass. The general issues to be considered as part of the route definition have been noted earlier in the report. However, some particular observations are worthy of note.

Some of the underpasses beneath the railways are narrow and limited dimensions. The photograph below indicates the sorts of underpasses that will be encountered.

Figure 1: Typical railway underpass

A number of observations can be made; firstly the underpass can only operate in single alternate directions. Heavy traffic flows at such locations (more than say 50 vehicles per hour two-way) will require management of the traffic to ensure safe operation, especially during winter months and during early morning and late evening when the light is poor.

Level crossing present a similar problem. An example of the sorts of crossing is shown in below. It can be seen that the crossing has little control on vehicle access which may lead to safety problems where considerable levels of traffic are generated by the pipeline.

FIGURE 2: Typical railway crossing without bridge

Especially in locations such as this with no vehicle control and considerable vertical deflections across the tracks there will be a danger of grounding. Such locations will need to be controlled to ensure safe operation.

1.7 APPENDIX A

1.7.1 Traffic Survey Forms

Especially in locations such as this with no vehicle control and considerable vertical deflections across the tracks there will be a danger of grounding. Such locations will need to be controlled to ensure safe operation.

WSP/RSK **Azerbaijan Pipeline Traffic Survey** **Form 1** **Base Sheet** **BP**

Count Location Ì åñòî ó÷åòà	Location No. Í î ì åð ì åñòà	Time of start Âðåì ÿ í à÷àëà	Time of finish Âðåì ÿ êî í öà	Date Äàòà

Name of Supervisor Èì ÿ Ñóï åðâàéçåðà	Name of Surveyor Èì ÿ Ñóï åðâàéçåðà
Signed Ï î äï èñü	Signed Ï î äï èñü
Direction of traffic	Direction of traffic

Pedestrians Ï åø åõî äû

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Pedestrians Ï åø åõî äû

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Animal Flocks Ñòàäà æèâî òí û õ

1	2	3	4	5	6	7	8	9	10	11	12

Total

Animal Flocks Ñòàäà æèâî òí û õ

1	2	3	4	5	6	7	8	9	10	11	12

Total

Bicycles Âåëèñèï åäû

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Motorcycles Ì î òî öèêëû

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Animal Drawn Carts Òåëåæêè

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Agricultural Vehicles Ñåëüñêî õî çÿéñòâåí í û é òðàí ñï î ðò

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Cars/Taxis Àâòî ì î áèëè

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84

Total

Minibuses

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24

Total

Buses Àâòî áóñû

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36

Total

Trucks Ãðóçî âèêè

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60

Total

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60

Total

Comments Ï ðèì å÷àí èÿ

WSP/RSK Azerbaijan Pipeline Traffic Survey BP

Form 2 Daily Summary Sheet

Location ID No.	Date
Count Location	Time of start
Direction	Time of finish
Name of Supervisor	Name of Surveyor
Signed	Signed

	Direction of traffic									Direction of traffic									
Hour From	9	10	11	12	13	14	15	16		9	10	11	12	13	14	15	16		
Hour To	10	11	12	13	14	15	16	17	Total	10	11	12	13	14	15	16	17	Total	Total for both directions
Pedestrians																			
Animal Flocks																			
Bicycles																			
Motorcycles																			
Animal Drawn Carts																			
Agricultural Vehicles																			
Cars/Taxis																			
Minibuses																			
Buses																			
Trucks																			
Total																			

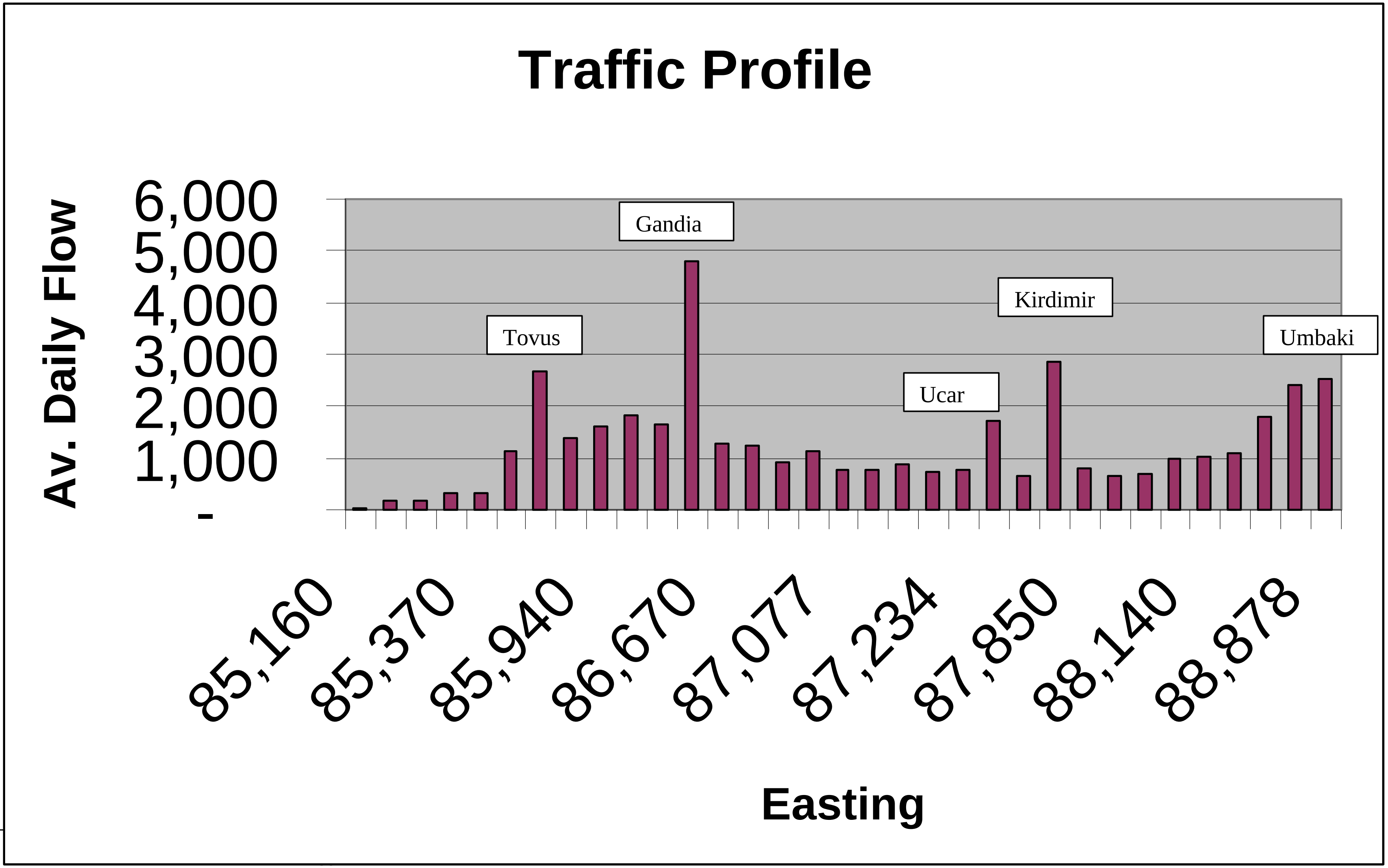
Comments

1.8 APPENDIX B

1.8.1 SUMMARY TRAFFIC DATA

Site ID	Location	Grid reference Easting	Northing	Road type	Averge daily flow (Vehicles)	Flow composition (%) Slow	Light	Heavy	Max flow Vehicle/hr
T1	Mbaki	88,878	44,630	Main	2,524	0	77	23	434
T2	Mbaki	88,805	44,585	Access	746	45	42	13	90
T3 (N-S)	Randjbar East	88,477	44,428	Access	153	3	76	21	31
T3 (E-W)	Randjbar East (EW)	88,477	44,428	Access	260	1	7	92	34
T4	Randjbar Main (Pirsaat)	88,455	44,434	Main	2,408	1	69	29	300
T5	Kazi-Magomed Access	88,370	44,429	Access	1,064	46	50	4	114
T6	Kazi-Magomed Main	88,325	44,435	Main	1,800	1	75	24	516
T7	Kazi-Magomed Access	88,330	44,443	Access	47	32	45	23	8
T8	Mugan	88,250	44,480	Main	1,083	10	65	25	107
T8	Mugan Access	88,250	44,480	Access	216	60	34	6	30
T9	Kasasu main	88,132	44,538	Main	1,001	2	74	25	103
T9	Kazasu access	88,132	44,538	Access	186	6	86	7	21
T10	Karasu (main road)	88,140	44,550	Main	1,036	5	69	26	106
T10	Karasu (access road)	88,140	44,550	Access	241	15	76	10	28
T11	Padar	88,001	44,600	Main	703	1	69	30	76
T12	Sigirli Main Road	87,908	44,634	Main	671	14	53	33	111
T12	Sigirli Access Road	87,908	44,634	Access	74	47	47	5	15
T13	Aksu Canal Main	87,850	44,657	Main	814	5	69	26	114
T14 west of cana	Aksu west access	87,850	44,643	Access	44	63	37	0	9
T14 east of canal	Aksu east access	87,773	44,681	Access	16	88	12	0	6
T15	Kurdamir	87,773	44,681	Access	44	31	66	4	11
T16	Kurdamir roundabout	87,687	44,715	Main	2,872	12	77	10	746
T16	Kurdamir roundabout	87,687	44,715	Access to In	2,564	13	75	12	373
A22 main	Kulabend Main Road	87,313	44,882	Main	665	7	75	18	83
A22 access	Kulabend access Road	87,313	44,882	Access	108	53	45	2	24
A23 main	East Ucar Main	87,260	44,880	Main	1,725	9	84	7	216
A23 access	East Ucar Access	87,260	44,880	Access	942	16	77	7	137
A25 main	Ucar Pipe Dump Central,	87,234	44,879	Main	767	2	77	21	87
A25 access	Ucar Pipe Dump Central,	87,234	44,879	Access	209	16	71	13	32
A26 main	Ucar West Main	87,221	44,878	Main	730	5	75	20	86
A26 access	Ucar West Access	87,221	44,878	Access	237	65	34	1	76
A27 main	Alikend Main Road	87,122	44,897	Main	872	3	74	24	192
A27 access	Alikend Access Road	87,122	44,897	Access	91	25	64	11	24
A28 main	Turianchay East Main Ro	87,078	44,914	Main	758	1	74	25	76
A28 access	Turianchay East Access	87,078	44,914	Access	11	82	0	18	3
A29 main	Turianchay West	87,077	44,915	Main	782	1	74	26	78
A29 access	Turianchay West Access	87,077	44,915	Access	20	70	30	0	6
A30 main W	Laki Pipe Dump Main Ro	87,054	44,924	Main	933	7	71	22	98
A30 main E	Laki Pipe Dump Main Ro	87,054	44,924	Main	1,125	16	67	17	103
A30 access N	Laki Pipe Dump Access	87,054	44,924	Access	933	7	71	22	98
A30 access S	Laki Pipe Dump Access	87,054	44,924	Access	922	23	69	9	115
A33 access SW	Yevlakh Pipe Dump Acce	86,815	44,965	Access	96	8	73	19	13
A33 access SE	Yevlakh Pipe Dump Acce	86,815	44,965	Access	1,533	1	85	15	162
A34 main	Yevlakh West	86,805	44,985	Main	1,256	2	81	17	90
A34 access	Yevlakh West Access	86,805	44,985	Access	356	15	79	6	32
A36 access	Mironabad	86,751	45,010	Access	229	23	71	6	30
A37 access	Neymatabad Access	86,743	45,011	Access	122	42	51	7	14
A39 main	Karabakh Canal	86,670	45,019	Main	1,267	3	79	18	106
A39 access	Karabakh Canal	86,670	45,019	Access	184	4	90	6	18
A40 access	St Kozan	86,566	45,030	Access	771	30	63	7	70
A41 access	Goranboy	86,560	45,031	Access	720	10	83	6	61
A42 access NE	Bursunlu	86,421	45,018	Access	1,333	3	72	24	109
A42 access NW	Bursunlu	86,421	45,018	Access	730	7	84	10	73
A47&A49 access	Dalmamedli	86,324	45,084	Access	2,557	6	79	15	193
A47&A49 access	Dalmamedli	86,324	45,084	Access	2,857	8	77	15	189
A50 main	Ganja Central E.	86,183	45,065	Main	4,793	8	83	9	497
A50 access	Ganja Central N.	86,183	45,065	Access	6,273	37	58	5	480
A51 access E	Gandja North, access roa	86,178	45,107	Access	1,215	17	70	13	117
A51 access SW	Gandja North, access roa	86,178	45,107	Access	2,061	13	77	10	217
A55 main	Shamkirchay Main Road	85,940	45,200	Main	1,619	3	81	16	150
A55 access	Shamkirchay Access Roa	85,940	45,200	Access	1,106	13	77	10	116
A57 access NE	Dallar Pipe Dump Access	85,873	45,268	Access	555	41	57	2	53
A57 access NW	Dallar Pipe Dump Access	85,873	45,268	Access	975	43	50	7	127
A61 access N	Zayam North	85,763	45,316	Access	393	20	74	6	67
A61 access S	Zayam South	85,763	45,316	Access	783	11	80	9	81
A62 main	Duz Kirikli Main Road	85,660	45,344	Main	1,403	13	82	4	129
A62 access	Duz Kirikli Access Road	85,660	45,344	Access	250	12	81	8	28
A64 main	Tovus Main Road	85,544	45,393	Main	2,677	14	78	8	280
A64 access	Tovus Access Road	85,544	45,393	Access	732	12	79	9	71
A68 main	West of Hasansu Chay, M	85,405	45,526	Main	1,150	22	75	3	101
A68 access	West of Hasansu Chay, A	85,405	45,526	Access	141	14	78	9	18
A70 main	St Poylu Main Road	85,370	45,673	Main	335	23	71	6	49

MAIN ROAD TRAFFIC PROFILE



RIVER CORRIDOR SURVEY

List of Tables

1 RIVER CORRIDOR SURVEY

1.1 INTRODUCTION

The proposed Baku-Tiblisi-Ceyhan (BTC) crude oil pipeline and the South Caucasus natural gas pipeline (SCP) follow a common route. The 442km section within Azerbaijan crosses over five hundred watercourses and irrigation channels. Many of the watercourses are dry during all or most of the year.

A river corridor survey was undertaken to record morphological and ecological features around the crossing points of the more significant rivers crossed by the proposed BTC pipeline and SCP. The rivers selected for survey were those that are usually flowing and have a wet channel in excess of 2 metres wide at, or close to, the proposed crossing point.

1.2 SURVEY METHODOLOGY

River Corridor Surveys (RCS) were carried out during October/November 2001, by Dr Janet Swan of RSK Environment Ltd., using the standard UK methodology (NRA 1992, Conservation Technology Handbook No.1). A few modifications were made to the recorded information (Section 1.3) to take account of the differences between UK and Azerbaijani rivers and to provide specific information relevant to pipeline construction.

Generally the surveys covered a section approximately 100m upstream and 200m downstream of the proposed crossing point. At a few locations lack of access led to a modified survey section; the actual sections surveyed are identified on each record sheet.

The proposed crossing points were located using a hand held GPS (Magellan 315) which was calibrated before the start of the survey. Each survey section was paced to identify the approximate location of 100 metres upstream and 200 metres downstream; the co-ordinates of the upper and lower limits of each survey section and any significant features were recorded.

Each survey section was sketched using the standard symbols identified in the NRA methodology, and a record sheet was completed (Section 1.3). Photographs were taken of each survey section (not included in this report).

In the absence of accurate base mapping at a suitable scale for an RCS, the course of each river section was mapped from aerial photos. Ortho-rectified photographs were not available which reduced the accuracy of this process. Information from the field sketches was transferred to the base maps and is included in Section 1.3.

1.3 SURVEY RESULTS

The River Corridor Survey records are presented in the order in which the rivers are crossed by the proposed BTC pipeline and SCP.

References to +ve and –ve banks relate to the direction of pipeline product flow and have no relevance to the direction of river flow. In all cases the –ve bank is on the ‘Baku’ side of the crossing and the +ve bank is closer to the Georgian border.

Record No.: 1
River Name: Djeyrankechmes
Approx KP (Route D2): 9.3
Date of Survey: 31/10/01

Grid Reference of upstream limit of section: 088 73 161E; 044 59 473N
Grid Reference of downstream limit of section: 088 73 095E; 044 59 303N
Grid Reference of approx centreline: 088 73 163E; 044 59 425N

Weather & flow conditions: Partial sun /cloud. Calm. Rained previous night and previous 4 days. Flow rate c.0.5m sec^{-1}**.**

Special & typical features of the river channel: Very meandering river with steep eroding cliffs. Stepped banks.

Marginal vegetation: None to flowing channel.

Bank zone habitats: *Tamarix; Salsola nodulosa; Alhagia pseudoalhagia; Crassuola sp;* emergent grasses; *Artemisia fragrans* growing within main (normally dry) channel.

Adjacent land-use: Desert. Some grazing. Gobustan Cultural Reserve on +ve bank.

Notes of insects/birds/mammals of special interest: Bird burrows in sand cliffs; many birds singing in *Tamarix* bushes. Numerous ant holes in sand.

Recreation features: Vehicle track crosses river in vicinity of centreline.

Known downstream sensitivities:

- Drains into the Caspian
- Flows through the Gobustan Cultural Reserve for approximately 1km south of the pipeline crossing point
- Flows through the southern outskirts of Sangachal before entering the Caspian
- No endangered flora or fauna.

Existing management of river banks etc.: None.

Additional Comments: Cliff stability will require careful planning if open cut or graded for Right of Way.

Record No.: 2
River Name: Pirsagat
Approx KP (Route D2): 42.1
Date of Survey: 1/11/01

Grid Reference of upstream limit of section: Western Route Export Pipeline
Grid Reference of downstream limit of section: 088 46 669E; 044 45 726N
Grid Reference of approx centreline: 088 46 666E; 044 45 753N

Weather & flow conditions: Sunny & breezy. Flow 0.25 m sec^{-1}

Special & typical features of the river channel: Dredged earlier this summer. Steep banks with all spoil on +ve bank.

Marginal vegetation: *Phragmites* dominated.

Bank zone habitats: Very disturbed. *Tamarix; Salsola sp; Alhagia pseudoalhagia.*

Adjacent land-use: Semi-desert with small scale agriculture.

Notes of insects/birds/mammals of special interest: 2 eagles. Frogs.

Recreation features: None.

Known downstream sensitivities:

- Drains into the Caspian
- Flows through Navagi 3.5km to south of pipeline crossing
- No protected flora at site
- *Nephron percnopterus* (Bird of European Conservation Concern) recorded approximately 2km from site

Existing management of river banks etc.: Dredged within last 6-12 months.

Additional Comments: Banks were left graded after installation of the WREP; this has altered flow characteristics and the banks are devoid of vegetation. Low ecological sensitivity but, subject to engineering constraints, the banks should be re-profiled after construction of new pipelines to match pre-existing status.

Record No.: 3
River Name: Agsu Canal
Approx KP (Route D2): 111.2
Date of Survey: 4/11/01

Grid Reference of upstream limit of section: 087 84 680E; 044 64 384N
Grid Reference of downstream limit of section: 087 84 816E; 044 64 161N
Grid Reference of approx centreline: 087 84 649E; 044 64 305N

Weather & flow conditions: Overcast and calm. Flow c. 1m sec^{-1}.

Special & typical features of the river channel: Wide straight channel. Bank erosion and vegetation indicates significant fluctuations in river level. High sediment load.

Marginal vegetation: +ve bank devoid of vegetation. –ve bank has fringe of *Phragmites.*

Bank zone habitats: +ve bank bare**.** –ve bank has scattered *Tamarix sp.* with some grass.

Adjacent land-use: Both banks have track with grazing. During survey, herders were present on both banks with sheep and cattle.

Notes of insects/birds/mammals of special interest: Birds. Rodent holes away from river. Burrows in all banks.

Recreation features: May be fished, but no activity observed.

Known downstream sensitivities:

- The Agsu canal flows into the River Kura approximately 40km south of the pipeline crossing point
- The villages of Ashali, Daiykyazimli and Piracheta lie close to the canal downstream from the crossing point
- No endangered flora or fauna records from close to site

Existing management of river banks etc.: Canalised river but no evidence of active/recent management.

Additional Comments: Reinstatement plan should address post-construction bank stability during periods of peak flow.

Record No.: 4
River Name: Goakchay
Approx KP (Route D2): 171.3
Date of Survey: 4/11/01

Grid Reference of upstream limit of section: 087 29 745E; 044 85 306N
Grid Reference of downstream limit of section: 087 29 655E; 044 85 156N
Grid Reference of approx centreline: 087 29 725E; 044 85 251N

Weather & flow conditions: Calm & fine but overcast. Flow c.1m sec^{-1}.

Special & typical features of the river channel: Wide channel with mud substrate where exposed. Vegetation indicates water level fluctuates significantly.

Marginal vegetation: Dense reed and rush.

Bank zone habitats: Steep banks. Stable on +ve side but slipping on –ve. Some willow on +ve bank. Top of –ve bank = *Artemisia fragrans; Salsola nodulosa;* pomegranate; legume; elm; bramble; broom; white poplar.

Adjacent land-use: Agricultural (arable) on –ve bank. Land beyond +ve bank not visible or accessible.

Notes of insects/birds/mammals of special interest: Pomegranate on –ve bank; none visible on +ve bank, but no access for survey therefore cannot be precluded. Most likely to be cultivated variety.

Recreation features: track running along –ve side.

Known downstream sensitivities:

- Flows into the River Kura (a considerable distance to the south)
- Villages likely to be affected within 10km to the south are: Kazyan, Lak, Khaladz and Boyat
- *Hystrix indica* (proposed RDB) recorded within 0.5km of river

Existing management of river banks etc.: None.

Additional Comments: Bank stability will require detailed planning if open cut.

Record No.: 5
River Name: Turianchay
Approx KP (Route D2): 193.5
Date of Survey: 5/11/01

Grid Reference of upstream limit of section:
Grid Reference of downstream limit of section:
Grid Reference of approx centreline: 087 05 565E; 044 86 750N

Weather & flow conditions: Warm, sunny & calm. Flow 1m sec^{-1}.

Special & typical features of the river channel: Wide, possibly canalised, channel.

Marginal vegetation: Almost none – probably reflects fluctuating water level and fast flow. Occassional *Phragmites*.

Bank zone habitats: Various grasses, *Phragmites sp*, *Tamarix; Salix sp (*probably *S alba or S fragilis* – but inaccessible); *Artemesia sp.*

Adjacent land-use: Scrub with track on +ve bank – no access or view of –ve bank.

Notes of insects/birds/mammals of special interest: Small aquatic mammal – probably water vole but not seen clearly (c. 20cm long with burrows at water level). Crested larks.

Recreation features: Some fishing – children upstream of survey section.

Known downstream sensitivities:

- Flows into the River Kura (a considerable distance to the south)
- No villages marked on map within 10km downstream of crossing
- No endangered flora or fauna close to site

Existing management of river banks etc.: None.

Additional Comments: Careful bank reinstatement will be required if open cut. WREP has reinstated well. Water vole survey advisable.

Record No.: 6 (+ve bank)
River Name: Kura (east crossing)
Approx KP (Route D2): 223.6
Date of Survey: 5/11/01

Grid Reference of upstream limit of section: 086 85 044E: 044 96 307N
Grid Reference of downstream limit of section: 086 85 222E; 044 96 141N
Grid Reference of approx centreline: 086 85 085E; 044 96 272N
Note: grid references are for top of bank and not water's edge.

Weather & flow conditions: Calm and sunny. Flow c2m sec^{-1}.

Special & typical features of the river channel: Very wide channel with reedbed on inside of bend.

Marginal vegetation: *Typha angustifolia.*

Bank zone habitats: Grass with *Salix alba, Tamarix;* scattered scrub.

Adjacent land-use: Grass/bare ground on top of bank. Further back is rough grazing and scrub.

Notes of insects/birds/mammals of special interest: Abundant wildfowl and waders including snipe, night heron and mallard; frogs; mosquitos. Many burrows in banks.

Recreation features: Fishing. Grazing.

Known downstream sensitivities:

- Drains into the Caspian, provides water supplies for innumerable communities
- Communities within approximately 10km downstream of crossing: Ashagi Karkhun, Arabsheki
- Endangered fauna found within 1km of crossing point:
    - Bufo bufo (RDB)
    - Monticola solitarius (European Conservation Concern: vulnerable)
    - Phalacrocorax pygmeus (European Conservation Concern: vulnerable and Species of International Conservation Concern: low risk)
    - Botarurus stellaris (European Conservation Concern: vulnerable)
- No endangered flora close to site
- Area of Potential Mineral Extraction 0.5 km downstream of the crossing point

Existing management of river banks etc.: None

Additional Comments: Disturbance of birds. Sediment/oil spills would affect wetland areas and fishing. Very high sensitivity.

Record No.: 6 (-ve bank)
River Name: Kura (east crossing)
Approx KP (Route D2): 223.6
Date of Survey: 5/11/01

Grid Reference of upstream limit of section: 086 85 123E; 044 96 476N
Grid Reference of downstream limit of section: 086 85 335E; 044 96 414N (N.B limit of access - approx.170m downstream from centrline)
Grid Reference of approx centreline: 086 85 212E; 044 96 451N

Weather & flow conditions: Calm & sunny. Flow 2m sec^{-1}

Special & typical features of the river channel: Very wide

Marginal vegetation: Grass

Bank zone habitats: Grass - grazed

Adjacent land-use: Grazing

Notes of insects/birds/mammals of special interest: Pomegranate 086 85 145E; 044 96 524N, but thought to be a cultivated variety. Many burrows. Bird nests in trees. Butterflies.

Recreation features: Fishing. Car access –recreational use likely at weekends.

Known downstream sensitivities:
See Kura (east crossing, +ve bank)

Existing management of river banks etc.: None

Additional Comments: Very wide crossing.

Record No.: 7
River Name: Karabakh Canal
Approx KP (Route D2): 245.1
Date of Survey: 4/11/01

Grid Reference of upstream limit of section: 086 66 148E; 044 99 273N
Grid Reference of downstream limit of section: 086 66 243E; 044 99 053N
Grid Reference of approx centreline: 086 66 180E; 044 99 216N

Weather & flow conditions: Warm. Sunny & calm.

Special & typical features of the river channel: Wide canal. Centre flowing faster (0.6m sec^{-1}) than margins (0.3m sec-1). Loose weed floating downstream.

Marginal vegetation: Patches of *Phragmites.*

Bank zone habitats: Grass and *Salsola dendroides.*

Adjacent land-use: Agricultural.

Notes of insects/birds/mammals of special interest: Birds in reeds.

Recreation features: Fishing. Water abstraction for irrigation from point near road bridge over canal (immediately N of survey section).

Known downstream sensitivities:

- Flows to the south
- Villages within 10km downstream of the crossing point: Yaldilly, Karamamedli, Malbinasi
- No endangered flora or fauna close to site

Existing management of river banks etc.: Dredging upstream of survey section.

Additional Comments: None; non open-cut crossing proposed for engineering reasons. Pollution prevention measures must be adequate to protect quality of abstracted water.

Record No.: 8
River Name: Goranchay
Approx KP (Route D2): 257.8
Date of Survey: 6/11/01

Note: Dry river – not mapped.

Grid Reference of upstream limit of section:
Grid Reference of downstream limit of section:
Grid Reference of approx centreline: 086 54 180E; 045 02 987N

Weather & flow conditions: Calm & sunny.

Special & typical features of the river channel: Dry. Channel c.2m deep; 8m between banks.

Marginal vegetation: No riverine vegetation.

Bank zone habitats: Grass with *Alhagia pseudoalhagia* and *Tamarix.*

Adjacent land-use: Desert on +ve side; narrow strip of desert then agricultural on –ve.

Notes of insects/birds/mammals of special interest: Birds singing.

Recreation features: Stream bed used as sheep herding track.

Known downstream sensitivities:

- Flows towards the Mingechaur Reservoir (which feeds into the Kura River)
- No mapped communities within 10km downstream of pipeline crossing
- No endangered flora or fauna close to site
- Soil extraction areas border the river on either side of the crossing point

Existing management of river banks etc.:

Additional Comments: Dried black material, possibly oil, in stream bed c.200m upstream of crossing point.

Record No.: 9
River Name: Kurekchay
Approx KP (Route D2): 276.5
Date of Survey: 6/11/01

Grid Reference of upstream limit of section:	+ve bank	086 36 955E; 045 03 642N
	-ve bank	086 36 957E; 045 03 543N
Grid Reference of downstream limit of section:	+ve bank	086 37 179E; 045 03 767N
	-ve bank	086 37 206E; 045 03 691N
Grid Reference of approx centreline:	+ve bank	086 37 053E; 045 03 656N
	-ve bank	086 37 083E; 045 03 556N

Note: +100m and –200m paced along river bed; grid references recorded on banks.

Weather & flow conditions: Calm & sunny

Special & typical features of the river channel: Very wide braided channel with narrow, meandering flowing channels. All channels very shallow with emergent broad leaved plants and grasses – watercress dominant in main channel.

Marginal vegetation: Grass and *Tamarix* with occasional *Typha latifolia.*

Bank zone habitats: Mud cliffs with abundant burrows. Many landslips – not individually mapped.

Adjacent land-use: Agriculture with village on –ve bank from –160m downstream.

Notes of insects/birds/mammals of special interest: Pomegranate on –ve bank at 086 37 051E; 045 03 547N (approximately centreline) – likely to be cultivated variety.
Frogs in some back channels. Bird holes in banks – significant numbers at +100m including possible bee-eater.

Recreation features: River used by villagers for clothes & vehicle washing; vehicle track; sheep/goat herding; children playing. Gravel extraction at various locations on river bank.

Known downstream sensitivities:

- Flows towards the Mingechaur Reservoir (which feeds into the Kura River)
- Communities downstream of the pipeline crossing include: Sametabad, Khasadali
- No endangered flora or fauna close to site

Existing management of river banks etc.: None identified.

Additional Comments: Minimise sediment disturbance during construction because of water use by villagers.

Record No.: 10
River Name: Korchay
Approx KP (Route D2): 292
Date of Survey: 7/11/01

Grid Reference of upstream limit of section: -ve bank 086 30 111E; 045 15 667N
+ve bank 086 29 975E; 045 15 802N
Grid Reference of downstream limit of section: -ve bank 086 30 227E; 045 15 874N
+ve bank 086 30 090E; 045 15 956N
Grid Reference of approx centreline: -ve bank 086 30 146E; 045 15 754N
+ve bank 086 30 009E; 045 15 856N
Note: +100m and –200m paced on bank tops – difficult to adjust for meanders.

Weather & flow conditions: Hazy sun; breeze.

Special & typical features of the river channel: Dammed upstream of survey section. *Typha latifolia* throughout with some submerged and floating dicots.

Marginal vegetation: *Typha latifolia* with occasional *Tamarix* and some stands of *Phragmites.* Some celery leaved buttercup.

Bank zone habitats: Closely grazed grass in river valley. *Salsola*, *Alhagia pseudoalhagia* on bank sides and top. Relatively few burrows.

Adjacent land-use: Track with agriculture beyond.

Notes of insects/birds/mammals of special interest: Many terrapins in reeds, frogs, good variety of birds, dragonflies, snake (30cm, grey, pencil thickness).

Recreation features:

Known downstream sensitivities:

- Flows towards the Mingechaur Reservoir (which feeds into the Kura River)
- Korchay State Forbidden Area is 4km downstream (to north)
- No mapped communities downstream from crossing point within 10km
- No endangered flora close to site
- Endangered fauna recorded within 1km of crossing point:
    - Francolinus francolinus (RDB and European Conservation Concern: vulnerable)
    - Tetrax tetrax (RDB and European Conservation Concern: vulnerable)
    - Alectoris chukar (European Conservation Concern: vulnerable)
    - Botarurus stellaris (European Conservation Concern: vulnerable)

Existing management of river banks etc.: None

Additional Comments: If open cut, construction will be easier during drier months. Bog matting (or equivalent) through the rushes is likely to be required. Duration of works should be kept to a minimum. If possible, treat as special section and avoid using as main right of way. Timing is important – there are likely to be breeding birds in rushes and banks. Dewatering may be necessary, in which case due regard must be paid to ecological issues. Very boggy among reeds at time of survey.

Record No.:	11
River Name:	Ganjachay
Approx KP (Route D2):	296
Date of Survey:	7/11/01 (-ve bank); 8/11/01 (+ve bank)

Grid Reference of upstream limit of section:	-ve bank 086 26 619E; 045 17 185N
	+ve bank086 26 567E; 045 17 230N
Grid Reference of downstream limit of section:	-ve bank 086 26 688E; 045 17 421N
	+ve bank086 26 543E; 045 17 411N
Grid Reference of approx centreline:	-ve bank 086 26 615E; 045 17 272N
	+ve bank086 26 539E; 045 17 306N

Weather & flow conditions: 7/11/01 – sunny with breeze; 8/11/01 overcast with breeze. Very low flow – only perceptible where channel narrow.

Special & typical features of the river channel: Dammed c300m downstream from centreline. Channel v. variable width with neglibible flow. Steep earth cliffs – slumped and eroded in places. Filamentous green algae suggesting eutrophic conditions. Narrow permanent stream with much wider flood channel. Some cobbles in flood area.

Marginal vegetation: Patches of *Tamarix. Rannunculus sp.* Grasses.

Bank zone habitats: Grass with *Salsola dendroide*, *Alhagian pseudoalhagia*, thistles and *Tamarix*. Heavily grazed and eroding.

Adjacent land-use: Agricultural.

Notes of insects/birds/mammals of special interest: Many burrows in banks and mud cliffs. Terrapins. Birds. Frogs. Small fish.

Recreation features: None.

Known downstream sensitivities:

- Water abstraction from impoundment behind dam
- Flows towards the Mingechaur Reservoir (which feeds into the Kura River)
- Korchay State Forbidden Area is 2.5km downstream (to north)
- No mapped communities downstream from crossing point within 10km
- No endangered flora close to crossing point
- Falco tinnunculus (Bird of European Conservation Concern: declining) within 2km of crossing point

Existing management of river banks etc.: None

Additional Comments: Bank stability and burrows in cliff should be taken into account during the planning phase.

Record No.: 12
River Name: Gancachay
Approx KP (Route D2): 298.6
Date of Survey: 7/11/01
Surveyor : Dr Janet Swan

Dry river , therefore not surveyed.

Grid Reference of upstream limit of section:
Grid Reference of downstream limit of section:
Grid Reference of approx centreline:

Weather & flow conditions: Dry river – now agriculture plants .
.

Special & typical features of the river channel:

Marginal vegetation:

Bank zone habitats:

Adjacent land-use:

Notes of insects/birds/mammals of special interest:

Recreation features:

Known downstream sensitivities:

Existing management of river banks etc.:

Additional Comments:

Record No.: 13
River Name: Sarysu
Approx KP (Route D2): 316.1
Date of Survey: 7/11/01

Grid Reference of upstream limit of section: 086 10 570E; 045 26 025N
Grid Reference of downstream limit of section: 086 10 543E; 045 26 199N (<200m downstream, but limit of access)
Grid Reference of approx centreline: 086 10 573E; 045 26 078N
Note: distances are very approximate as no level ground to pace.

Weather & flow conditions: Flow c. 0.5m sec^{-1}. Warm & sunny. Light breeze.

Special & typical features of the river channel: Choked with tall reeds. Steeply incised channel except at WREP crossing which has been left graded.

Marginal vegetation: Dense reeds.

Bank zone habitats: Dense reeds and scrub with willow and alder. *Salsola* at WREP crossing.

Adjacent land-use: Desert with grazing.

Notes of insects/birds/mammals of special interest: Birds, butterflies, frogs. Terrapins heard but not seen. A lot of bird song and movement in the undergrowth.

Recreation features: None

Known downstream sensitivities:

- Flows into the Kura River, upstream of the Mingechaur Reservoir
- The communities of Kadirli and Yenikend are located within 10km downstream
- Shamkir Reserve is 3.5km downstream
- Samukh State Hunting Area is 1km downstream
- No endangered flora close to crossing point
- Endangered fauna recorded within 0.75km of crossing point:
    - Hystrix indica (proposed RDB)
    - Chettusia leucura (RDB)

Existing management of river banks etc.: None.

Additional Comments: Good reinstatement will be required and should include encouragement of marginal & bankside vegetation**.**

Record No.:	14
River Name:	Gashgarachay
Approx KP (Route D2):	316.7
Date of Survey:	7/11/01

Grid Reference of upstream limit of section:	086 09 986E; 045 26 188N
Grid Reference of downstream limit of section:	086 10 025E; 045 26 188N
Grid Reference of approx centreline:	086 09 934E; 045 26 071N

Weather & flow conditions: Sunny & calm.

Special & typical features of the river channel: Fast flowing. Cobble bed with patches of loose sediment.

Marginal vegetation: Grasses and dicots. *Ranunuculus spp.*

Bank zone habitats: Earth cliffis in places 0 up to 1.5m high. Otherwise cobble and grass with *Tamarix* scrub. Burrows in banks.

Adjacent land-use: Pasture.

Notes of insects/birds/mammals of special interest: Frogs. Birds. Probably good for invertebrates – fast flowing over cobble.

Recreation features:

Known downstream sensitivities:

- Flows into the Kura River, upstream of the Mingechaur Reservoir
- The communities of Kadirli and Yenikend are located within 10km downstream
- Shamkir Reserve is 3.5km downstream
- Samukh State Hunting Area is 1km downstream
- No endangered flora close to crossing point
- Endangered fauna recorded within 1.3km of crossing point:
    - Hystrix indica (proposed RDB)
    - Chettusia leucura (RDB)

Existing management of river banks etc.: None

Additional Comments: None.

Record No.: 15
River Name: Karasu
Approx KP (Route D2): 320.9
Date of Survey: 9/11/01

Note: no grid references and not drawn because no access along channel

Grid Reference of upstream limit of section:
Grid Reference of downstream limit of section:
Grid Reference of approx centreline:
WREP crossing (about 100m downstream of proposed BTC crossing) 086 06 402E; 045 24 567N

Weather & flow conditions: c 1m sec^{-1}

Special & typical features of the river channel: 1.5m wide. Flast flowing at WREP crossing – widens out immediately downstream as flows into rushes. Depth unknown but >0.5m.

Marginal vegetation: Dense tall reeds – prevented access for full survey.

Bank zone habitats: Mosaic of reed species with *Salsola* desert away from channel. Many areas of reed recently cut.

Adjacent land-use: Agriculture.

Notes of insects/birds/mammals of special interest: Birds among reeds. Small burrows in grassland.

Recreation features: None. Extensive grazing along valley.

Known downstream sensitivities:

- Flows into the Kura River, upstream of the Mingechaur Reservoir
- The community of Yenikend is located 10km downstream
- Shamkir Reserve is 4km downstream
- Samukh State Hunting Area is 1km downstream
- No endangered flora close to crossing point
- Endangered fauna recorded within 0.15km of crossing point:
    - Hystrix indica (proposed RDB)
    - Falco tinnunculus (Bird of European Conservation Concern: declining)
    - Plegadis falcinellus (Proposed RDB, Bird of European Conservation Concern: declining)

Existing management of river banks etc.: Bund left/created on –ve bank of WREP crossing

Additional Comments: None.

Record No.: 16
River Name: Shamkirchay
Approx KP (Route D2): 332
Date of Survey: 9/11/01

Grid Reference of upstream limit of section:
Grid Reference of downstream limit of section:
Grid Reference of approx centreline: 085 97 205E; 045 26 951N

Weather & flow conditions: Sunny & calm.

Special & typical features of the river channel: Dry river bed – cobble in silt. Extensive gravel/cobble extraction. Main channel has bank 405m high on –ve side and 1m on +ve.

Marginal vegetation: None.

Bank zone habitats: Ecological desert. Sparse grasses and ruderal species.

Adjacent land-use:

Notes of insects/birds/mammals of special interest: Occassional birds. Burrow in –ve bank.

Recreation features: None.

Known downstream sensitivities:

- Flows to north into the Shamkir Reservoir (which feeds the Kura River)
- Shamkir Reserve is 4km downstream
- Shamkir State Forbidden Area is 6km downstream
- Communities within 10km downstream: Yeniyabad, Kur
- No endangered flora or fauna close to crossing point

Existing management of river banks etc.: Quarrying

Additional Comments: None.

Record No.:	17
River Name:	Zayamchay
Approx KP (Route D2):	357
Date of Survey:	9/11/01

Note: Not mapped because no ecological sensitivity.

Grid Reference of upstream limit of section:	085 74 302E; 045 34 255N
Grid Reference of downstream limit of section:	085 74 309E; 045 34 467N
Grid Reference of approx centreline:	085 74 344E; 045 34 329N

Weather & flow conditions: Calm & sunny.

Special & typical features of the river channel: Broad dry cobble/silt river bed c. 400m wide. Eroded banks both sides c 2m high on +ve bank and 4m on –ve bank at centreline. Further flood zone 2-300m wide on +ve side = grass.

Marginal vegetation: None.

Bank zone habitats: Grass.

Adjacent land-use: Grazing.

Notes of insects/birds/mammals of special interest: Burrows in banks ond river margins. Particularly large burrow in –ve bank at 085 74 487E; 045 34 243N.

Recreation features:

Known downstream sensitivities:

- Flows to north into the Shamkir Reservoir (approximately 8km)
- Shamkir State Forbidden Area is 7.5km downstream
- No communities adjacent to the river downstream from crossing point
- No endangered flora close to crossing point
- Endangered fauna within 0.5km of pipeline crossing:
    - Testudo graeca (RDB)
    - Falco tinnunculus (Bird of European Conservation Concern: declining)
- Archaeological site (burial mounds and bridge) 0.5km to east

Existing management of river banks etc.: Gravel extraction c. 150m upstream.

Additional Comments: Archaeologically important camel dung bridge supports upstream from proposed crossing point. Will require clear briefing of workforce about their archaeological importance.

Record No.: 18
River Name: Tovuschay
Approx KP (Route D2): 377.1
Date of Survey: 10/11/01
Surveyor : Dr Janet Swan

Grid Reference of upstream limit of section: 085 56 748E; 045 42 378N
Grid Reference of downstream limit of section: 085 56 910E; 045 42 604N
Grid Reference of approx centreline: 085 56 814E; 045 42 450N

Weather & flow conditions: Calm; partial sun.

Special & typical features of the river channel: Wide cobble river bed with small flowing channel. Vehicle track along river bed – crosses channel in many places.

Flowing channel: Flow rate c.0.3m sec^{-1}. Cobble/silt bed. Water depth 0.1- 0.2m Channel width 1.5 – 6.0. Seriously eutrophic with green/yellow algal mats and *Lemna*.

Marginal vegetation:
Grass with some patches of *Mysotis xxx* water forget-me-not and *Mentha sp.*

Bank zone habitats:
Sand /cobble cliff to main river channel.
Cobble for flowing river channel.

Adjacent land-use:
-ve = semi-desert
+ve = agricultural

Notes of insects/birds/mammals of special interest:
Some birds.
Occasional burrows in cliffs.

Economic features:
Upstream has gravel/cobble extraction and rubbish tipping.
Several dwellings close to river bank with water extraction for irrigiation.

Known downstream sensitivities:

- Flows towards Shamkir Reservoir (11km downstream)
- No mapped communities along river between crossing point and reservoir
- No endangered flora close to crossing point
- Endangered fauna recorded downstream (4km):
    - Testudo graeca (RDB)
    - Aquila rapax (RDB, Bird of European Conservation Concern: vulnerable)
    - Hystrix indica (proposed RDB)

Existing management of river banks etc.: None.

Additional Comments: None.

Record No.: 19
River Name: Hasansu
Approx KP (Route D2): 397.8
Date of Survey: 11/11/01

Grid Reference of upstream limit of section: no GPS readings (military installation nearby)
Grid Reference of downstream limit of section:
Grid Reference of approx centreline:

Weather & flow conditions: Sunny & windy. Flow 2m sec-1.

Special & typical features of the river channel: Shallow mountain stream in deeply incised valley. Clear water with some algae and monocots. Probably good for invertebrates.

Marginal vegetation: Grasses & dicots – no access for ID except for small section of grassy bank.

Bank zone habitats: Earth cliffs with dense shrubs and tall reeds. Some *Tamarix. Vitis sp.* Some burrows.

Adjacent land-use: -ve is semi-desert. +ve is semidesert and agricultural

Notes of insects/birds/mammals of special interest: Crabs, birds (surprisingly few). Good vegetation diversity and structure. Dragonflies. Wagtail.

Recreation features: Trout fishing from small holding.

Known downstream sensitivities:

- Small holding dependant on river for water supply.
- Electrofishing.
- Waterbuffalo and other livestock drink from river.
- Flows towards the Kura River (4.5km downstream)
- No mapped communities along river between crossing point and Kura River
- Endangered fauna recorded at crossing location:
  - Plegadis falcinellus (Proposed RDB, Bird of European Conservation Concern: declining)
  - Manduca atropos (RDB)
  - Endangered fauna recorded 1.25km from crossing point:
  - Testudo graeca (RDB)
  - Endangered flora recorded 1km from crossing point:
  - Glycyrrhiza glabra (Proposed RDB)

Existing management of river banks etc.: None

Additional Comments: Ecologically diverse. Sediment release from bank grading and crossing must be very carefully controlled.

Record No.: 20
River Name: Kura (west crossing)
Approx KP (Route D2): 411
Date of Survey: 12/11/01

Grid Reference of upstream limit of section: -ve bank 085 37 543E; 045 67 631N
+ve bank 085 37 521E; 045 67 827N
Grid Reference of downstream limit of section: -ve bank 085 37 777E; 045 67 691N
+ve bank 085 37 674E; 045 67 871N
Grid Reference of approx centreline: -ve bank 085 37 627E; 045 67 650N
+ve bank 085 37 547E; 045 67 839N

Weather & flow conditions: Overcast & breezy (force 3-4). Cool (10^{o}C). Flow 2-3m sec^{-1}.

Special & typical features of the river channel: Wide fast flowing river. Some *Myryophyllumsp, Ceratosterma sp.*, algae.

Marginal vegetation: Submerged filamentous plants near margins.. Hawksbit. Plantain (?water dock)

Bank zone habitats: Mud cliff 1-2m high. Grass with *Tamarix*. Some burrows.

Adjacent land-use: Grazing.

Notes of insects/birds/mammals of special interest: Kingfishers. Mouse burrows among *Tamarix*. Terrapins. +ve bank has much more diverse habitats than –ve bank, especially downstream of crossing point.

Recreation features: Grazing. Fishing.

Known downstream sensitivities:

- Birds
- Flows towards east, ultimately reaching the Caspian
- Kariyazi Aquifer immediately upstream from this location
- Kariyazi-Agstafa State Forbidden Area immediately upstream from this location
- Community 5.5km downstream: Kesaman
- No endangered flora close to crossing point
- Endangered fauna recorded just upstream and up to 5km downstream of crossing point:
    - Chettusia leucura (RDB)
    - Alcedo atthis (Bird of European Conservation Concern: declining)
    - Testudo graeca (RDB)
    - Circus cyaneus (Bird of European Conservation Concern: vulnerable)
    - Porphyrio porphyrio (Proposed RDB, Bird of European Conservation Concern: rare)

Existing management of river banks etc.: Recent burning – probably controlled burn for scrub control but may have been accidental.

Additional Comments: High sensitivity. Many opportunities to improve marginal habitats.

Record No.: 21
River Name: Kurudera
BTC RVX No.: 422.3
Date of Survey: 12/11/01

Grid Reference of upstream limit of section:
Grid Reference of downstream limit of section:
Grid Reference of approx centreline: 085 29 508E; 045 74 120N
Note: Not mapped

Weather & flow conditions: Cool and overcast.

Special & typical features of the river channel: Narrow flowing channel 0.5 to 2m wide and 0.1m deep in wider dry river bed.

Marginal vegetation: None.

Bank zone habitats: Sand cliffs to main +ve bank and downstream on –ve side.

Adjacent land-use: Semi-desert.

Notes of insects/birds/mammals of special interest:

Recreation features: None

Known downstream sensitivities:

- Flows into Kura River 10km downstream (to SE)
- Located within Kariyazi Aquifer
- Comes close to Kariyazi-Agstafa State Forbidden Area approximately 10km downstream
- No communities directly on route of Kurudera between crossing point and Kura River
- No endangered flora close to crossing point
- Endangered fauna recorded less than 1km from crossing point:
    - Testudo graeca (RDB)

Existing management of river banks etc.: None

Additional Comments: Fly tipping on –ve bank included barbed wire, metal, tiles (possibly asbestos) and many small bottles (possibly chemical).

1.4 SUMMARY

Table 1-1 summarises the ecological sensitivity of each river crossing on a scale of 1 to 5, where 1 denotes high sensitvity and 5 denotes low sensitivity. The assessment is inherently subjective, but is intended as an indication of the relative importance of each river, in ecological terms.

The Kura and Hasansu rivers are the most sensitive along the route; this has been taken into account during the environmental assessment and design of the pipeline.

Table 1-1 Main Azerbaijan river crossings - ecological sensitivity

River Ref. No.	River	Crossing Point (KPs based on Route D2)	Ecological Sensitivity (1 = high; 5 = low)	Width[1] & flow rate of wet channel Nov. 2001	Comments
1	Djerankechmes	9.3	2	3m; 0.4m sec^{-1}	Wide river bed with narrow stream flowing at time of survey. Sensitivity relates to overall species diversity within river system rather than aquatic fauna; many burrows were observed in banks. Bank stability is an issue due to the erodable nature of the bank materials and the lack of vegetation. River flows highly seasonal (flow increases considerably during spring). Typically exhibits high sediment load
2	Pirsagat	42.1	3/4	3m; 0.25m sec^{-1}	Narrow canalised river with slow flow. High sediment load. Dredged within last 12 months.
3	Agsu Canal	111.2	4	25m; 1m sec^{-1}	Wide canalised river. High sediment load. Low apparent ecological sensitivity but has the potential to transport contaminants to more sensitive areas.
4	Geokchay	171.3	3	15m; 1m sec^{-1}	Narrow canalised river in deep cutting. Vegetation indicates wide fluctuations in water level. High sediment load. Diverse bank flora and bird life.
5	Turianchay	193.5	2	15m; 1m sec^{-1}	Incomplete survey because dense scrub precluded adequate access. Possible habitat for water voles. Potential to carry contaminants downstream rapidly.
6	Kura (east crossing)	223.6	1	>150m; 2m sec^{-1}	Wide fast flowing river with extensive fishing and wildlife value. Reedbed downstream from crossing point is particularly valuable for birds. Given the high flow rate, the river has the potential to transport contaminants downstream rapidly.
7	Karabach Canal	245.1	4	25m; 0.5m sec^{-1}	Canalised river with marginal vegetation. Abstraction point for irrigation immediately upstream of crossing point. Low apparent ecological sensitivity but has the potential to transport contaminants

[1] Widths and flow rates are visual estimates only and relate to a single site visit at each location.

Table 1-1 Main Azerbaijan river crossings - ecological sensitivity

River Ref. No.	River	Crossing Point (KPs based on Route D2)	Ecological Sensitivity (1 = high; 5 = low)	Width[1] & flow rate of wet channel Nov. 2001	Comments
					to more sensitive areas
8	Goranchay	257.8	5	dry	Small and dry (at the time of the survey)
9	Kurekchay	276.5	2/3	3m; 0.3m sec^{-1}	Wide braided channel – only narrow channels flowing. Mud cliffs have abundant holes. River well used by villagers for washing etc. Also used widely for watering livestock.
10	Korchay	292	2/3	3m; 0.5m sec^{-1}	Braided river with narrow flowing channels within extensive areas of marshy reedbeds. Ecologically diverse (habitat for terrapins and a wide range of birdlife). Also used widely for watering livestock. In the event of a spill, contaminant migration might be partially impeded by the reeds but could have significant local effects. Believed to have greater flow in Spring.
11	Ganjachay	296	3/4	3-13m; 0.2m sec^{-1}	Channel of variable width but negligible flow. Many burrows in cliffs. Dammed c.300m downstream from pipeline crossing point. It is probable that contaminant migration would be limited by the presence of the dam in the event of a pollution incident upstream of it.
12	Gancachay	298.4	5	dry	Dry river – currently agricultural plots.
13	Sarysu	316.1	3	1.5m; 0.5m sec^{-1}	Small stream with good species diversity.
14	Gashgarachay	316.7	2/3	2-3m; 2m sec^{-1}	Fast flowing with good species diversity. Also used widely for watering livestock.
15	Karasu	320.9	3	1.5m; c. 0.5 sec^{-1}	Narrow watercourse within a wide channel, mainly vegetated by reeds. Valuable bird habitat. In the event of a spill, contaminant migration might be partially impeded by the reeds but could have significant local effects.
16	Shamkirchay	332	5	dry	Wide but dry channel. Very low ecological value or sensitivity. The dry river bed has been extensively exploited for gravel extraction,

Table 1-1 Main Azerbaijan river crossings - ecological sensitivity

River Ref. No.	River	Crossing Point (KPs based on Route D2)	Ecological Sensitivity (1 = high; 5 = low)	Width[1] & flow rate of wet channel Nov. 2001	Comments
					with extraction taking place upstream at time of survey.
17	Zayamchay	357	5	0.4m;	Very low ecological sensitivity and almost no flowing channel. Archaeological feature (bridge supports) within dry area of channel.
18	Tovuzchay	377.1	4	1.5-6m; 0.3m sec^{-1}	Wide cobble river bed with narrow flowing channel. Main channel eutrophic. Flow may increase in spring and therefore introduce the risk of any pollution incident impacting downstream receptors.
19	Hasansu	397.8	1	3-6m; 2m sec^{-1}	Fast flowing clear stream. Ecological diverse and valuable habitat. Smallholding immediately downstream with livestock drinking from the river. Locals regularly catch large trout in the river – thought to spawn locally. A pollution incident at the crossing point could have serious adverse impacts and could be carried considerable distance downstream.
20	Kura (west crossing)	411	1	>100m; 2-3m sec^{-1}	Fast flowing and wide. Extensive fishing. Diverse birdlife (including kingfishers). Wetland & islands used by birds just downstream from proposed crossing. Pollution incidents at the crossing point could lead to rapid migration of contaminants downstream.
21	Kurudera	422.3	3	2-3m; 0.5m sec^{-1}	Narrow flowing channel c. 0.1m deep at the time of the survey with sand/silt substrate. Cobbles/sand throughout dry portions of river bed. Sand cliffs downstream provide potential nesting habitat. Fly tipping including chemical bottles on bank. Karyazi wetland downstream increases sensitivity.

CONTAMINATED LAND

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1 CONTAMINATED LAND

1.1 INTRODUCTION

The purpose of this report is to describe areas of contamination, which may be crossed by the proposed pipeline corridor, and to identify such areas that may put the proposed pipeline or workforce at risk. It should be noted that this report is a preliminary contamination review. A separate Contamination Baseline Report will be produced under the requirements of the HGA.

1.2 DATA SOURCES

In the preparation of this report a number of reference sources have been reviewed. As the proposed pipeline follows the existing "Western Route Export Pipeline" (WREPA) for much of its route, reference materials detailing areas of contaminated land along the WREPA have been used, together with more up to date baseline information collected in summer 2000 and winter/spring 2001. Information provided in the EIA for the WREPA was based on field survey work, literature review reports prepared by members of the Azeri scientific community, and clarification meetings held with the authors of the reports, as detailed below.

The contaminated land section has been based on the following sources of information:

- September 2001 – Contamination survey of Pipe Dumps and Camp Locations undertaken by RSK Environment Ltd on behalf of BP
- January/February 2001 - baseline survey of those areas where the proposed proposed pipeline route deviates significantly from the WREPA undertaken by Azerbaijan Environment and Technology Centre (AETC) on behalf of BP
- August/September 2000 - rapid reconnaissance survey of the WREPA undertaken by Environment Resources Management (ERM) on behalf of BP
- 1997 - baseline survey of WREP undertaken by AETC on behalf of Azerbaijan International Operating Company (AIOC) as part of the Environmental Impact Assessment of the WREP
- Literature review on contamination along the WREPA corridor by Dr R Mamedov, Scientific Center 'Nafta', Institute of Geology (December 1996)
- Supplementary details and clarifications provided by Dr R Mamadov in meeting with Dr. Heike Pflasterer held in Baku (February 1997)
- Literature review on soils and agrochemistry along the WREPA corridor by Prof. G Yagubov, Institute of Soils and Agrochemistry (December 1996)
- Supplementary details and clarifications provided by Prof. G Yagubov in meeting with Dr. Heike Pflasterer held in Baku (February 1997)

1.3 AREAS OF OBSERVED CONTAMINATION

Table 1-1 outlines the findings of field work carried out during 2000 and 2001. This work identified twenty three sites of observed soil contamination close to the proposed route of the pipeline.

In the majority of instances, the observed contamination was the result of uncontrolled disposal of wastes (fly tipping).

Table 1 Observed contamination along the proposed pipeline route

NEAREST KP	CONTAMINATION SOURCE	POTENTIAL CONTAMINANTS	APPARENT DEPTH	PROXIMITY TO PIPELINE CENTRELINE (M)
0	Oil industry	Hydrocarbons	Surface	600
51	Fly tipping/asbestos tiles	Mixed wastes	Surface	Within 20
52	Fly tipping	Mixed wastes	Surface	120
55	Oil industry - old oil exploration site with degraded oil, separation ponds and cuttings	Hydrocarbons	Unknown	70
64	Other Industrial (proposed camp/pipe dump site). White fibrous deposit in patches	Unknown, possible asbestos	Surface	500
77	Oil industry - old well site	Hydrocarbons	Unknown	Within 20
92	Oil industry – probable former oil exploration site with iron rich water in ponds	Heavy metal/iron	Unknown	40
223	Vehicle oil 4m from East bank of Kura in waterlogged ground	Hydrocarbons	Unknown	Within 20
224	Fly tipping/asbestos tiles	Asbestos tiles	Surface	400
227	Municipal	Household waste	Surface	40
231	Oil industry	Hydrocarbons	Unknown	300
254	Fly tipping - possible asbestos tiles plus household waste, paint cans, oil cans	Asbestos	Surface	50
271	Oil industry - disused oil well. Actively leaking oil and water into 3 lagoons around wellhead	Hydrocarbons	Unknown	40
276	Oil industry pumping station	Possible hydrocarbons	Surface	80
304	Fly tipping/asbestos tiles. Close to river, stream and earth dam	Asbestos tiles	Surface	Within 20
308	Industrial activities and fly tipping - possible smelting site- building rubble	Metals, hydrocarbons, mixed wastes	Unknown	Within 20
338	Fly tipping - possible asbestos tiles	Asbestos	Surface	20
343	Fly tipping - possible asbestos tiles	Asbestos	Surface	Within 20
354	Fly tipping	Asbestos tiles	Surface	60
364	Fly tipping including possible asbestos tiles, rubble, car remains, wire, cans	Asbestos, mixed wastes, solvents, metals	Surface	40
377	Fly tipping - possible asbestos tiles	Asbestos	Surface	60

Table 1 Observed contamination along the proposed pipeline route

NEAREST KP	CONTAMINATION SOURCE	POTENTIAL CONTAMINANTS	APPARENT DEPTH	PROXIMITY TO PIPELINE CENTRELINE (M)
395	Building rubble and fly tipping with possible asbestos tiles.	Asbestos	Surface	30
422	Fly tipping - barbed wire, metal, glass (chemical) bottles, tiles (possibly asbestos) on East bank of Kurudera River	Asbestos, mixed wastes, solvents, hydrocarbons, metals	Unknown	Within 20

1.4 HYDROCARBON CONTAMINATION

In the Gobustan Area (KP0-52), the proposed pipeline has been routed to avoid existing pipelines. No contamination from oil pipeline leakages was observed. The proposed pipeline corridor appears not to be affected by contamination from the three exploration fields crossed in this area (Miaidjik, Turagay and Solakhay).

In the Shirvan Steppe section (KP52 to 224) the pipeline crosses, or is routed close to, three exploration drilling fields where drilling activities have been undertaken in the past: Small Harami (north of Kazi-Magomed), Padar and Karadjarle. Contamination within these oil fields is usually restricted to the immediate vicinity of the drill site.

In the Karabakh Plain area (KP224 to 256) the proposed pipeline route crosses the Amirax oil prospecting area where oil contamination due to bombing of a well during the conflict with Armenia has been reported (Mamedov, 1996). Elsewhere, contamination within these oil fields is usually restricted to the immediate vicinity of the drill site. No wells were identified within the pipeline corridor with visible contamination.

In the Lesser Caucasus Plain and Lowlands area (KP256-442) the pipeline traverses the Borsunlu, Dalimammedli, Giragkasaman, Dallar-Tovuz, Khatunli and Akstafa oilfields, some of which are in operation. There is only local contamination around the drill sites within these fields. One disused oil well near Borsunlu (KP271) was identified as actively leaking oil and water.

1.5 RADIATION

The exploration and production of oil creates a number of potential sources of contamination. Radiation from radionuclides may be released by hydrocarbon operations such as exploration drilling wells, oil collection points and oil storage tanks. Mamedov (1996) indicated that the Gobustan region has a general background radiation level of between 4 and 15μrhr^{-1}. However, in areas of intense tectonic and mud volcano activity, the background levels become elevated to 20-22μrhr^{-1}. These levels are considered to be within ‘normal’ background radiation levels of <33μrhr^{-1} (2.5$mZvyr^{-1}$) according to the established standard (NRPB 76/87).

The background radiation level in the Shirvan Plain area is lower than in Gobustan, at between 5-8μrhr^{-1}, due to the less active tectonic regime. There is still the potential for elevated levels of radiation in the form of radionuclides, hydrocarbons, phenols and heavy metals to be released from hydrocarbon operations.

In the Karabakh Plain area the background radiation level is low and stable at 5.5-6 μryr^{-1} due to the less active tectonic regime. Hydrocarbon operations could also have released elevated levels of hydrocarbons, phenols, heavy metals and radionuclides.

The background radiation level in the Lesser Caucasus Plain and Lowlands area is believed to be relatively low and stable (around 6μryr^{-1}), although the area has not been as intensively surveyed as the eastern areas traversed by the pipeline corridor.

1.6 FLY TIPPING AND ASBESTOS

Contamination in the form of surface fly tipping was observed at a number of sites during the 2000/2001 surveys. It generally comprised municipal waste consisting of various materials such as glass, metal, rags etc. The sites often contained remains of roofing tiles, which may consist of asbestos and as such may pose a hazard to health and safety of the workforce during pipeline construction activities. Two sites were identified where possible asbestos roofing tiles occurred on the sites of demolished buildings.

Figure 1 Site of surface contamination (fly tipping)

The principal concern relates to the nature of the tiles that were observed on the surface. If the tiles are composed of asbestos (which is a high possibility in such areas), then they will pose a Health and Safety risk to employees during construction of the proposed pipeline.

Figure 2 Surface contamination (suspected asbestos tiles)

1.7 INDUSTRIAL CONTAMINATION

In the Shirvan Plain section of the proposed pipeline, Kazi Magomed and Ucar are small industrial bases where industries such as printing, brick making and cotton processing take place. They are also oil storage bases. The proposed pipeline corridor is located 1km to the north of Kazi Magomed and 5km to the south of Ucar.

The Karabakh Plain area traversed by the proposed pipeline route has the potential for contamination mainly due to the industrialization at Yevlakh. The industry at Yevlakh includes concrete and ferro concrete production, asphalt production, wool processing and oil storage facilities. The proposed pipeline corridor is located 1 km to the south-west of Yevlakh.

Industry, military activity and oil exploration in the Lesser Caucasus Plain and Lowlands area have the potential to cause contamination within the proposed pipeline corridor. The town of Ganja has a high level of industrial activity including concrete production, aluminium oxide production, machinery manufacturing, non-ferrous metal plant, instrument engineering plant, wood processing, furniture manufacture and oil storage facilities. The towns of Tovuz, Kazakh and Akstafa also have oil bases and light industry such as wine distilleries and bread baking. The lack of up-to-date technology for controlling emissions to air and water leads to the potential for heavy contamination in such areas. The proposed pipeline corridor is located approximately 8 km north of the outskirts of Ganja.

Where the proposed pipeline route is located in close proximity to such industrial areas, there is a possibility that it may be impacted by contamination from these sources through airborne emissions, soil, groundwater or surface contamination.

1.8 AGRICULTURAL CONTAMINATION

The Gobustan region, east of Kazi Magomed is too dry and the soils too saline to be used for extensive agricultural purposes.

Within the Shirvan Steppe section of the proposed pipeline route, the area from Ranjbar to the Kura River east of Yevlakh is a flat land area that has been used extensively for agriculture. The intense farming practices in the area have had a profound effect on the soil characteristics. The land is intensively cultivated arable farmland used mainly for cotton and cereals, with smaller areas of rice and pasture. The soils have become depleted and crops are patchy and sparse in places. There is a possibility that the soils in this area may be contaminated with high levels of pesticides and/or herbicides.

Soils are reportedly contaminated with pesticides and herbicides throughout the Karabakh Plain area.

Agriculture in the Lesser Caucasus Plain and Lowland area is similar in type and intensity to the Shirvan and Karabakh Plains, with the addition of vineyards and orchards towards the west in the foothills of the Small Caucasus. There is therefore a possibility that the soils may be contaminated with high levels of pesticides and/or herbicides.

1.9 MILITARY AREAS/ORDNANCE

In the Gobustan region, the proposed pipeline crosses a military area between KP5 and KP13. This area was apparently used for military training purposes and is reputed to contain anti-personnel mines. There is also the possibility of live ordnance being found.

In the Karabakh Plain area the proposed pipeline route crosses the Amirarx oil prospecting area which, as mentioned, was reportedly damaged by bombing during the conflict with Armenia, resulting in local crude oil contamination and the possibility of live ordnance still being found.

In the Lesser Caucasus Plain and Lowland area, there is a military training area north of the western Kura crossing at Poylu, extending westwards to Jandari Lake and the Georgian Border. The presence of ordnance (and possibly radioactive materials) in this area may be significant. Therefore this area has been avoided by the proposed pipeline route by re-routing to the south through the Karayazi Aquifer area.

1.10 NATURAL CONTAMINATION

In the Gobustan Area, between KP0 and KP29, natural seepages of crude oil occur in small quantities from mud volcanoes and faults. Similarly, there may be elevated levels of hydrocarbons and phenols in the vicinity of the proposed pipeline due to natural (mudflow and seepage) and industrial sources, such as leaking oil pipelines. Heavy metals can also be associated with natural mud flows emanating from the numerous mud volcanoes e.g. the Turagay mud volcano, the flanks of which are approximately 0.5 km to the south of the proposed pipeline at KP17.

1.11 CONTAMINATION SURVEY OF PIPE DUMPS AND CAMP LOCATIONS

Walkover surveys were carried out at the beginning of September 2001 at the following proposed pipe dump locations:

- Sangachal
- Mugan
- Kurdemir

- Ucar
- Laki
- Yevlak
- Ganja
- Dollar
- Zayam
- Polyu
- Bayuk Kassik

And the following camp location:
- Ganja

At each location, surface soil samples were taken for laboratory analysis and internationally recognised guidelines were used to assess the samples. The following guidelines were used, ‘Guidance on the assessment and Redevelopment of Contaminated Land’ ICRCL Guidance Note 59/83 - UK, New Dutch List Guidelines and EH40/98 Occupational exposure limits (HSE 1998).

The ICRCL (Interdepartmental Committee for the Redevelopment of Contaminated Land) was set up in 1976, to consider the development of contaminated sites. In order to assess whether a particular site was contaminated, two ‘trigger’ values were created, called the ‘threshold’ and ‘action’ values. These trigger values create three possible contamination concentration zones:

- Below the ‘threshold’ value was declared uncontaminated
- Above the ‘action’ value, the presence of the contaminant has to be regarded as undesirable or even unacceptable, so some kind of remedial action is required
- Between the two values, there may be a need to consider the contamination and take action where circumstances demand it. The decision to do so will be based on “informed judgement”.

Analysis was carried out on the samples to identify the levels of Arsenic, Cadmium, Lead, Chromium (and Chromium VI) and Selenium that are harmful to human and animal health by ingestion. Samples were analysed for Zinc, Copper and Nickel, as they are known to be phytotoxins (substances harmful to plants). In addition to the above, samples were taken in order to analyse for the following contaminants, Poly-Aromatic Hydrocarbons (PAH), Total Petroleum Hydrocarbons (TPH) and Diesel Range Organics (DRO) and Chrysotile (white asbestos).

The following results were obtained:

- 3 sites (Sangachal, Laki and Yevlak) exceeded ICRCL threshold values for arsenic. 1 site was above the ICRCL action value (Ganja pipe dump)
- 2 sites (Laki and Ganja Pipe Dump) were above ICRCL threshold values for Mercury
- 3 sites (Kurdemir, Yevlak and Dollar) were above ICRCL threshold values for Nickel
- No sites were above ICRCL threshold values for Cadmium, Chromium or Chromium VI, Lead, Selenium, Zinc, Copper
- No sites were above the ICRCL threshold value for PAHs
- No sites were above the Dutch Intervention level for TPH – DRO
- 4 sites (Kurdemir, Ucar, Yevlak and Dollar) have elevated chrysotile (white asbestos) levels

In summary the levels of contamination were low, indicative of light industrial use. Only one site (Ganja pipe dump) had a determinand (arsenic) level over the ICRCL action value.

1.12 PUBLIC HEALTH ISSUES

Large areas of population along the route such as Kazi-Magomed, Kurdamir, Ucar, Yevlakh, Ganja, Tovuz, Akstafa and Kazak are associated with industry, industrial discharges and municipal sewage. In the majority of settlements, central sewage collection and treatment facilities are absent. The situation is aggravated during periods of high precipitation, when contamination of surface and groundwater bodies by sewage, domestic and industrial wastes takes place. This is a particular problem in the area between Kazi-Magomed and Yevlakh, where cases of malaria and anthrax were reported in 1996.

1.12.1 Malaria

Malaria is a febrile disease caused by a parasite that is transmitted by mosquitoes. Of the four types of malaria (faciparum, vivax, ovale and malariae), falciparum can be lethal.

The most common form of malaria in Azerbaijan is vivax malaria, which is responsible for milder diseases. Unless correctly treated it can hide in the liver, causing relapses months or even years later. However, if treated immediately and correctly, recovery is complete.

There was an alarming upsurge in malaria cases in Azerbaijan during the mid-1990s. This is being reversed through the efforts of a public-private partnership brokered in 1998 by the Roll Back Malaria global partnership.

During its first year of operation the malaria program, funded by a private sector multinational company and supported by international and other UN agencies, helped reduce malaria cases in the country by over 50 percent.

Twenty years ago malaria was virtually eradicated from Azerbaijan. However, over the past three years there has been a 120 fold increase in its incidence, 23 cases being reported in 1993 and 2802 in 1995. (British Medical Journal, 25 May 1996)

Certain mosquito control programmes can be adopted to reduce the mosquito population, and hence the occurrence of malaria. These include draining swamps and ditches, eliminating standing water and preventing mosquito access to living areas.

Protection from malaria is a personal responsibility, with preventative measures including the use of mosquito nets, “covering up” after dusk and the use insect repellent. Antimalarial medication is also an option, which either prevents or represses malarial symptoms.

1.12.2 Foot and Mouth disease

Foot and mouth disease occurs only in cloven hoofed animals, and does not affect humans. Animals affected include sheep, cattle, pigs, goats, deer and rats.

The disease is highly contagious and is spread rapidly through livestock. Humans, although unlikely to contract the disease, are often responsible for spreading it, as it can be carried on skin, clothing and shoes. Similarly, motor vehicles can spread the disease. In certain climatic conditions, foot and mouth can be borne by the wind to distances of 60 km (over land) to 300 km (over water).

The disease causes reduced fertility, low milk yields and death. It is not possible to treat the disease other than by vaccination although animals can recover from it in several weeks.

The most effective method for combating the spread of foot and mouth disease is early detection, coupled with culling of infected animals.

The last reported case of foot and mouth disease in Azerbaijan was in 1996. A vaccination programme has recently been investigated in order to prevent an influx of the disease to the country.

1.12.3 Anthrax

Anthrax is an acute infectious disease carried by the bacterium *Bacillus anthracis.* Anthrax occurs most commonly in wild and domestic vertebrates (sheep, cattle, goats, camels and other herbivores). It may also occur in humans exposed to infected animals or tissue from infected animals.

Anthrax is most common in agricultural regions (particularly southern and eastern regions of Europe). When outbreaks are found in humans, this is generally due to occupational exposure to affected animals or their products.

Transmission occurs by inhalation, ingestion or through the skin. Spores can survive in the soil for many years, and can result in infection of humans who are involved in handling products from infected animals, or by inhaling anthrax spores. However, direct person-to-person communication of anthrax is extremely unlikely to occur.

Anthrax vaccines for both humans and animals are available, and are said to be 93% effective.

Anthrax occurrences in humans in Azerbaijan between 1992 and 1996 are indicated in table 1-2. The disease is treatable with antibiotics, but these must be started early in the infection. If anthrax remains untreated it can be fatal. There have been reports of anthrax affecting areas of the proposed pipeline route in Azerbaijan in 2000/2001, however, no further information is currently available on these outbreaks.

Table 2 Anthrax cases in Azerbaijan

YEAR	NUMBER OF CASES OF HUMAN ANTHRAX
1992	33
1993	55
1994	50
1995	45
1996	76

1.12.4 Cholera

Cholera is a bacterial disease affecting the intestinal tract. It is caused by the Vibno cholera germ. Epidemics occur mainly in Central and Southern America. In recent years, there have been outbreaks of cholera in the former Soviet Union, including the north Caucasus area.

The disease is passed in faeces. It is spread either by eating food or drinking water contaminated by the faecal waste of an infected person. This is more common in underdeveloped countries lacking adequate water supplies and proper sewage disposal.

A vaccine for cholera is available; however, this offers only 50% efficacy. The best guard against contracting cholera is, therefore, thought to be careful personal hygiene and the avoidance of unsafe food or water in countries where the disease is incident.

GEOHAZARDS

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1 GEOHAZARDS

1.1 INTRODUCTION

This report clarifies the different types of geohazards (geological hazards) that will be incident on the BTC pipeline during construction and operation. Geohazards are defined as geological phenomena or conditions, either natural or man-made that are dangerous (or potentially dangerous) to the environment and its inhabitants. Natural hazards include earthquakes and volcanic eruptions, and, in this instance, fluvial erosion at watercourse crossings, particularly those associated with larger, or ephemeral rivers. Ground subsidence due to mining would be an example of a man-made geohazard.

1.2 DATA SOURCES

Reference has been made to the following reports and documents during the preparation of this section on geohazards affecting the BTC pipeline. As in other sections, reference materials relating to the WREP have also been consulted:

- January-February 2001 - baseline survey of those areas where the proposed BTC route deviates significantly from the WREP undertaken by Azerbaijan Environment and Technology Centre (AETC) on behalf of BP
- August/September 2000 - rapid reconnaissance survey of the WREP undertaken by Environmental Resources Management (ERM) on behalf of BP
- Baseline survey of WREP undertaken by AETC on behalf of Azerbaijan International Operating Company (AIOC) as part of the Environmental Impact Assessment of the WREP. (1997)
- Review of Publications on Geology along the Western Pipeline Route. (1996)
- Report on Anthropogenic Impacts on the Seismic Regime (1995)
- Atlas of Mud Volcanoes of the Azerbaijan Republic (1971)
- USA Uniform Building Code, Volume 2. Structural Engineering Design (1997)
- Seismic Review Report (2000)
- Preliminary Assessment of Mud Volcano Risk to Pipelines and Proposed Facilities Sites (August 2000)
- USGS National Earthquake Information Centre
- ESO Earthquake Database,
- Series of reports relevant to river crossings and hydrology (see section 1.6.2)

1.3 SEISMICITY

Much of the seismic information included in this appendix report was gathered during the production of the Seismic Review Report (August, 2000) carried out for the BTC pipeline. The main objectives of the document were to summarise the seismic activity in the area through which the BTC pipeline is routed, to identify BTC pipeline, facilities and AGI specific risks, and to identify and describe possible mitigation measures for the design and construction of the BTC pipeline.

The region through which the BTC pipeline is routed in Azerbaijan is subject to earthquakes, which have the potential to disrupt the BTC pipeline by deforming or shearing the pipe due to ground faulting or flexing.

The region between the Black Sea and the Caspian Sea is part of the central Asian segment of the Alpine-Himalayan foldbelt and comprises the Great Caucasus fold and thrust belt in the north, and the Lesser Caucasus-Pontides fold and thrust belt in the south. The mountain ranges of the Caucasus were formed by the collision of the African, Arabian and Indian tectonic plates with the Eurasian plate.

The Great Caucasus Mountains are geologically very young, having formed during the Middle Pliocene. The Lesser Caucasus, found to the south, have been folded and thrusted towards the north just east of the Black Sea. Compressional uplift and thrusting separated a once continuous basin into western and eastern parts, the eastern part of which was to become the Kura basin.

The eastern and western parts of the Great Caucasus Mountains are found to differ in structure with respect to trends and seismicity. One of the main distinctions is the presence of deep earthquakes in the eastern Caucasus at depths of up to 100 km. Earthquakes in the western region occur at much shallower depths, typically 30 km.

Continuing plate convergence means that Azerbaijan experiences high seismic activity. Over 500 seismic events of varying intensity have been recorded since 1600 (Aganirzoyev, 1987). Recent research and monitoring has been carried out in order to identify general background seismic characteristics, define possible factors which lead to destabilization of the seismic regime and to determine the degree of seismic danger. Some theories postulate that the high tension stress regime under the Caspian has increased by 1.5 degrees due to anthropogenic effects (eg, oil extraction) and resulted in an increase of background seismic levels from 7.5 degrees to 9 degrees (Kerimov, 1995).

1.3.1 Earthquake severity

Three classes of seismic activity are generally recognized, namely tectonic, volcanic and artificially induced. The tectonic variety is by far the most devastating and is caused by stress build up due to movements of the plates that make up the earth's crust. The Caspian is located in a zone stretching from the Mediterranean to the Himalayas that is characterised by tectonic earthquakes.

Data about the severity of earthquakes in Azerbaijan are usually given in Energy Classes (K), whereas Europeans are used to Magnitude (M). Both these systems are comparable and describe the energy at the source of an earthquake. Intensity figures based on the Richter Scale cannot be directly compared as they relate to surface effects of an earthquake. Many local earthquake reports use units of intensity measured on a scale of 1-12. Intensity is a relative measure of earthquake effect at any given location dependent on the size of the earthquake and the distance from the epicentre. Table 1 compares these three units, which describe the energy released at the epicentre, the so-called focus of the earthquake.

Table 1 Comparison of energy classes and magnitudes of earthquakes

ENERGY CLASS (K)	MAGNITUDE (M)	INTENSITY (EPICENTRE)	DESCRIPTION (INTENSITY)
9	3	I	Felt by few under especially favourable conditions
10	3.5	II	Felt by few at rest, especially on upper floors of buildings
11	4	III	Felt noticeably: houses and cars shake, exaggerated effect indoors compared with outdoors
12	5	V	Felt by all: windows broken, unstable objects overturned.
13	5.5	VI	Felt by all: heavy furniture moved, instances of fallen plaster. Damage is slight
14	6.1	VII	Tangible damage to poorly constructed buildings, damage to buildings of good design and construction is negligible.

The BTC pipeline route crosses a seismic area where earthquakes occur that are up to magnitude 8 on the Richter scale. Highest densities of earthquake epicentres with energy classes (K) greater than 9 occur north of the BTC pipeline route in the foothills of the Great Caucasus, near Shemaka and Ivanovka, where strong earthquakes have led to the complete destruction of cities in the past.

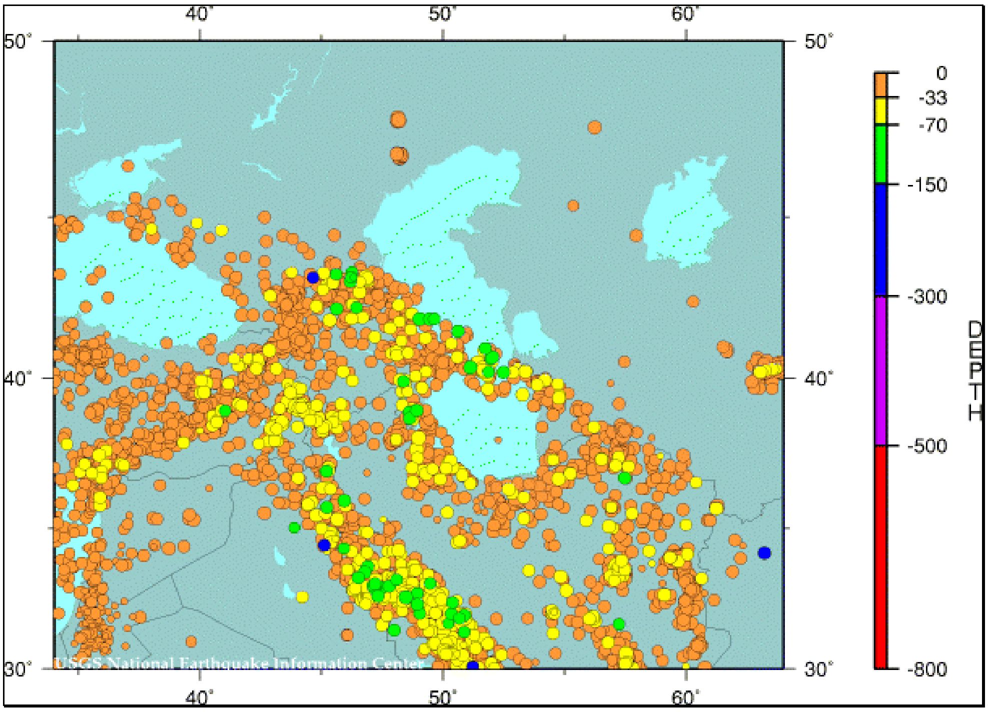
Earthquake data from 1960-1990 were recorded from the Baku archipelago, near Apsheron, indicating numerous earthquakes with energy class (K) up to 11 (up to 4 magnitude). Seismic events of energy class 12 (K) (magnitude 5) were recorded in the Lower Kura lowland. Statistical data from 1990 - 1997 indicate the occurrence of events with energy classes (K) of 13 (magnitude 5.5) in the coastal part of East Azerbaijan including the Baku archipelago, and also strong earthquakes in north-eastern Iran. Generally, a zone of earthquakes surrounds a large part of the Southern Caspian (as shown in Figure 1), however, most of the strongest earthquakes occur onshore, associated with tectonic movement in the Caucasus mountain regions.

However, strong earthquakes with an epicentre further away from the BTC pipeline route can still have strong intensities along the BTC pipeline route, as shown in Table 2.

Table 2 Intensity of earthquakes occurring in other areas within the BTC pipeline corridor

LOCATION	YEAR	INTENSITY ON SURFACE ABOVE EPICENTRE (I)	INTENSITY ALONG PIPELINE (I)	DISTANCE OF EPICENTRE FROM PIPELINE
Shemaka	18591872190 2 ?????	8 -– 9	5 - 6	ca. 35km
Dagestan	1948	7 -– 8	6	ca. 250km
Saatli -– Sabirabad	1959	8	8	ca. 25km
Tovuz Region	1962	7 -– 8	7 - 8	0km
Caspian	1961	8	7	ca. 100km

Figure 1 Measured earthquake event distribution and depth (in metres), 1973-2000



The probability of the occurrence of earthquakes along the Kura trough has been calculated by the Azerbaijan Institute of Geology (see Table 3). They also recorded intensities of earthquakes in periods of 3 and 4 years as shown in Table 4.

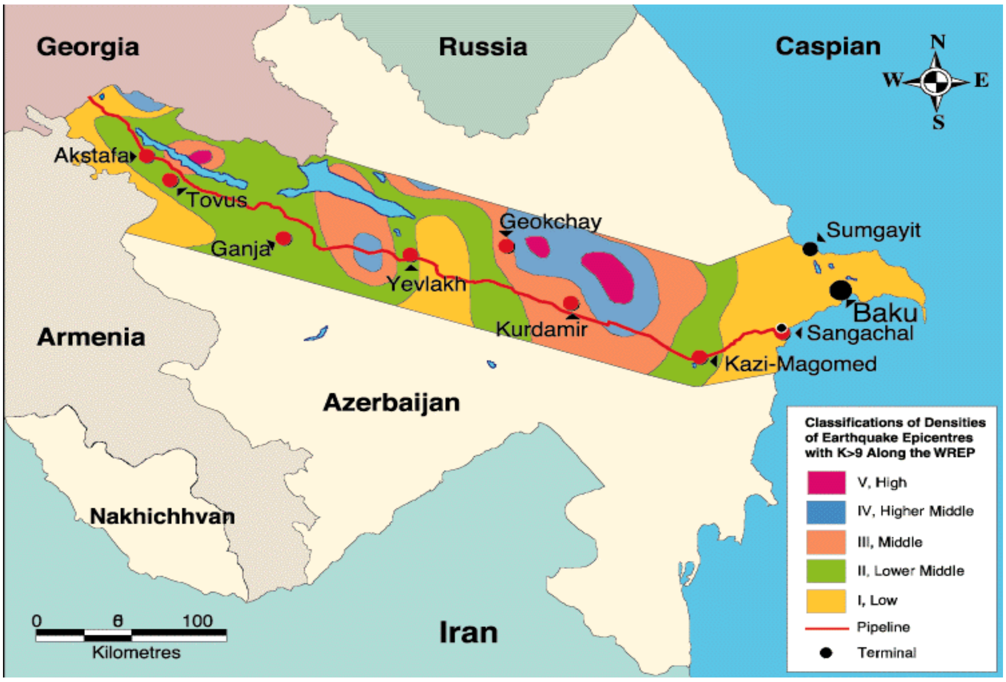
Table 3 Probability of strong earthquakes in the Kura Trough and the Shemaka - Ismaili area (calculated per 1000 km2)

MAGNITUDE (M)	YEARS TO OCCUR
6.7 - 7.2 (Kura Trough)	10,000
6.7 (Kura Trough)	2,000 - 3,000
6.1 (Kura Trough)	800-1,000
6.1 - 7 (Shemaka Area)	15 - 35

Table 4 Severity of earthquakes along the pipeline route for different periods between 1965 and 1994

ENERGY CLASS (K)	1965 - 1967	1970 - 1972	1973 - 1975	1976 - 1978	1979 - 1981	1982 - 1985	1986 - 1989	1990 - 1994	TOTAL
K = 9	18	22	23	35	48	20	25	23	214
K = 10	13	4	8	10	12	10	24	10	91
K = 11	3	1	3	4	2	3	3	1	20
K = 12	1	--	--	1	4	--	--	3	9
K = 13	--	--	--	--	2	--	--	--	2
Total	35	27	34	50	68	33	52	37	

Figure 2 Classification of densities of earthquake epicentres of K > 9 along the BTC pipeline, based on the WREP



1.3.2 Seismicity along the BTC pipeline route

Medium density earthquake zones cover about one third of the length of the BTC pipeline route, with more than 200 epicentres identified within 30km of the route since 1962. Larger earthquakes further removed from the route may still be significant.

The highest densities of earthquake epicentres occur along the BTC pipeline route in a zone from Kazi-Magomed to 25km east of Kurdamir (KP52 to KP107) and for another 15km from Mingechaur (KP243) to Goranboy (KP258), as indicated in Figure 2 based on the WREP pipeline route.

Due to the disproportionate density distribution of the epicentres, four seismic zones can be classified along the BTC pipeline route. These are described from east to west below.

1.3.2.1 Sangachal to Kazi-Magomed (KP0-52)

Only a few epicentres are located within the zone around Gobustan and the severity of earthquakes here are mainly of energy class (K) 9. However, the Apsheron Basin in which this area is located is generally a zone of high tectonic and seismic activity, and the risk of an earthquake affecting the BTC pipeline either by displacement or landslide should not be discounted.

The most recent severe earthquake with an epicentre affecting this region occurred in November 2000.

The frequency of earthquakes for the areas of Shemaka and Apsheron is given in Table 5.

Table 5 Frequency of earthquakes for the Shemaka and Apsheron regions

AREA	PERIOD OF YEARS	INTENSITY (I)	NUMBER OF OCCURRENCES	AVERAGE PERIODICITY IN YEARS
Shemaka	1872 - 1963	7 - 8	7	12 - 13
	1902 - 1954	6 - 8	136	2 - 3
	N/A	7	N/A	17 - 20

1.3.2.2 Kazi-Magomed to Ucar (KP52-178)

Earthquakes of energy class (K) 9 - 11 are registered in this highly active seismic zone, the boundaries of which are delineated by the fault at Kazi-Magomed and a major fault running parallel to the Kura River from approximately the Karasu river crossing as far as the Georgian border.

1.3.2.3 Ucar to Yevlakh (KP178-223)

The density of epicentres present in this zone corresponds to a lower to middle density and the earthquakes mainly have energy class (K) values of 9 and 10.

1.3.2.4 Yevlakh to the Georgian border (KP240-442)

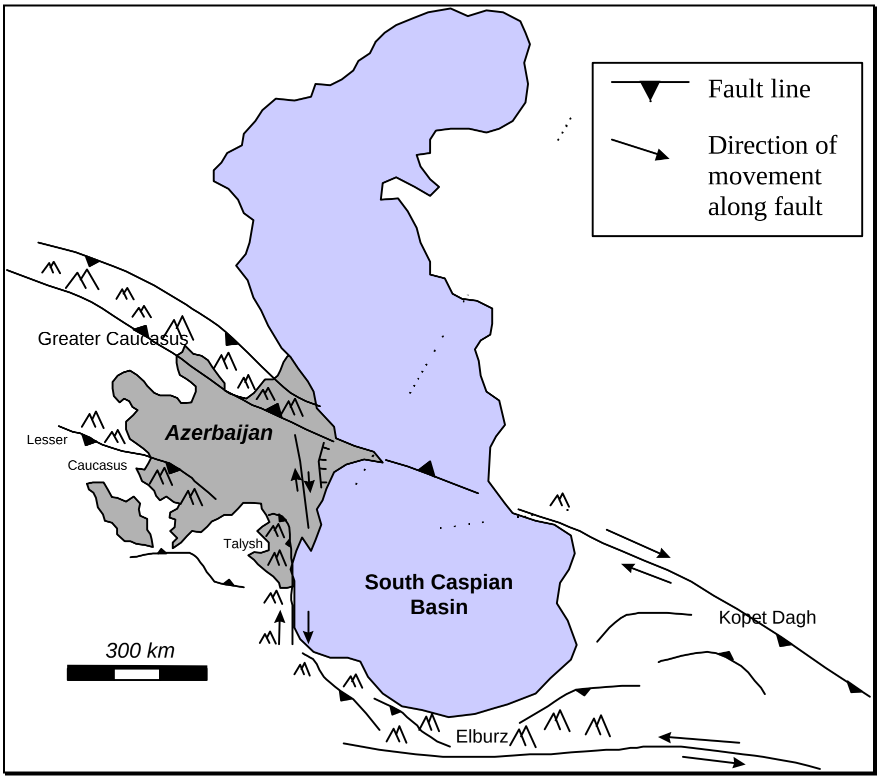
This zone is characterised by a more even distribution of epicentres, mainly with energy class values (K) of 9 and 10. However, this section is a zone of high tectonic and seismic activity and the risk of an earthquake impacting the BTC pipeline, either by displacement or landslide, has been investigated during detailed surveys being undertaken by seismic specialists.

1.3.3 Active fault zones

The BTC pipeline route crosses several fault zones and tectonic units. A seismic survey commissioned by BP has identified several major faults traversed by the BTC pipeline route. The sources of earthquakes can quite often be traced to these major faults. The general orientation of active faults is from the north-west to the south-east.

Earthquake intensities (K) in active fault zones are generally considered to be in the range of 8. The highest earthquake intensities are found in areas where known active faults are present. Pipeline failure due to displacement along active fault zones during seismic events cannot be excluded, and the areas of highest activity are located at the eastern and western ends of the BTC pipeline in Azerbaijan. Landslides caused by events of high intensity are possible in the steep, unconsolidated areas of Gobustan and the Lesser Caucasus lowlands. In addition, damage caused by strong events further away from the BTC pipeline (eg breaching of the Mingechaur water reservoir) will also be considered. Figure 3 shows the tectonic regime along the BTC pipeline route.

Figure 3 Tectonics of the Caspian region (modified after Allen and Tull, 1997)



1.3.4 Fault identification

A thorough investigation into seismic hazards presented by faults was carried out by EQE International, on behalf of BP Exploration (Shah Deniz) Ltd. The main scope of works was to identify active faults, characterise them for engineering design purposes and carry out ground motion hazard assessments.

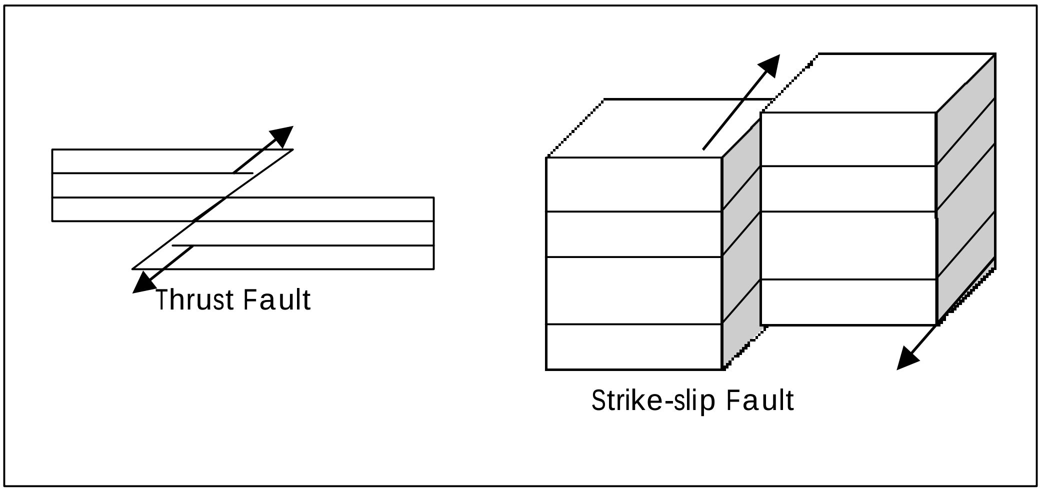
The Kura Valley, through which the BTC pipeline passes for much of its route, is not prone to active tectonic faulting. At both the western and eastern ends of the route, the active geological structures of the Great and Lesser Caucasus Mountains are encountered.

Where east-west faults are present, the fault type is generally of a compressive thrust nature, whilst northeast or northwest trending faults exhibit generally lateral strike-slip movements. Thrust faults are typified by one block being forced over the other, with the angle of dip of the fault plane being less than 45°. In strike-slip faulting, the two blocks move laterally past each other. A combination of these two fault types can occur, where blocks involved in thrust faults also move laterally. Thrust faulting and strike-slip faulting are both shown in Figure 4.

In many areas, slope instability hazards coincide with active faulting, which suggests that the faulting is at least in part responsible for the presence of slope instabilities.

Study of aerial photographs of the BTC pipeline route revealed that the BTC pipeline route crosses five active faults. Details of these are provided below.

Figure 4 Thrust and strike-slip faulting



1.3.4.1 Fault crossing number 1 (KP24)

This fault has strike-slip displacement, and is found in association with two active mud volcanoes. This fault can be seen to be a secondary feature associated with the primary displacement noted on the main fault located at KP29. The surface rupture can be seen to be approximately 7km in length. This fault is thought to be of secondary risk, as it is expected only to rupture in association with the main fault at KP29.

1.3.4.2 Fault crossing number 2 (KP 29)

This fault has been classified as a thrust fault, although there is no noticeable offset of the younger alluvial sediments. Fault location at the crossing point with the BTC pipeline has been extrapolated from obvious surface faulting to the south of the pipeline/fault intersection. The fault has a length of at least 22km. Movement of this fault can be predicted from data collected from the surface offset south of the BTC pipeline route.

1.3.4.3 Fault crossings number 3 and 4 (KP50-51)

Two fault scarps are found near KP50-51. The eastern scarp is and older fault with multiple surface faulting offsets. The western scarp is a young surface fault that has deviated from the older eastern fault. At the BTC pipeline crossing locations, the two fault scarps are approximately 0.5km apart. The fault scarps then join approximately 1.5km north of the BTC pipeline crossing.

The overall sense of movement of this fault system is thrust. Where the BTC pipeline crosses the scarps, right-lateral strike-slip movement is anticipated, with a small vertical offset. This change in sense of movement on the fault is due to a change in fault strike close to the BTC pipeline crossing. The overall fault trend is northwest to southeast. This alters to a north-south orientation at the BTC pipeline crossing, forming an S shape.

The mapped length of this fault is over 100km, and marks the boundary of the Great Caucasus thrust terrain and the alluvial Kura Valley.

1.3.4.4 Fault crossing number 5 (KP412-420)

The BTC pipeline route in this area abuts the northwest trending fault scarp at KP412-413 and again at KP420 (as observed on aerial photographs). The scarp is a northwest-southeast trending, southwest directed thrust scarp. Small drainage channels have formed deep trenches in the scarp slope, and no offset of the young sediments is noted. This indicates that the fault has not moved in the time required for small drainages to dissect the fault scarp. This fault extends for approximately 100km. The fact that the scarp face is very old suggests that recurrence of significant ruptures is very infrequent, and this fault therefore provides a lower risk than faults exhibiting younger scarps or compound scarps. (Compound scarps indicate repeated movement along the same fault trace in the recent geological past).

The fault offsets sediments of the Kura River Valley. In this area, the compressive structures of the Lesser and Great Caucasus begin to merge, resulting in active deformation of the sediments in the relatively narrow valley.

1.3.5 Soil Liquefaction

Tremors during an earthquake can cause the water pressure within sediments to increase to the point at which the soil particles can readily move with respect to each other. This phenomenon is known as liquefaction and may be triggered as a result of seismic activity. Preferential conditions for liquefaction occur in saturated soils when the strength or stiffness of a soil is reduced by earthquake shaking or other rapid loading. Earthquake shaking can often trigger this increase in water pressure, but this can also be caused in connection with construction related activities such as blasting.

In relation to the BTC pipeline route, this hazard is minimal, as most of the sediments are rich in clay, which is far less prone to liquefaction than well-sorted sands. The area where this is most likely to occur is between the West Kura crossing (KP409) and the Georgian Border.

During the course of the review of aerial photographs, an effort was made to identify geomorphic evidence of liquefaction. Soil liquefaction is a concern along the Kura Valley, as overbank sediments are prone to liquefaction and lateral spread during ground shaking. The aerial photographs did not show any evidence of liquefaction in Azerbaijan. The most logical explanation for this is that the poorly sorted deposits of gravel, sand and silt, with a high clay content, are not highly prone to liquefaction. However, analysis based on aerial photographs cannot be considered definitive, and geotechnical sampling and testing has been undertaken, which will quantify liquefaction potential and soil susceptibility along the proposed route.

1.3.6 1.3.6 Significant historical earthquakes

The most significant historical earthquake to occur in the Eastern Caucasus region was recorded on January 1st 1668. The magnitude of the earthquake was measured on the uniform Moment Magnitude (Mw) scale to have a magnitude of 7.5 Mw. This scheme allows for the physical properties of the earthquake and is therefore seen to be the most appropriate measure for representing the true force of the earthquake. The area of strongest seismic activity was located 300 km west of Baku in a relatively small area of the eastern Caucasus that has a history of relatively frequent earthquakes. Other major historical earthquakes were registered in both Georgia and Armenia.

The largest earthquake to occur within the BTC pipeline region in recent years took place on November 25th 2000, close to the Caspian Sea (USGS, 2000). At least 27 people were killed (three from the earthquake, 21 from heart attacks and three on November 26th from a natural gas explosion associated with a Soviet era pipeline which resulted from the failure of a valve damaged by the main shock) and more than 400 were injured in the Baku area. Some structural damage occurred and utilities were disrupted in the Baku area. The magnitude of the earthquake was recorded as 6.3 Mw, with the epicentre located very close to Baku. The effects were felt across Azerbaijan and in Turkmenistan, Russia, Georgia and in northern Iran.

An earthquake was recorded on June 4th 1999 in the Eastern Caucasus region. The approximate location of the epicentre was greater than 50 km to the north of the BTC pipeline route. With a magnitude of 5.5 Mw, the earthquake caused up to US$2.5 million damage in the Agdas area, Azerbaijan. The epicentre was registered at a depth of 33 km. 15 people were injured and approximately 50 houses damaged in the immediate area. Three people were injured at Ucar (a town close to the proposed BTC pipeline route, near KP79) and several houses damaged at Agali, with the total damage for central Azerbaijan estimated at US$5 million. The effects of the earthquake were felt in parts of Armenia and Georgia and in the Ardabil region of Iran.

A search centred on the mid-point of the BTC pipeline route, with a search radius of 250 km was carried out using the database present on the ESO web page. The search period selected was from 1994 to the present day, to augment previously carried out earthquake searches. The results of this search indicated that two earthquakes of magnitudes 3.8 and 4.1 Mw were recorded in February of 1998 and 1994 respectively. Both of these earthquakes had epicentres located in Russia, and as such only minor effects would have been evident in the BTC pipeline locality.

1.4 MUD VOLCANOES

Mud volcanoes, which form both onshore and offshore, are a feature of the geology of eastern Azerbaijan, producing a potential geohazard to pipeline construction and operation. Mud volcanoes are the points at which pressure within the earth's crust (up to 6km deep) is released. Mud and larger clasts of rocks, liquids and gases erupt from the ground surface. Mudflows form as the mud travels downslope. With time the material erupted creates a conical or plateau-like structure. Mud volcanoes are associated with a neotectonic setting, and weak undercompacted gas and clay-rich sequences.

Mud volcanoes form in only a few areas worldwide, with almost half of all known mud volcanoes globally being situated in Azerbaijan. More than 300 have been discovered in the marine or terrestrial environment of the country (Guliyev & Feizullayev, 1997). These surface features are generally relatively short-lived (in geological terms), and they tend to migrate along fault lines or planes of weakness.

Eruptions can be violent and unexpected, ejecting debris many hundreds of metres into the air, and some are associated with pyroclastic flows. A further potential issue is that gases discharged by mud volcanoes may be flammable.

Over 300 mud volcanoes are present in Azerbaijan, the majority of which are associated with anticlinal fold structures. Mudflows 10m thick, several hundred metres wide and 5-10 km in length have been recorded in Azerbaijan (Jagubov *et al.*, 1972). Mud volcanoes found along the BTC pipeline route are concentrated in the Gobustan region (KP0-29).

1.4.1 Morphology of mud volcanoes

Mud volcanoes have source areas in the form of a caldera (basin-like rimmed structure) at their summits. The summits are often marked by small conelets or liquid filled hollows. From this summit area mud tracks are seen, along which the mud will preferentially flow. In certain conditions mudflows may radiate from the source, mantling the entire hillside. The mud is collected in an accumulation zone of low-angled, overlapping mudflow lobes, with characterisic compressional and tensional structures. Recent lobes are dark blue/grey/green and unvegetated. Weathering lightens the colours of the lobes to brown/yellow/grey. The maximum recorded flow run-out from the source is 2.9 km (Otman-Bozdag volcano), with the average distance for accumulation zones being 0.8-2.3 km from the source.

Ground rupturing may occur in association with mud volcano activity, and further associated hazards include loading by mudflows, subsidence and ground displacement. Mudflows under certain conditions can be quite fast moving, which could put stress on pipelines due to unexpected loading. Erosion of mudflow lobes results in the formation of gullies, with eroded material being formed into piedmont plains.

Eruptions of varying magnitudes have been recorded, and are classified into four categories:

- **Type I -** Eruption of a large volume of mud volcano breccia with numerous rock fragments, accompanied by explosions of varying strength, the emission of powerful gas jets (with or without combustion) and the formation of fissures
- **Type II -** Explosion of gas and formation of large fissures, without emission of flowing mud
- **Type III -** Relatively small outflow of mud volcano breccia without intense gas emission
- **Type IV -** Extrusion of breccia, with negligible gas emission

The likelihood of a new mud volcano developing at a previously unaffected site is considered to be very low. Only four new mud volcanoes have been recorded within a 17,600km^2 area in Azerbaijan over the last 100 years. Newly formed mud volcanoes tend to be very small features, with many phases of eruption being required to develop the pronounced cone or plateau-like form.

Figure 5 Mud Volcano Vent

1.4.2 Risks to pipeline and facilities

The nature of the hazard posed to the BTC pipeline varies in relation to the type of mud volcano encountered. Hazards within the source area of the volcano are associated with the release of combustible gases. These can be expelled at rates up to 16m3 per minute. Approximately 40% of eruptions are believed to include associated gases that spontaneously ignite, with flame heights exceeding 100m. Extremes of temperature are felt up to 2km away (core temperatures reach 1,200°C).

Mud volcanoes can be extremely hazardous, for example the eruption of the Bozdag- Gezdeg volcano in 1902 resulted in the deaths of 6 men and 2,000 sheep. A further incident in 1961 resulted in the hospitalization of eight casualties, several of whom died.

Ground rupturing is also associated with the mud volcano source area. Consequences of this include extrusion, subsidence or displacement along fissures and faults around the vent area.

Mudflow tracks, which may be up to 100m wide, can be 1m thick (although less than 5m is more usual). In addition to this, areas of subsidence or ground displacement along fissures and faults may extend from the vent to these regions.

1.4.3 Mud volcanoes along the BTC pipeline

Mud volcanoes with a potential impact on the BTC pipeline route are displayed in Figure 6 and on the Environmental Route Maps, Volume 2. They are concentrated at the eastern end of the BTC pipeline route, in the Gobustan area (KP0-52).

Otman-Bozdag volcano, one of the largest in Azerbaijan, lies a few kilometres to the north-west of the Sangachal Terminal (KP0). The 300m diameter crater peaks at over 400m above the surrounding plain. Mud breccias flow from the volcano onto the existing plain, producing a complex fan of overlapping mud flows and reworked sediment.

Figure 6 Locations of mud volcanoes along the BTC pipeline route

The Otman-Bozdag volcano is active, with eruptions being registered in 1845, 1904, 1922, 1951, 1965 and 1994. Three major fissures have been recorded on the volcano summit. Mudflows would be required to reach lengths of 4.9km in order to affect the BTC pipeline. This is considered to be unlikely, even if an event of the maximum predicted magnitude were to occur.

The Turagay Mud Volcano (approximately 2.5km to the south of the BTC pipeline route at KP17) last erupted in 1955 and although it is not currently active, further eruptions are considered likely.

In the region of the Structural-Front Mud Volcano Complex (Mud Volcano Ridge, shown in Photograph 1-1) there is an estimated moderate risk to the BTC pipeline structure. In this region, two parallel faults (crossed by the BTC pipeline route at approximately KP 24 and 30) running north-west to south-east define an area in which mud volcanoes form along the trend of the fault lines.

The main concern at this site is where the pipelines cross broad mud breccia fields where active mud volcanism is occurring. As mud volcanism is fracture-controlled in this region, there is a reasonable potential for the opening and/or shear of fresh fractures, which could damage buried pipelines. The possibility for gas emission and ignition occurs in this area, although there are considerable uncertainties over the lifetime of the BTC pipeline. Existing mud volcanoes in the Mud Volcano Ridge area have been avoided.

Table 6 Proximity of mud volcanoes to the BTC pipeline route

MUD VOLCANO	DISTANCE FROM PIPELINE ROUTE
Otman-Bozdag	4.9km
Turagay	2.5km
Mud Volcano Ridge	Crossed by route

1.5 GEOHAZARDS RELATING TO TERRAIN

1.5.1 Erosion and soil-related geohazards

Although the majority of the route passes through easily dug soils and rocks, it is possible that in certain areas there will be a requirement for ripping or hammer breaking prior to back hoe excavation. In addition to this, badlands (highly dissected terrain) are encountered for approximately 30km west of Ganja (KP352-382). Here, a combination of highly erodible, silty clay soils and steep slopes and narrow ridges may lead to severe erosion problems alongside or adjacent to the BTC pipeline corridor. Soil erosion control measures will be required to minimise both the environmental impact and the long-term risk of pipeline exposure. See section 1.6.4 for information on the low threshold velocities required to entrain erodible soils in the SE slopes of the Great Caucasus (Kuznetsov et al., 1998).

1.5.2 Terrain-related hydrological geohazards

Risks to the BTC pipeline caused by hydrological issues include the potential for sheet flooding across the Sangachal Coastal Plain.

The Mud Volcano Ridge region is home to many trench-like wadis. These channels have a tendency for rapid migration. There is a high potential for gully-head retreat with small soil pipe collapses occurring along the narrow ridgeline to the north of the mud volcanoes. On the plains to the west of Kurdamir lateral movement of straight artificial channels (canalised rivers and deep drainage canals) also occurs, as they are gradually transformed into meandering channels.

Other hydrological issues include the presence of small soil collapse features, known as sinkholes, which occur frequently along surface drainage lines. Possible impacts resulting from these features include differential settlement of foundations in the Sangachal Terminal area and collapse around the BTC pipeline.

1.5.3 Landslides

Landslides in the Azerbaijan region generally occur as a result of rainstorms, earthquakes, volcanic activity and various human activities. The greatest potential for landslides to occur would therefore be at the eastern end of the BTC pipeline route, where earthquakes are more prevalent.

1.5.4 1.5.4 Debris flows

Debris flows tend to be rivers of rock, earth and other surface fragments saturated with water. They are caused when water accumulates rapidly in the ground, for example during heavy rainfall or rapid snowmelt, when the earth is changed into a flowing river of mud. Debris flows move rapidly down slopes or through channels. Debris flows can reach several kilometres from their origins, carrying trees, cars and other materials.

Flows are generally thick, viscous mixtures of water and sediment, with flow velocity being highly dependent on water content. A higher water content will result in a faster flow. Typical speeds are approximately 15kmhr^{-1} although speeds up to 20kmhr^{-1} are not uncommon in Azerbaijan. Mudflows, a specific type of debris flow associated with mud volcanoes, are dealt with in Section 1.4. Other types of debris flow may be expected in regions of higher relief, where elevated levels of precipitation occur.

1.5.5 1.5.5 Other hazards

Saline soils and associated groundwater may cause pipeline corrosion. Soil erosion also occurs in certain areas (see Geology and Soils Report, Part 8, Baseline Reports Appendix).

The re-instatement of silt-rich soils that are highly erodible is anticipated to be difficult. The BTC pipeline corridor may be subject to severe erosion events. Sinkholes (soil collapse features) are also a frequent occurrence along surface drainage lines.

1.6 GEOHAZARDS AFFECTING PRINCIPAL PIPELINE RIVER CROSSINGS

1.6.1 Aims and scope of section

The purpose of this section is to describe and interpret available baseline information on the main river crossings for the BTC pipeline route; to make a preliminary assessment of the nature of river channel instability along the route corridor; and to identify the key crossings which could potentially impact detrimentally on the BTC pipeline and which require special attention in crossing design. Recommendations for subsequent mitigation and monitoring of the actively-eroding sections are made in Section 10 of the ESIA.

The level of appraisal is that of a desk study, supplemented by linewalk data and reconnaissance reports produced by other workers for the BTC and WREP pipelines. This section should be read in conjunction with the Hydrology and Water Quality (Part 10) and Hydrogeology (Part 3), Baseline Reports Appendix. This section, and the reports and sections cited, should provide a basis for appraisal of river crossing impacts, problems and mitigation measures recommended.

The specific objectives are to:

- Present and discuss information on and bank erosion, channel instability problems
- Identify the key crossings of the route, i.e. those potentially posing a hazard to the BTC pipeline

Data sources based on reconnaissance field data and linewalk approaches are listed in Section 1.6.2.

1.6.2 Information sources

This section is based on the following information sources, produced from 1996 to 2001:

- Fookes and Bettess 6/9/2000 report 'Field visit to Azerbaijan, August 2000, to assess geohazards to principal pipeline river crossings, of existing and future routes and ground truthing of the Azerbaijan desk studies' (Rev02, October 2000)

- Environmental Assessment of Alternative Export Options: Volume 5 - River Crossing Survey. Dames and Moore, July 2000
- Environmental constraints report; Kvaerner 2000
- Literature Reviews by Azerbaijan scientists, including those of Professors Kashkay of the Institute of Geography at the Academy of Sciences in Baku and Professor Firdowsi Aliyev of the State Committee of Geology and Mineral Resources for the Azerbaijan Republic, produced in 1996, 1998 and 2000, and the State Committee of Geology, 2001
- Prof. Rena Kashkay (2000) 'River hydrology along the AZERIGAZ pipeline route' report, written as a desk study for the Azeri Gas Line
- Linewalk re-route information generated by AETC and ERM staff in 2000-2001
- Reconnaissance field data collected by D.M. Lawler in November and December 1996
- The Hydrological sections written for the Western Route Export Pipeline in Azerbaijan (WREPA) EIA, produced by AETC in April 1997

Note that there is an absence of published scientific papers relevant to river crossing appraisal in Azerbaijan, such as river processes, fluvial geomorphology, river engineering or hydraulics.

1.6.3 River crossing datasets

A number of basic hydrological datasets exist in Azerbaijan (see Hydrology and Water Quality Baseline, Part 10, Baseline Reports Appendix). However, very limited hydraulic and fluvial geomorphological or sedimentological information exists in Azerbaijan, and the few flow data that are readily available have been produced for gauging stations often far removed from pipeline crossing sites. Mean discharge data are available, and these have been converted into gross stream power data for selected major rivers. Shear stress data and cross-section geometry information at river crossings are not yet available.

The following limitations of the datasets should be noted:

1. Technique uncertainty. Generally, little information is readily available on the hydrological monitoring techniques adopted, so it is difficult to place confidence limits on the published datasets.
2. Dated data. The hydrometric network in Azerbaijan was severely curtailed after 1991/92, so few datasets exist for the last ten years: this makes quantification of current conditions difficult. Early hydrological data will not reflect subsequent climatic variations, basin landuse changes, shifts in channel cross-sectional geometry shifts, channelization projects, gravel winning operations, new abstractions, water resource development schemes and, for coastal stations, fluctuations in the level of the Caspian Sea.
3. Remote data. Many flow measurement sites (river gauging stations) tend to be located in, or near the foot of, the Caucasus Mountains, mainly because this is considered to be the limit of significant runoff generation in these rivers. Therefore they are sometimes considerable distances upstream (or occasionally downstream) of the BTC route. Substantial caution is warranted, therefore, in extrapolating data from the point of flow measurement to the BTC pipeline crossing itself. Some rivers, as in many semi-arid environments, actually lose discharge in a downstream direction, because transmission, irrigation and abstraction losses outweigh runoff generation in the lower reaches.

4. Few data on extremes. The data provided tend to be means, and further information is needed on hydrological extremes, such as flood magnitude and frequency, especially bankfull conditions, in order to assess environmental risk to pipeline integrity.
5. Limited analytical publication. Very little hydrological or fluvial data or analyses (e.g. flow frequency/duration curves; recurrence interval statistics) have been published for Azerbaijan in the peer-reviewed international scientific literature.

1.6.4 Fluvial geomorphological setting

Erodible soils, steep mountain terrains, and highly seasonal snowmelt and semi-arid hydrological regimes drive active erosional processes throughout many of the drainage basins crossed by the route. High fluvial sediment transport rates relate to high soil erosion rates driven by steep slopes, intense rainstorms (despite low annual precipitation totals), highly seasonal snowmelt-driven flows, flash floods, freeze-thaw processes in the mountain zones, fine erodible soils and limited vegetation cover. In fact, the rivers of the Great Caucasus such as these carry more suspended sediment than almost any other region in the FSU (Bobrovitskaya, 1996). Erosion scars are visible in many places on the existing WREPA ROW (URS/Dames & Moore, 2000), e.g. Korchay and Shamkirchay. Severe erosion and sediment transport problems are key issues in pipeline engineering and integrity in Azerbaijan (URS/Dames & Moore, 2000). Soils are easily eroded once vegetation is removed and surface sediments disturbed (e.g. during pipeline construction). For example, Kuznetsov et al. (1998) found that for pre-mountain cinnamonic steppe-like soils, chestnut soils and light-chestnut soils on the surface of the south-eastern slope of the Great Caucasus, average scouring velocities required for a flow 2 cm deep varied from just 0.20 - 0.24 m s^{-1}.

1.6.5 Regional scale channel instability

Many of the fluvial systems examined near or on the BTC route are meandering or braided and appear to be active and dynamic, especially in the west, where the BTC pipeline approaches the foothills of the Lesser Caucasus. Many of the Kura tributaries are high-energy, mountain rivers many occupying laterally mobile floodplain zones or incised into narrow gorges. These will require careful crossing.

Braided systems are normally characterised by large channel width-depth ratios, high energy conditions, high bedload transport rates, a flashy (quickly-responding) discharge regime and active lateral instability. Braided systems tend to occur on steeply-sloping valley floors where large quantities of coarse sediment are frequently mobilised to build the braid bars, and copious but variable flows are available to reorganise the bed materials frequently and erode the banks relatively easily. The steep channel slopes of the Caucasus rivers and their seasonally concentrated meltwater regimes generate high-energy conditions ideal for channel degradation, bank erosion and channel course switching. Necessary sediment supplies are probably generated by mountain landslides, gully washouts, channel bank, erosion, and occasional mud flows and sheetwash events. This snowmelt domination of the regime for most of the rivers in Azerbaijan is a key control (Lawler, 1997), which explains the high river flow seasonality (see Hydrology and Water Quality Report, Part 10, Baseline Reports Appendix).

The strongly seasonal and snowmelt-dominated flow regimes of almost all Azerbaijan rivers also encourage braiding activity. Strong seasonality also means that the timing at which river systems are inspected or surveyed in the field is vital. It is easy to form the impression of Azerbaijan rivers being tame, quiescent rivers, if they are visited in the late summer to late winter low-flow period (July to February), when despite a large cross-section, commonly only one or two small divided channels, if any, are occupied by water. To appreciate fully the power of the rivers crossed by the BTC, it is necessary to visit during the March – June snowmelt period when flows, erosion rates and sediment fluxes are rising or peaking.

1.6.6 Indicators of channel dynamism

Dynamic channels result from the interaction of high river energy levels with erodible boundary materials. Strong indicators of channel dynamism in the major Kura tributaries crossed by the BTC pipeline, especially in the west, include:

- Extensive and severe bank erosion at many of the sites visited, including around existing pipelines and structures (eg Figures 7 to 9) evidenced by:
    - Undercut bank profiles creating overhangs
    - 'Fresh', steep, bare, bank faces supporting limited short-root vegetation, with concave-upward bank profiles
    - Erosion cliffs running for many metres upstream and downstream of the crossing locations
    - Tension cracks behind certain bank faces (often the precursor to mass failure)
    - Loose, easily-erodible sand and gravel bank materials, readily disturbed by touch or walk-over
    - Some damage to existing revetments and other bank protection works
    - Damage to bridge supports and old pipelines in places
- Sparse vegetation on the braid bars, and an absence of algae on the gravel bed material: this normally indicates recent particle transport. Imbrication and particle size distribution information (Dames & Moore, 2000).
- Velocities and stream power levels high enough to set typical bed materials in motion and to deform the channel boundary (see Table 2, Hydrology and Water Quality Report, Part 10, Baseline Reports Appendix)
- High suspended sediment concentrations and loads (see Hydrology and Water Quality Report, Part 10, Baseline Reports Appendix)

1.6.7 Assessment of channel instability at pipeline crossings

Bank erosion and channel-change problems should always be viewed in a drainage basin context, because:

- Instability zones can themselves migrate downstream over timescales similar to the design life of a pipeline
- Coarse sediments from upstream activities can change local cross-section shapes and sizes and influence velocity structures and bed scour and bank erosion rates in the vicinity of pipelines
- The river flows responsible for on-site erosion are generated by snowmelt and/or rainstorms in headwater zones

A full contemporary channel erosion survey was outside the scope of this ESIA. AETC and ERM personnel carried out walkover surveys during summer 2000 and winter 2001. Channel reconnaissance survey sheets (partly based on Thorne (1998) proforma) were completed for each watercourse crossing, upon which were recorded information on: channel width and depth (low flow and bankfull estimates); identification of channel pattern (planimetric form); water presence/absence at time of survey; mean flow velocity estimates; bank erosion inventory, including spatial extent and dominant failure mode; bed/bar material grain size and qualitative information. A river corridor survey (following UK EA guidelines) was also undertaken for all main rivers crossed by the route during November 2001 (see River Corridor

Survey Report, Part 5, Baseline Reports Appendix). An extensive library of indexed colour print and digital photographs of river reaches (upstream and downstream views) has been assembled by AETC and Kvaerner along with particular features such as collapsing banks, vulnerable braid bars, exposed pipeline sections etc. Simple river water quality measurements were also made in December 1996 by D.M. Lawler (1997) and by Environmental Resources Management (2000).

Linewalk data have revealed fairly widespread lateral channel activity along the BTC route, indicating regional-scale instability. Bank materials are relatively fine-grained in the lowland river reaches, but are coarse in the mountain rivers, especially in the west. Bank erosion scars are numerous, and affect a number of crossings (see below for specific rivers). The main retreat mechanism appeared to the surveyors to be mass failure, with some tension cracking in the riparian zone evident. In some of the meander bends, undercutting of the outer banks has been reported, with associated cantilever collapse of the overlying sediments. Bank protection schemes have already been implemented, indicating an awareness of previous problems by the authorities. Some rivers (e.g. Aksu and Girdemanchay in the east) have been channelised for long stretches to stabilise flows and reduce erosion problems.

Selected actively-eroding reaches are shown in Figures 7 to 9.

Figure 7 Extensive bank erosion at a branch of the Ganjachay River (KP 295)

Figure 8 Close-up of erosion processes at the Geokchay River (KP 175)

Note: Erosional notches cut into soft, unconsolidated silts and clays. Evidence of instability.

Figure 9 Pipe exposed by erosion in wadi

1.6.8 Bed scour / degradation

River bed gravels appear fresh, without significant algal growths, and are likely to be mobile during parts of the high-flow season, in March - June). Some evidence of severe bed scour and channel degradation was found by some reconnaissance surveyors, including in Fookes and Bettess (2000). A good example of severe bed degradation was revealed by the presence of the old AGP pipeline suspended several metres above the channel bed where it was originally positioned some 20 years earlier (See Fookes and Bettess (2000) & AEO 2000). Anthropogenic disturbance of bed fabrics through gravel winning is important in some rivers (e.g. Shamkirchay River).

1.6.9 Hydraulic data

Information on river hydraulic conditions is lacking in many developing countries, including Azerbaijan. Data on velocity, stream power, boundary shear stress and energy slope is important in pipeline construction, hydrotesting and operation, especially in the following impact areas:

- River channel instability at river crossings especially bed scour
- Sediment transport rates, which are correlated with specific stream power to a power of 1.5 (Thorne et al. 1996)
- Direct fluid abrasion effects on exposed pipelines or supporting structures
- Estimates of time-of-travel and dispersal patterns for introduced contaminants to migrate to receptors (e.g. fuel and lubrication oil leakages from pipeline construction plant)

Average stream powers in Azerbaijan are high by global standards, reflecting the high discharges and slopes of their montane character. Channel stability analysis for the purposes of estimating setback distances or burial depths at pipeline crossings will be undertaken during detailed design.

1.6.10 Sensitive river crossings

Different reports consider a differing range of watercourse crossings, and identify a varying subset of sensitive, actively-eroding or unstable crossings. This probably reflects the paucity of the data and the few analyses undertaken, as well as the different project briefs, the nature of sensitivity being appraised and the different pipelines examined. It may also relate to the timing of any associated field visits with respect to the critical seasonal flow period between March and June. Examples include the following: the WREPA Environmental Monitoring Plan (1997, p.17) identifies 13 key crossings from 35 considered; Fookes and Bettess (2000) following a desk study of numerous crossings, examined 13 crossing locations on 7 principal rivers, identifying 4 as sensitive (class C or above); while the Dames & Moore (2000) AEO report consider 10 river crossings on the WREPA in Azerbaijan, 7 of which are assessed as highly sensitive, with 4 of these discussed in detail.

The following discussion is based on the reasonably detailed AEO Report by Dames & Moore (2000), which aims to identify those crossings which deserve special attention at the design stage either because bank erosion/bed scour problems could threaten pipeline integrity and/or of elevated risk of watercourse pollution. There are many gaps in the dataset, as Dames & Moore (2000) acknowledge, and no details are given of how the variables have been derived (e.g. bed material sampling: has this been achieved through a Wolman count to give frequency-by-number particle size distribution data or bulk-sieving or image analysis?). Nor is information presented on particle size distribution measures, average river discharges or scour depth calculations.

The four key rivers identified in the Dames & Moore (2000) report are as follows:

- Shamkirchay River
- Karabakh Canal
- Kura River East (downstream of Mingechaur reservoir)
- Kura River West (upstream of Mingechaur reservoir)

Further discussion of these four key crossings follows, largely reproduced from Dames & Moore (2000).

1.6.10.1 Shamkirchay River (KP332)

The Shamkirchay River in the west (KP332) experiences high levels of scour and erosion. Therefore, detailed engineering design was undertaken for this crossing during rehabilitation work in early 1999. This design is based on a 1 in 100-year flood event, which is relatively typical for design in this area (though the 1 in 500-year flood event may be a stronger planning basis). Data availability here is reasonably good, and flood frequency estimates, scour depth calculations and grain size analyses have been completed at this crossing. The existing crossing location will be affected by the continuing gravel mining upstream and downstream of the site, and Dames & Moore (2000) argue that the crossing location and type requires significant evaluation in the future.

Figure 10 Shamkirchay River (Dames & Moore, 2000)

Figure 11 Shamkirchay River (Dames & Moore, 2000)

1.6.10.2 Karabak Canal

The main canal crossed by the pipeline is the Karabakh Canal (KP245). The Karabakh Canal, which is concrete lined and recharges from the Kura River at the Mingechevir Reservoir carries significant amounts of water for many important uses including irrigation and industrial supply.

Figure 12 Karabakh Canal

1.6.10.3 Kura River East (KP223.5)

The Kura River is arguably the most important water resource for Azerbaijan. It provides an essential source of water for human use and is a key habitat for many important fauna and flora.

The river at the current Kura River East crossing has traditionally experienced bank erosion problems, with remedial works to stabilise banks evident. Despite being primarily controlled by the Mingechaur reservoir, the river has a very large drainage basin area here (some 66800 km^2) and still has considerable potential for flow fluctuations. The site is subject to added complications associated with downstream sand and gravel mining operations which may compound scour and bank migration effects.

Figure 13 Kura River East (KP 223.5)

1.6.10.4 Kura River West

The Kura River West crossing is upstream of the key Mingechaur and Shamkir Reservoirs. As a result, many of the issues associated with the Kura River East crossing are amplified as the environmental significance of a spill event or construction disturbance are likely to be far greater at this point. This section is subject to extremely high uncontrolled discharges and far more seasonal fluctuation in flow compared to the Kura River East location. Data availability for this crossing is relatively good. The river is highly active and has the potential for significant lateral migration. The site is subject to added complications associated with several upstream crossings and gravel mining operations which apparently compound scour and bank migration effects.

Figure 14 Kura River West (KP 410)

1.6.10.5 Other river crossings

In addition, Fookes and Bettess (2000) identify the Tovuzchay crossing as requiring extra attention (KP377). Crossings of the smaller wadis in the drier eastern parts of the route in Gobustan also require extra attention. Channel instability is potentially a significant issue in the Gobustan region which is characterised by high erosion rates (Kashkay, 1996; Lawler, 1998). Although semi-arid channels by nature, and generally dry, they can be subject to intense flash flooding. This normally leads to considerable scour-and-fill of the bed, upslope migration of gully headcuts (eg Leopold et al., 1964), and some lateral instability.

1.6.11 Conclusions

Erodible soils, steep mountain terrains and highly seasonal snowmelt and semi-arid/flash-flood hydrological regimes drive active erosional processes throughout many of the drainage basins crossed by the route. Many of the fluvial systems examined near or on the BTC route are active, dynamic and meandering or braided, especially in the west, where the BTC pipeline approaches the foothills of the Lesser Caucasus.

Bank erosion, channel course switching and bed degradation are relatively common. Bank erosion is evidenced by steep, bare, undercut banks, extensive erosion cliffs, tension cracks behind certain bank faces, loose, easily-erodible sand and gravel bank materials, and damage to existing revetments and bridge and trestle supports and old pipelines. Bed scour is apparent through suspension of old pipelines as 'pseudo-aerial' crossings which were once installed on the river bed.

Each river crossing will have a different range of disturbances and potential impacts to be mitigated, as well as different levels of risk of damage by erosion or flash floods.

Different sources argue for varying number of sensitive river crossings. However, there are at least 7 major river crossings which deserve special attention in crossing design because they are of high sensitivity, 4 of which special consideration and further analysis. These are

Shamkirchay, Karabak Canal and Kura East and West crossings. Tovuzchay may also prove problematic to the BTC pipeline, as may some of the wadis in the east (Gobustan region).

GEOLOGY AND SOILS

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1 GEOLOGY AND SOILS

1.1 INTRODUCTION

This geology and soils report describes the nature of geological units and features of the proposed proposed pipeline route corridor. There is also a comprehensive section on soil types, with a subsequent section on topography and geomorphology.

1.2 DATA SOURCES

The geology and soils information included in this appendix has been collated from a number of sources. Due to the similarities between the proposed route and the "Western Route Export Pipeline" (WREP), some of these reference sources were produced originally in connection with the original surveying for the WREP. Baseline information specific to the proposed was collected between summer 2000 and winter/spring 2001. All of these sources have been used in producing this report, namely:

- January-February 2001 - baseline survey of those areas where the proposed proposed route deviates significantly from the WREP undertaken by AETC on behalf of BP
- August/September 2000 - rapid reconnaissance survey of the WREP undertaken by Environment Resources Management (ERM) on behalf of BP
- Baseline survey of WREP undertaken by AETC on behalf of Azerbaijan International Operating Company (AIOC) as part of the Environmental Impact Assessment of the WREP. 1997
- Supplementary details and clarifications provided by Dr R Mamadov in meeting with Dr. Heike Pflasterer held in Baku (February 1997)
- Supplementary details provided by Prof. G. Yagubov in meeting with Dr Heike Pflasterer held in Baku (February 1997)
- Literature review on contamination along the WREP corridor by Dr R Mamedov, Scientific Center 'Nafta', Institute of Geology (December 1996)
- Review of Publications on Geomorphology and Relief Along the Western Pipeline Route. 1996
- Mamedov, G.Sh. & Yagubov, G. Sh. 1996. Review of Publications on Soil Cover Along the Western Pipeline Route
- Review of Publications on Geology Along the Western Pipeline Route. 1996
- Literature review on soils and agrochemistry along the WREP corridor by Prof. G. Yagubov, Institute of Soils and Agrochemistry (December 1996);
- Soils of Azerbaijan (Map). 1991
- Atlas of Mud Volcanoes of the Azerbaijan Republic. 1971

1.3 GEOLOGY

1.3.1 Introduction

The proposed pipeline route is mainly underlain by extensive areas of alluvial sediments. Active seismic fault zones are known to be present in the region, and mud volcanoes are also a significant issue.

The proposed pipeline route follows the east-west line of the extensive lowlands in Azerbaijan which lie between the Greater Caucasus mountains (maximum elevation 5047m) and the Lesser Caucasus mountains (maximum elevation of 3,740m).

1.3.2 Underlying geology

The area along the proposed pipeline route, from the Sangachal Terminal in the east to the Georgian border in the west, is located along the southern extension of the Greater Caucasus mountain range at a distance of approximately 60-70km. The formation of the Caucasus is associated with the Alpine-Himalayan orogenic belt which originated due to the closure of the Tethyan ocean and the subsequent collision of the Eurasian continental plate with the African and Indian continental plates.

The regional structure is dominated by compressional deformation of sedimentary rock, which led to the formation of nappes verging towards the south-east. There was some volcanic activity during this long period of compressional tectonism. Thrust faulting in the Late Miocene period lifted Jurassic and Cretaceous rocks over the Pliocene deposits of the Great Caucasus. Associated fault zones are located along the margins of this zone and have been a focal point for seismic events. Of particular importance are vertical faults orientated in a north-east/south-west direction which also led to block faulting of the basement.

The area to the south and north of the Caucasus extension is dominated by Oligocene to Quaternary age sediments. These are relatively flat lying in the north (mainly Quaternary) whilst in the south they have been subjected to minor folding events which have exposed Oligocene and Quaternary rocks at the surface (as shown in Table 1).

The whole area has been subject to much tectonic activity and the proposed pipeline route crosses an active seismic area where fault-related earthquakes up to intensity 8 on the Richter scale occur, principally between Kazi-Magomed and Borsunlu.

Relatively recent (Cretaceous, Tertiary and Quarternary) sedimentary rocks are divided into several tectonic units by a number of active fault zones.

Highly folded and faulted sedimentary rocks (sandstones, clays, marls, schists and limestones) dating back to the Jurassic are intruded by volcanics. The tectonic units and associated faulting found along the proposed pipeline are indicated in Figure 1.

Table 1 General stratigraphic column of sedimentary rocks along the proposed pipeline

ERA	PERIOD	DIVISION
		Recent (QIV)
	Quaternary	Late (QIII)
		Middle (QII)
		Early (QI)
		Late (N2)
	Pliocene	Middle (N2)
	Neogene	Early (N2)
CENOZOIC		Late (N1)
	Miocene	Middle (N1)
		Early (N1)
	Oligocene	Late (P3)
	Palaeogene	Early (P3)
	Eocene Palaeocene	(P2) (P1)

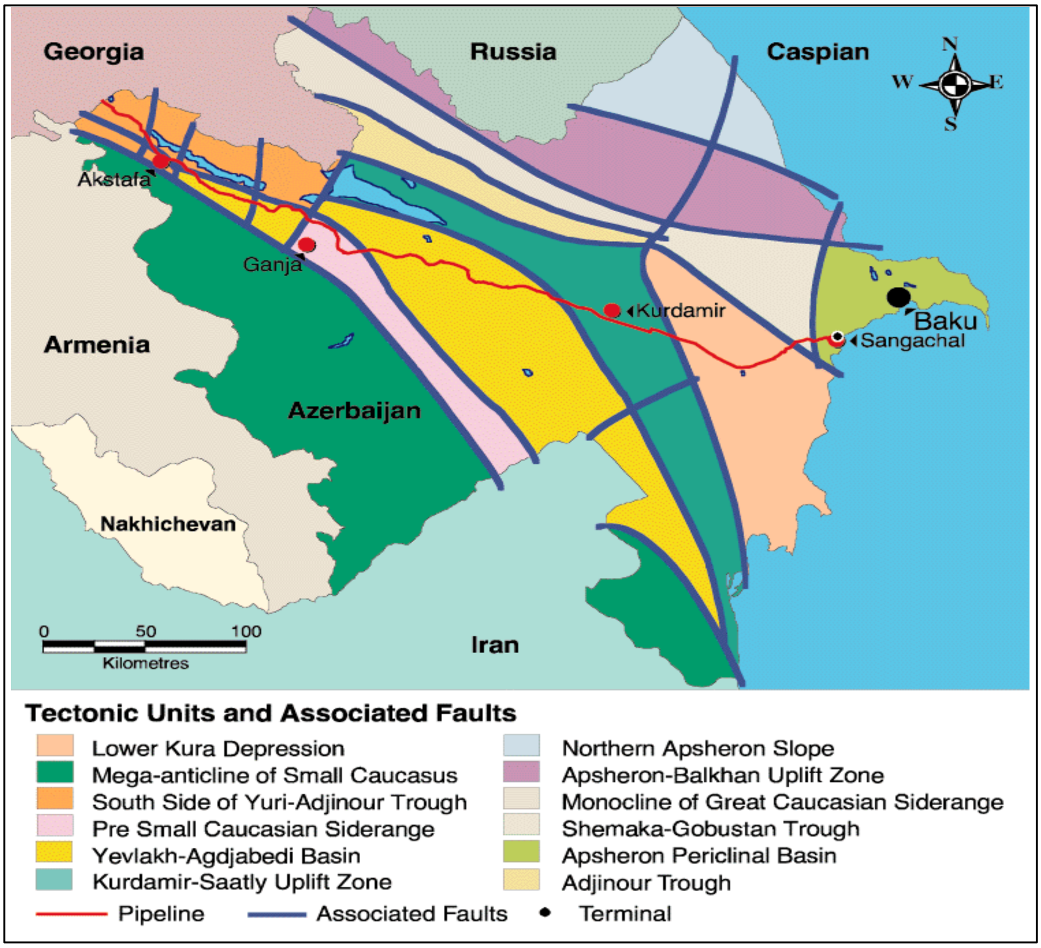
Table 1 General stratigraphic column of sedimentary rocks along the proposed pipeline

ERA	PERIOD	DIVISION
MESOZOIC		Late (K2)
	Cretaceous	Early (K1)

The proposed pipeline corridor passes through several tectonic units which are separated by major faults. These units are from east to west:

- Apsheron Periclinal Basin
- Shemaka - Gobustan Trough
- Lower Kura Depression
- Kurdemir - Saatly Uplift Zone
- Yevlakh - Agdjabedi Basin
- Pre-Lesser Caucasian Side Range (Monocline)
- Shamkor Anticline
- South Side of Yori - Adjinour Trough, and
- Mega-Anticline of Lesser Caucasus

Figure 1 Tectonic Units and Associated Faults Along the proposed pipeline



The major fault zones that separate the tectonic units are:

- Yashma Flexure
- Agichay - Alyat Fault (Jurassic - Neogene)
- Western Caspian Fault (Jurassic - Neogene)
- Mingechaur - Lenkoran Fault
- Kura Fault (Jurassic - Palaeogene)
- Pre-Lesser Caucasian Fault (Jurassic - Palaeogene)
- Ganjachay - Alazan Fault
- Kazakh - Signakh Fault

The geology of the proposed pipeline corridor can be divided into three distinct terrains. These are, from east to west:

- Sangachal to Kazi-Magomed (KP0-52)
- Kazi-Magomed to Borsunlu (KP52-272)
- Borsunlu to the Georgian border (KP272-442)

The geological setting of each of these areas is described in turn below.

1.3.2.1 Sangachal to Kazi-Magomed (KP0-52)

From Sangachal to the south-eastern slopes of the Big Harami mountain range the proposed pipeline route crosses a small scale anticline and syncline zone which is orientated in a north-west to south-east direction. This area is part of the Apsheron Periclinal Basin and the Shemaka-Gobustan Trough. Locally developed anticlinal structures, complicated with faulting of various orientations and magnitude, expose a variety of sediments. They are dominated by Cenozoic sediments of Palaeocene to Quarternary age, comprising many different and various thicknesses of argillaceous and arenaceous deposits. These molasse sediments are erosion products derived from the uplifted Caucasus mountain range to the north-west, and overlie a basaltic basement which is located at approximately 20-25km depth.

The anticlinal zones consist of mainly Pliocene deposits which are composed of sandy argillites, marls and limestones locally intercalated with shingle beds. The intramountainous basins are made of Quarternary clay, sand and shingle of alluvial, proluvial or lacustrine origin. These sediments are mainly unconsolidated and did not experience diagenesis. The north/south or north-west/south-east oriented Yashma Flexure, the faults at Kazi-Magomed and Agichay-Alyat are considered to be active and cut through Neogene to Quarternary layers. However, the amount of displacement along these faults is unknown. In this area mud volcanoes also occur and these features are described in detail in the Geohazards Report, Part 7 of the Baseline Reports Appendix. Neotectonic movements have led to subsidence with amplitudes of 400-600m in the Apsheron Basin.

1.3.2.2 Kazi-Magomed to Borsunlu (KP52-272)

In this section the proposed pipeline crosses the Lower and Middle Kura Depression which is a vast alluvial/proluvial plain. The sedimentary cover of the mesozoic basement reaches 5,000m thickness and is composed of Palaeogene and Neogene aged deposits. The Quarternary sediments have a thickness of 800-1,400m. A subsidence rate of up to 5,600m is recorded for the Middle Kura zone, and 1600m for the Lower Kura zone. Tectonics in this section are difficult to assess, however smaller tectonic structures such as the Naftalan and Khasanbulag Anticlines reveal fold structures. Deep seated faults are located at a depth of 3-7km and have a north/south or north-west/south-east direction. They are not cutting through sediments of Pliocene to Quaternary age, but are a source for seismic events eg the Western Caspian Fault which is situated in a depth of 3-3.5km. The amount of dislocation along these faults is uncertain, and it is unclear whether some of the faults are still active. Furthermore, a magma chamber has been identified which is causing bulging of the Mesozoic basement.

1.3.2.3 Borsunlu To The Georgian Border (KP272-442)

In this section the proposed pipeline corridor is located within a narrow band of the Kura River alluvial plain, the continuation of the Middle Kura zone, situated between the Great Caucasus in the north and the Lesser Caucasus in the south. Smooth, Quarternary anticlinal structures, with amplitude of 400-600m are developed due to the tectonics of the Lesser Caucasus. They expose rocks of Middle to Upper Jurassic, Upper Cretaceous and Neogene to Palaeogene age which have a varying lithology (eg, carbonates, intrusives and volcanics). The proposed pipeline corridor is located approximately parallel to the Pre-Lesser Caucasian Fault which effects Jurassic to Palaeogene sediments and forms the southern border between the alluvial plain and the Lesser Caucasus. The northern boundary is formed by the Kura Fault which cuts through Jurassic to Palaeogene formations. The tectonic setting is complicated with faulting of various orientations and magnitude. The Mesozoic basement is block faulted and the overlying geology, of Cretaceous to Palaeocene age, has also experienced intense fault formation (overthrusts, reverse faults, etc.) which are today hidden under the Quarternary cover. Remote sensing and geophysical data reveal transversal faults which are located along the river valleys coming from the north-eastern slopes of the Lesser Caucasus. However, no information about the amount of displacement along these faults is available.

1.3.3 Surface geology

Over most of the route, the solid geology is mantled by varying thicknesses of alluvial deposits.

The first 25km of the proposed pipeline route is typified by alluvial deposits and stony clays. Also found in this region between KP0 and KP29 are active mud volcanoes. Associated mudflows occur in this area and comprise breccias up to 10m in thickness. Mud volcano breccias, mud and wash-down deposits occur, particularly at the base of the Turagay Mud Volcano (KP17) and the Mud Volcano Ridge area (KP25-28). In some areas the mud flows are susceptible to rapid rates of erosion.

Limestone, marls and mud breccia outcrops occur in the section between Sangachal and Kazi-Magomed and rock is likely to be encountered near the surface in this area.

The rest of the proposed pipeline route from Kazi-Magomed to the Georgian border is covered by alluvium. The alluvial plain is still accreting due to the high sediment load of the rivers with catchments in the Great and Lesser Caucasus mountains, which are among the highest of any rivers in the world.

In the Kazi-Magomed region, the underlying geology is typified by sandstones, interspersed with limestones and other deposits. The rocks are highly weathered and consequently very soft.

The flood plains of the Kura River have an underlying geology typified by mainly loose, unconsolidated sand and alluvium. There is some occurrence of mountain outwash deposits and lacustrine sediments.

Surface cover is only expected to be thin where underlying rock is resistant to erosion or where weathered material has been moved downslope. This is possible on the higher ground of the Gobustan area and hilly sections of the Lesser Caucasus Lowlands.

1.3.4 Economic geology

The pipeline is, however, routed close to three areas where sand and gravel extraction occurs:

- Downstream (approx. 200m) from the Kura East River crossing (KP224) there is active sand and gravel dredging
- At the Shamkir River crossing gravel extraction is currently taking place at the crossing point and immediately downstream (KP332)
- Upstream (approx. 1km) of the Tovuz River crossing (KP377)

With the exception of the Shamkir River crossing, the scale of aggregate extraction in these areas appears to be limited, probably providing a source of aggregate for the local area. The extent of extraction at Shamkir is greater, and is likely to be of regional importance.

Oil and gas exploration and production has taken place along certain sections of the route and some areas are still active concessions. However, although the route passes close to disused (and sometimes leaking) oil exploration or production wells, current production facilities have been avoided. This is discussed further in the Contamination Baseline Report, Part 6 of the Baseline Reports Appendix.

1.3.5 Mud volcanoes

Mud volcanoes are the dominant geological features in the eastern part of the proposed pipeline corridor.

Over 300 mud volcanoes are present in Azerbaijan, the majority of which are found in the Gobustan region (which the proposed pipeline route passes through between KP0 and KP29). Their distribution is related to anticlines and they are orientated in chains along the axes of these folds and/or along the lines of larger faults, in a north-west to south-east orientation. They are formed at the points at which pressure within the earth's crust (up to 6km deep) is released.

Generally they are found where high Pliocene sedimentation rates were able to keep up with rapid subsidence. Deposits of the Caspian Depression, mainly derived from the Caucasus mountain range, are heated, possibly due to interaction with hydrocarbon deposits. They rise to form mud diapirs intruding into the overlying sedimentary layers which crack and effuse into the submarine or terrestrial environments.

Mud and larger clasts of rocks, liquids and gases erupt from the ground surface. Eruptions can be violent and unexpected, and the gases discharged may be flammable. Mudflows form as the mud travels downslope away from its source. With time the erupted material will form a conical or plateau-like structure.

As mud volcanoes are geologically short-lived and tend to move along fault lines, the direction of migration of mud volcanoes should be considered, as well as the existing locations.

Only three mud volcanoes are located close enough to the proposed pipeline route to be considered a potential threat (Environmental Route Maps, Volume 2)). Otman-Bozdag mud volcano, one of the largest in Azerbaijan, lies 4.6km to the north-west of the Sangachal Terminal (KP0). The Otman-Bozdag volcano is active, eruptions being registered in 1845, 1904, 1922, 1951, 1965 and 1994.

The Turagay Mud Volcano (located approximately 2.5km to the south of the proposed pipeline route at KP17) last erupted in 1955 and although not currently active, further eruptions are considered likely.

In the region of the Structural-Front Mud Volcano Complex (Mud Volcano Ridge), two parallel faults (crossed by the proposed pipeline route at approximately KP24 and 29) running north-west to south-east define an area in which mud volcanoes form along the trend of the fault lines (Environmental Route Maps, Volume 2).

During strong eruptions the basic mud containing rock fragments, water, oil and gas at temperatures of up to 1200°C can be ejected up to 100m into the air. Although only some mud volcanoes of Gobustan show recent mudflows, all are believed to be active.

Further information on mud volcanoes and also faulting, earthquakes and seismicity is provided in the Geohazards Report, Part 7 of the Baseline Reports Appendix.

1.4 SOILS

1.4.1 Methodology

The contents of this section are based on the results of an original survey carried out for the WREP and further surveying conducted for the proposed pipeline. The survey based its observations on terrain analysis, which identifies soils from their correlation to landscape features.

Although various soil types have been identified along the proposed pipeline corridor, according to their grain size they are all clays or loam, and many are highly saline. In the eastern area carbonaceous clays give rise to desert vegetation. Significant deposits of alluvial soils are found along the central and western portion of the proposed pipeline route. With adequate irrigation these soils are extensively used for agricultural purposes all year round.

1.4.2 Soils along the proposed pipeline route

The principal differentiating characteristic of soils in the study area is the soil moisture regime, the main elements of which involve interaction of factors such as climate, soil evolution, and drainage. Landform is also an important issue with regard to soils, due to issues of drainage and soil erosion.

Several characteristics are common across the range of soils identified within the study area. All soils react vigorously with dilute hydrochloric acid, which classifies them as calcareous (strongly alkaline). The soils observed are predominantly clayey and dense; in many areas they are also saline.

Mamedov & Yagubov (1996) identified various soil types along the proposed pipeline corridor. From the Sangachal Terminal at KP0 to Mingechaur, north of KP244 the soils can generally be classified as dense clays. From Mingechaur to the Georgian border (KP442) the clays tend to be more silty and therefore less dense. However, close to the rivers, which originate in the Lesser Caucasus, shingle beds are also developed.

Table 2 Classification of Particles According to their Grain Size (1mm = 1,000 mm)

GRAIN SIZE	PARTICLE
> 63mm	Cobble
63mm – 2,000 µm	Gravel
2,000 - 63µm	Sand
63 – 2µm	Silt
< 2µm	Clay

The soil types along the proposed pipeline can be classified into four distinct areas, which are described from east to west below.

1.4.2.1 Eastern section (Gobustan-KP0-52)

The Gobustan area covers the foothills of the south-eastern Great Caucasus (KP0-52). All soils observed were locally highly alkaline and saline in nature. Grey-brown soils prevail, but immature grey soils also occur. These soils can be very dense with permeabilities ranging from 0.05-0.1m day^{-1} due to the fine clays and silts deriving from mud volcanism. However, grain size composition given by Mamedov & Yagubov (1996) ranges from 21% to 69% of particles smaller than 0.01mm and they are therefore classified as silt/clay. Carbonaceous clays were observed along part of the route.

Close to the Sangachal Teminal (KP0) in the eastern part of the Gobustan area light coloured (light grey-brown), saline, carbonaceous clays which contained shell fragments and pebbles were observed. Rock outcrops of sandy carbonates occurred in places. Further to the west the soils were locally saline or very saline and showed gypsum crusts, especially along silty wadis. Outcrops of carbonate and marls, intercalated with mud volcanoes producing basic, and often oily, mud were found. Water erosion of the soil has lead to the creation of gully and ravine complexes in the foothills of the Gobustan area.

The soils in the first 25km of the proposed pipeline route comprise yellow brown silty and stony clays and loams with consistencies varying from soft and loose to slightly hard. The soil structure is generally fine to medium and subangular. Vegetation in this area is extremely sparse, as the area is typified by semi-desert. Shrubs and grasses are present in some areas (particularly in association with watercourses), amongst large expanses of bare ground.

The area between the Caspian Sea and the Kura River is generally hot and dry. The vegetation, out of necessity, is adapted to drought and, in much of the area, to soil salinity. The majority of the landscape is occupied by plains, which are interrupted at different locations by stream channels (fluvial lands), sloping lands and disturbed lands.

Plains soils between Sangachal and KP52 are prone to overland flow. In locations where runoff concentrates, one often finds steep-sided ravines deeply etched into the surface. The soil surface often has a platy structure 3–5mm thick that, until disturbed or thoroughly saturated, serves as a partially impenetrable barrier to infiltration and results in high soil aridity. Where overland flow is an important part of the local hydrology, small dunes occur at the base of clusters of grasses and shrubs.

1.4.2.2 Central section (Shirvan Plain-KP52–224)

This flatland area extends from near the village of Ranjbar, east of Kazi-Magomed to the east of the Kura River near Yevlakh (KP52-224), and covers a large area of the Kura River zone. The soils are silty grey soils with a high organic content around Kurdemir and a low to medium humus content in the area between Ucar and Yevlakh (KP177-224). The grain size of these soils ranges from clays to alluvial sands. Fans of alluvial wetland meadow soils occur around the various branches of the Geokchay and Turianchay rivers.

The soils consist mainly of pale and dense clays which are mostly saline (although grain size does vary widely across the region). Due to intensive agriculture they seem to be depleted and crop growth is often low. Humus rich soils were not observed.

The soils found in the region of Kazi-Magomed (KP52) are similar to those found in the Gobustan region, with a pale brown colour, sandy loam texture and slightly sticky and friable consistency. Vegetation is classed as mainly grass, although this is very patchy. Grazing of grassland by sheep and goats is common.

West of Kurdamir (around KP130), in the area of the former lake of Shilian, the clays are grey to dark grey, and are classified as meadow marsh and marsh soils. Deep desiccation cracks and teepee structures typical of salty soils were often observed. Wind and water erosion of the soils in this area is not significant.

The plains occupy the majority of the landscape east of the Kura River crossing at KP224. Beginning at sea level at the edge of the Caspian Sea, the plains landscape gains altitude until it abruptly returns to sea level in the vicinity of the village of Ranzbarilar, where it becomes part of the Shirvan plain of central Azerbaijan. The plains landscape is interrupted at different locations by stream channels (fluvial lands), sloping lands and disturbed lands.

The soils found on the plains of the study area are depositional soils that are generally pale coloured (light yellowish brown) loam with a composition that includes significant quantities of silt, clay or sand. Cultivation has been carried out in the Kura flood plain. Crops include wheat and cotton, and much of the land is employed for grazing cattle and sheep.

West of Ranzbarilar the soils characteristics alter. Unless irrigated, they tend to be highly cracked, these rifts staying open for much of the year. Highly cracked soils in hot climates are known to accumulate salts. Salt pollution of soils is a problem throughout the irrigated area east of the Kura River at KP224. Poor irrigation practice is generally the cause of salination. Some soils are so severely affected by soil salinity as to have a salt flock structure or crust to their upper surface.

Tillage in this region is deep, usually using mouldboard ploughs followed by harrowing. During surveys, there was no evidence of disk ploughs or cultivators being used. Agriculture has destroyed the berm over parts of the existing WREP pipeline, especially on the plains near Ganja. In other areas fill material has settled to below the level of the soil surface, creating a kind of parabolic channel. This is most prominent in saline soils having a hard to very hard, blocky structure, and may result from inadequate preparation of fill material.

Slopes perpendicular to the proposed pipeline route occasionally traverse the plains. Soil erosion and deposition play a role in soil formation in these regions, so that gravel from upland areas might cover soils lower on the slopes. Where the landscape is rolling or hilly, sand is therefore likely to be a greater constituent of the soil, with pale colour and infertility being typical. Such soils have little resistance to erosion, and when severely eroded become classified as ‘badlands’.

Soils in the fluvial regions differ from their drier counterparts in that they are often associated with hilly, rolling, and undulating terrain: their occurrence is rarely abrupt, but results as a transition with other land forms. In fluvial regions the soils tend to convey water and lie entrenched below the level of the natural land surface.

In landscapes with a cooler climate than the plains close to Sangachal, a higher level of rainfall is registered which makes the area suitable for some forms of rain-fed agriculture. Regions in the study area are used for a mix of rain-fed and irrigated farming of such crops as maize, cereals, hay, and grapes. Their landscape is more diverse and higher in altitude than are the warmer plains. Rivers, some of which are deeply incised, act to divide upland plains into discrete segments. Wet lowlands have more relief than dry lowlands. Their soils resist salt accumulation. As with most plains soils, the soils found on wetter plains develop a thin platy crust (3–4mm thick), which reduces infiltration. Tillage breaks up the crust, so that it is less of a feature on valley and plains soils than on sloping lands, where the potential for runoff and soil erosion is high.

Within the study area, there are areas of disturbed land associated with roadways, construction of different kinds and the existing WREP pipeline corridor. For example, there is evidence of highly cracked soils concentrated along the working width of the existing WREP pipeline corridor. In these areas soils have been so mixed as to lack observable diagnostic characteristics. As they contain subsoil mixed with soil from the surface, their general impact is to reduce soil fertility. This becomes extreme in areas that are compacted which may also be prone to drought and on sloping ground where the topsoil may be washed away completely. The effect of disturbed lands is to reduce plant density, vigour and biomass. In agricultural areas, the existing pipeline corridor serves as an entry point for invasive weeds. Areas of disturbed soils, which have a soft consistency, attract burrowing animals such as rabbits and foxes.

1.4.2.3 Western section (Karabakh Plain KP224-256)

The proposed pipeline route crosses the northern part of this plain from east of Yevlakh to the Goran railway station near the village of Goranboy (KP224-256). The soils consist of alluvial flood plain meadow forest soils near the Kura River. West of the Kura River grey soil with low or medium humus content prevails with intercalated alluvial soils, which consist of the alluvium of various watercourses sourced in the Lesser Caucasus. Grey soils, as well as light chestnut coloured soils, which are occasionally saline, also occur.

In this area alluvial deposits are present irregularly, with soils typified by grey-brown silty, sandy and clayey loams. The vegetation encountered is mixed, varying from natural, uncultivated regions, to semi-natural and agricultural lands. Grazing is widespread, with a few cultivated areas that have been used predominantly for the cultivation of vines and maize. A general trend was noted of grazed areas on valley sides, with cultivation and irrigation in the valley bottoms.

1.4.2.4 Western section (Lesser Caucasus Plain - KP256-442)

This area covers the western part of the Kura River Plain and the foothills of the Lesser Caucasus. It stretches from the Goran railway station up to the Georgian border (KP256-442). Close to the rivers alluvial wetland meadow and Tugay soils occur. In other places chestnut soils which are partly saline prevail. The proportion of grain size of < 0.01mm varies between 16% and 60%, which classifies it as a loam.

Pale to grey brown, saline and partially loamy clays occurred in the area between the villages of Goran (KP256) and Borsunlu (KP273). Light grey-brown/brown, silty clays prevailed in the area between Borsunlu and Deller (KP341), whilst further to the west pale grey-brown silty clays, which are locally saline, are found. From the village of Asagli to the Georgian border chestnut coloured clays prevail. Soil erosion caused by rainwater run-off and the subsequent creation of gullies occurs in the hilly parts of the proposed pipeline route along the south side of the Shamkir Lake (KP329-387) and north of Agstafa (KP392-400).

The permeabilities of the described soils to pure water ranges from 0.05-0.1$mday^{-1}$ at Gobustan, through < 0.8$mday^{-1}$ for the Shirvan and Karabakh Plains to values of up to 10$mday^{-1}$ in the Lesser Caucasus Plain and Lowland.

At the western end of the proposed route, from the west Kura River crossing to Jandari Lake, the soil is generally a sandy or clayey loam, light brown in colour, with a slightly hard consistency and angular structure. Natural vegetation in this area ranges from mosses, shrubs and low grasses in upland regions to reeds, low trees and shrubs (Tugay forest-type vegetation) on the flood plain.

In the cool, upland environments typical soils are depositional soils with little soil horizon development. They support deep ploughing, but trenching (as for the pipeline) may well exceed their ability to retain soil fertility, and soil quality will diminish. Most soils in this category are irrigated for hay or maize during the summer, followed by rain-fed cereal production during the winter. Fields are small and although tillage will be by tractor-drawn mouldboard ploughs, much of the subsequent labour is by hand.

Seasonally cracking soils are present in some areas with fairly low levels of moistness. This means that they are pale-coloured, often brown with a tendency towards shades of grey. These soils tend to be more of a nuisance than a problem. They tend to become sticky when wet, and vehicles can be difficult to manage during irrigation or the rainy season. Tillage requires careful attention to soil moisture content: too wet and ploughs become difficult to pull; too dry and they become hard. Well managed, these soils will retain their fertility and provide good yields.

Where hills (or undulating or rolling lands) associate with plains-like valleys in close proximity the soils are typically pale-coloured and shallow soil on sloping lands, where soil erosion is a factor in soil development. Because the soils are thin, they are easily damaged by construction and compaction. Their principal uses include watershed, habitat, and limited grazing; they are unsuited to most forms of horticulture.

Undulating, rolling or hilly lands often precede, or follow, fluvial lands in the landscape sequence. If undulating, their soils may resemble those of the plains. If occurring downslope of rolling or hilly terrain, however, their surface may become covered by gravels transported from above. They have a low suitability for farming because of soil drought enhanced by internal drainage. Rolling and hilly lands usually contain soils similar to those described in the preceding paragraph. They often are skeletal, which means that gravel makes up an important part of their composition.

1.4.3 Occurrence of gypsum-rich soils

Gypsum (hydrated calcium sulphate) is often found both on and just below the soil surface. The resulting saline conditions are highly aggressive towards steel and concrete used in pipeline construction. Gypsum growth within soil can also lead to heave, with solution of gypsum resulting in ground collapse beneath foundations and pipes.

1.5 TOPOGRAPHY AND GEOMORPHOLOGY

The topography and geomorphology along the proposed pipeline route can be characterised into three distinct sections as described below.

1.5.1 Sangachal to Kazi-Magomed (KP0-52)

The Gobustan area consists of plains and low mountains with elevations of up to 400m. They are part of the tectonic structure of the Apsheron Basin and the Shemaka-Gobustan Trough.

The landscape along the first 25km of the proposed pipeline route is mainly semi-desert. Erosion and denudation occur in the hilly areas with a series of flat-topped steep-sided hills crosscut by highly eroded seasonal channels creating steep slopes, badlands, gorges, gullies and the local exposure of carbonaceous bedrock.

The topography rises to meet the ridge of mud volcanoes at KP25, reaching elevations of up to 400m, for example the Turagay mud volcano and a slope of up to approximately 15°,. This is where the proposed pipeline route reaches its greatest altitude. Mud volcanoes are distinct features of this area and are described in detail in the Geohazards Report, Part 7, Baseline Reports Appendix. Intra-mountainous basins which consist of alluvial, proluvial and deluvial sediments of the mountain ranges and mud volcanoes are intercalated.

The landscape in the region of Kazi-Magomed has moderate undulating relief, with generally gentle slopes dissected by erosional stream channels.

1.5.2 Kazi-Magomed to Yevlakh (KP52-224)

From the west of Kazi-Magomed to the Kura Valley at Yevlakh the central part of the proposed pipeline route consists of the vast Shirvan Plain. In this area Quarternary alluvial deposits from the Great and Lesser Caucasus form huge fans, cones and terraces (Novocaspian formations). The topography is flat and altitudes are low, varying from -12 to 10mamsl. The sedimentary cover of the basement reaches more than 5,000m thickness and is of Mesozoic and Cenozoic age. The Shirvan Plain is highly intersected by rivers sourced in the Great Caucasus and by irrigation canals.

The landscape of the Korchay region is comprised mainly of undulating plains with slight slopes and fairly low relief.

1.5.3 Yevlakh to the Georgian Border (KP224-442)

The western section of the proposed pipeline route consists of the Karabakh Plain and the foothills of the Lesser Caucasus up to Poylu, where the proposed pipeline route crosses the Kura River. The cover of Palaeogene to Miocene sediments reaches a maximum thickness of 2,000 to 3,000m. The monoclinal deformation dips towards the Kura River in the north. This section is characterised by Quarternary alluvial and proluvial deposits which are derived mainly from the Lesser Caucasus.

North of the Kura River the plain is fed by alluvium from the Great Caucasus Mountains, the watershed being situated near Poylu at an altitude of 197m. The major braided rivers are located in this section, where altitudes range from 80 to 330m.

Close to Shamkir, to the east of the western crossing of the Kura River, the proposed pipeline route crosses undulating hills and valleys. The valleys sometimes comprise fairly wide alluvial plains. Due to the moderate relief, drainage is generally good, with rivers draining the hills, and drainage ditches on more level cultivated areas of ground.

To the west of the river, the route crosses the Lesser Caucasus Plain and Lowlands. This low relief topography has good drainage in the form of drainage ditches and canals. Within this region an area of badlands has developed for approximately 30km to the west of Ganja (between approximately KP352 and 382).

The topography in the region of the Karayazi aquifer (KP411-442) is generally flat, being on the wetland flood plain of the Kura River.

1.5.4 Summary of geomorphological features

In summary, in the east, the main geomorphological features are the mud volcanoes and the wadis. The wadi channels only contain flowing water on an irregular basis and are characteristic features of semi-arid or arid environments prone to flash floods.

The central section comprises the flat agricultural lands of the Kura floodplain.

Towards the western end of the route, the river channels are mainly wide and braided with channel width typically in excess of 100m.

CLIMATE AND METEOROLOGY

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1 CLIMATE AND METEOROLOGY

1.1 INTRODUCTION

This report describes the climatic environment along the proposed pipeline route through Azerbaijan, mainly based upon information collected along the existing Western Route Export Pipeline (WREP), focusing in particular on thermal conditions, humidity, precipitation and wind speed.

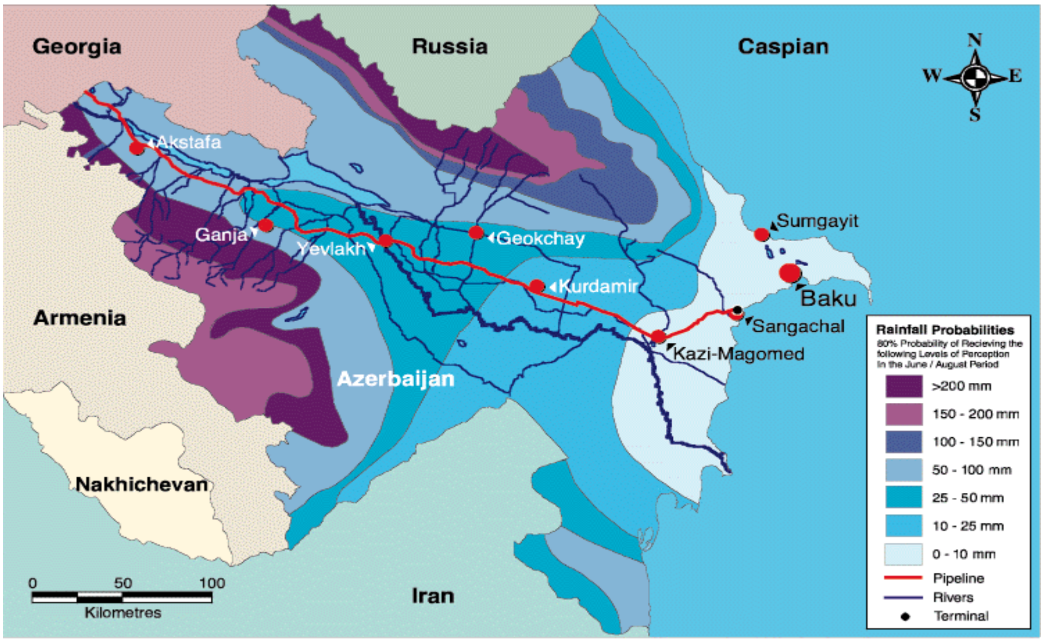
1.2 DATA SOURCES

A desktop study or literature review of existing data regarding climate and air quality in the pipeline corridor was prepared by Professor Eyubov, Head of the Climatology Department at the Institute of Geography (Eyubov, 1996). The information in this section is based on this study. In addition, other publications, including one on bioclimate resources (Eyubov, 1993b) and the detailed maps contained within the Agroclimate Atlas of Azerbaijan (Eyubov, 1993a), were referred to in the preparation of this study.

Azerbaijan has numerous meteorological stations, some of which have been collecting data for over 100 years. This means that long-term climatic averages are relatively reliable. Ten of the stations are in proximity to, and at fairly regular intervals along, the proposed pipeline route, as shown in Figure 1-1. The information on which this appendix report is based was mainly gathered from these stations, (Eyubov, 1996) namely :

- Baku,
- Puta (near Guzdek),
- Alyat,
- Kazi-Magomed,
- Kurdamir,
- Yevlakh,
- Ganja,
- Shamkir,
- Kazakh and
- Akstafa.

Figure 1-1: Location of meteorological stations along the proposed pipeline



Standard techniques were used to collect data on the normal suite of meteorological variables, including hours of sunshine, solar radiation fluxes, air and soil temperature (at the surface and 200mm depth), atmospheric humidity, precipitation, and wind speed/direction. In addition, automatic rain gauges were used to gather data on rainstorm magnitudes and frequencies, factors that are very significant in with regard to the hydrological and geomorphological processes that may affect pipelines.

Many different climate types are represented in Azerbaijan. Eight of the 11 commonly classified climate types can be found in the Republic.

The climate of the eastern part of the proposed pipeline corridor, around Guzdek, can be classified as a subtropical, temperate semi-desert/dry steppe type, which is characterised by hot summers (air temperatures of up to 40°C), high evapotranspiration rates in summer, high wind speeds, low humidity and low rainfall (< 200mm p.a.).

To the west, the climate becomes slightly cooler, wetter and less windy, as altitudes rise to over 300 metres above mean sea level (mamsl – define the acronym and which sea it relates to) and distance from the Caspian Sea increases. The influence of the Caspian Sea moderates the climate along the eastern portion of the proposed pipeline route, and keeps winters warmer and summers cooler than might be expected for these latitudes (with an average of 40°N).

1.3 TEMPERATURE

1.3.1 Sunshine and solar radiation

The number of sunshine hours experienced along the proposed route is high by global standards. The Agroclimatic Atlas of Azerbaijan (Eyubov, 1993) shows that most regions receive approximately 2,200 hours of sunshine per annum, however this total decreases to around 2,100 hours for Kurdamir in the Shirvan Plain and rises to 2,320 hours for Ganja.

Around 60% of this total is incident between June and August when, for example, up to 11 hours of sunshine per day can be expected in Baku. This declines to an average of just three hours per day for Baku in winter.

Mean annual solar radiation fluxes alter little along the proposed pipeline corridor. They vary between 128 and 132kcal cm^{-2} at the eastern end, and decline to a little less than 124kcal cm^{-2} at the slightly cloudier western end, a region with one of the lowest annual solar radiation levels in Azerbaijan. In the winter period, between October and March, the whole route receives a solar radiation flux of only between 36 and 40kcal cm^{-2}.

1.3.2 Air temperature

The large inputs of solar energy noted above, combined with limited thermal moderation by cooling vegetation (especially around the eastern semi-desert part of the route) means that air (and soil) temperatures are high, particularly in the peak of summer. The mean annual temperature increases steadily eastwards from approximately 12°C at the Georgian border to 13.2°C at Ganja and 14.6°C at Alyat. Alyat is registered as one of the warmest places in Azerbaijan. It has been suggested by Hadiyev (1996) that mean air temperatures have risen significantly in the Trans-Caucasian region over the last 100 years.

Seasonal changes can be identified by studying the monthly averages given in Table 1-1. The coldest month is usually January; and the warmest are July and August. Mean January air temperatures at Puta, near the coast, and Ganja are 3.4°C and 1.1°C respectively, while in Akstafa the January mean drops to -0.1°C. In July the cooling effect of the Caspian means that average monthly temperatures are virtually the same at Puta and Ganja (25.8°C and 25.4°C respectively). The hottest parts of the proposed pipeline corridor in July are normally in the centre of the Republic, around Kurdamir and Yevlakh (both 27.3°C). These locations are far enough inland to be isolated from the moderating effects of the Caspian, yet not at a sufficiently high elevation to be affected by altitudinal cooling (see Table 1-1).

As regards temperature extremes, mean monthly minimum air temperature in January varies from 0.7°C at Puta to -2.4°C at Ganja. The lowest temperatures ever recorded at these two meteorological sites, however, are -17°C and -18°C respectively (and -24°C at Kurdamir). Mean monthly maximum air temperature in July varies from 30.4°C at Puta to 34.6°C at Kurdamir. The highest air temperatures ever recorded at Puta and Kurdamir are 41°C and 43°C respectively.

Table 1-1 Air temperature statistics for meteorological stations along the proposed pipeline (°C)

STATION	JANUARY					APRIL				
	MEAN	AVE MAX	AVE MIN	ABS MAX	ABS MIN	MEAN	AVE MAX	AVE MIN	ABS MAX	ABS MIN
Puta	3.4	6.6	0.7	21	-17	10.9	15.3	7.5	34	-2
Alyat	3.4	7.2	0.0	22	-16	11.7	16.7	7.5	36	-1
Kurdamir	1.4	6.2	-2.1	20	-24	12.6	19.2	7.1	34	-2
Yevlakh	1.7	6.9	-2.2	20	-18	13.5	20.2	7.4	35	-3
Ganja	1.1	5.5	-2.4	19	-18	12.0	18.2	6.7	33	-4
Kazakh	0.0	5.0	-4.0	18	-25	11.1	17.5	5.7	31	-5
STATION	JULY					OCTOBER				
	MEAN	AVE MAX	AVE MIN	ABS MAX	ABS MIN	MEAN	AVE MAX	AVE MIN	ABS MAX	ABS MIN
Puta	25.8	30.4	21.5	41	12	16.3	20.0	12.7	35	-2
Alyat	26.4	31.2	21.9	40	12	10.6	20.9	12.7	34	1
Kurdamir	27.3	34.6	20.6	43	14	15.9	22.3	11.2	35	-4
Yevlakh	27.3	34.0	20.4	42	11	15.6	21.9	10.2	36	-5
Ganja	25.4	31.8	19.0	40	10	14.3	19.9	9.6	34	-5
Kazakh	24.0	30.3	17.9	39	7	13.2	19.0	8.1	33	-6

1.3.3 Soil temperature

The temperature of the soil is dependent on the nature of the soil surface, but also on the amount of solar radiation incident on the area, and on energy balances found at the surface. The following issues are of relevance:

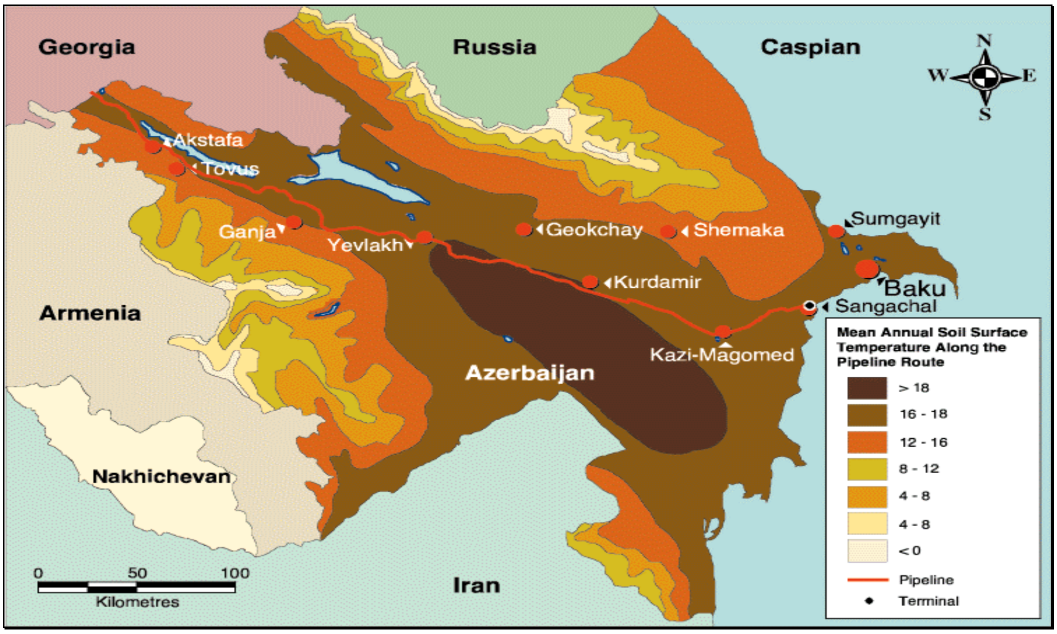
- Soil particle grain size and sorting, which influence thermal properties, such as conductivity (eg fine-grained materials conduct heat more efficiently to depth, moderating soil surface temperatures)
- Soil moisture content (wet soils conduct heat downwards more easily, minimising diurnal heating and nocturnal cooling of the surface)
- Vegetation cover, which tends to subdue the seasonal and diurnal temperature ranges, all other factors being equal

The mean annual soil surface temperature map for central Azerbaijan is presented in Figure 1-2. Mean daily soil surface temperatures are around 2°C-3°C higher than air temperatures. This is due to the following factors:

- Very strong heating of the soil surface as a result of incident solar radiation (especially in summer),
- The lack of a shading/transpiring vegetation cover
- A limited soil moisture supply that could be evaporated and therefore cause cooling

Mean annual soil surface temperatures are relatively constant along the route, varying between 16°C and 18°C. The highest temperatures, above 18°C, are reached in the Shirvan Plain, and towards the east of the route (see Figure 1-2). In summer, soil surface temperatures can be extreme, and maxima have exceeded 70°C at Akstafa in the west and at Sabirabad in the Shirvan Plain. Mean July temperatures along the whole route vary between 30°C and 35°C. In January, mean soil surface temperatures along the entirety of the route lie between 0°C and 3°C, except near Guzdek where average values tend to exceed 3°C.

Figure 1-2 Mean annual soil surface temperature along the proposed pipeline



1.4 ATMOSPHERIC MOISTURE

1.4.1 Evapotranspiration

Potential evapotranspiration (PE) is strongly linked to temperature regimes. PE is the maximum amount of evaporation and transpiration that can take place if an unlimited moisture supply is available. PE rates, at more than 800mm in eastern Azerbaijan and 600mm in the west in the April to October period , are very high. The summer evapotranspiration peak is controlled by the following factors:

- Large solar radiation receipts (up to approximately 130kcal cm^{-2})
- Substantial periods of unbroken sunshine
- High air temperatures (commonly up to between 30°C and 35°C)
- High wind speeds which enhance replacement of dry air supplies
- Low atmospheric humidity which, according to standard flux-gradient principles, allows near-surface air to accept large volumes of evaporating moisture from the surface materials

The fact that potential evapotranspiration losses exceed precipitation inputs by a significant margin is largely responsible (along with soil salinity and overgrazing problems) for the sparse vegetation cover in the eastern part of the route. Irrigation systems are extensive in the central parts of the proposed corridor, and replenish evaporated and transpired soil moisture to sustain agricultural activity (Wolfson and Daniell, 1995).

1.4.2 Humidity

Mean annual absolute humidity increases from around 11 gcm^{-3} in the west to around 13 gcm^{-3} in the eastern coastal areas. Strong seasonality exists, however, and in the Shirvan Plain lowlands, values range from 4.0 to 7.2 gcm^{-3} in January, and 14.3 to 22.2 gcm^{-3} in August. Mean annual relative humidity displays little spatial variability, increasing from 67% at

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Shamkir to 72% at Kurdamir. Summers are hot and dry, and peak relative humidities are achieved in winter. The highest average humidity recorded is 87% in Kurdamir during the winter, a value that declines to 72% in July.

1.5 PRECIPITATION

1.5.1 Annual and seasonal precipitation

Average annual precipitation decreases steadily from around 350 to 400mm near the Georgian border to 104mm at Puta (see Table 1-2). Rainfall is the most strongly varying climatic parameter in the proposed corridor (see Figure 1-3). The arid desert plain in the Guzdek/Sangachal region is one of the driest areas in Azerbaijan. Variability from year to year is high, as is common with semi-arid and arid environments, and Puta has received as much as 390mm in one year (1968), and as little as 78mm in another (1925). Similarly, annual totals at Akstafa have ranged from 567 to 253mm (as shown in Table 1-2). It should be stressed, however, that it is the much greater precipitation (and snowmelt processes) in the vicinity of stations like Sheki in the Caucasus ranges (greater than 1,000mm in many areas) which controls the magnitude and seasonal variation of flows in the rivers crossed by the proposed pipeline, rather than rainfall over the proposed pipeline route itself (see Figure 1-4).

Table 1-2 Precipitation statistics for meteorological stations along the proposed (mm) (year given in brackets)

STATION	JANUARY			APRIL		
	MEAN	AVE. MAX.	AVE. MIN.	MEAN	AVE. MAX.	AVE. MIN.
Puta⊗	12	79 (1905)	1 (1898)	10	70 (1911)	0 (1957)
Alyat Why 3 entries?	16			20		
Kurdamir Why 3 entries?	22	68 (1937)	1 (1912)	32	88 (1923)	2 (1950)
Ganja Why 3 entries?	10	34 (1893)	0 (6 yrs)	27	64 (1895)	0 (1950)
Akstafa	13	43 (1957)	0 (6 yrs)	38	92 (1912)	0 (1943)
Puta⊗	2	48 (1922)	0 (19 yrs)	16	132 (1946)	1 (2 yrs)
Alyat	4					
Kurdamir	17	121 (1926)	0 (9 yrs)	33	134 (1951)	0 (1954)
Ganja	23	92 (1922)	0 (2 yrs)	22	95 (1951)	0 (1952)
Akstafa	32	139 (1906)	0 (4 yrs)	30	120 (1951)	2 (1932)
STATION	TOTAL FOR YEAR			⊗ Because of a lack of reliable records extreme data are given for Baku, where average annual precipitation is 198 mm		
	MEAN	AVE. MAX.	AVE. MIN.			
Puta⊗	104	390 (1968)	78 (1925)			
Alyat	188					

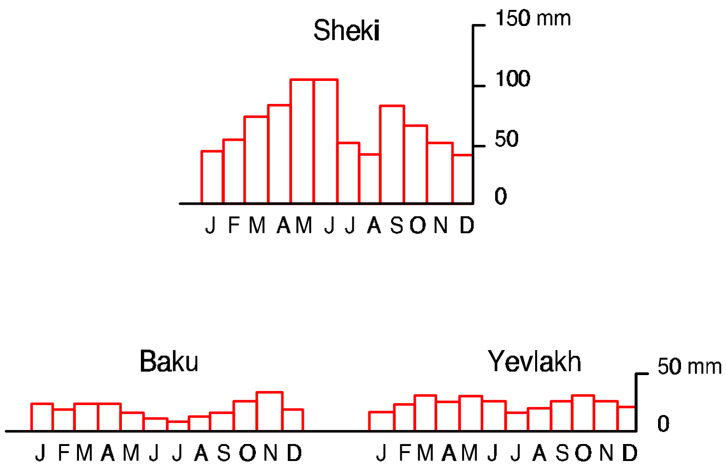
`

Table 1-2 Precipitation statistics for meteorological stations along the proposed (mm) (year given in brackets)

STATION	JANUARY			APRIL		
	MEAN	AVE. MAX.	AVE. MIN.	MEAN	AVE. MAX.	AVE. MIN.
Kurdamir	325	551 (1963)	195 (1947)			
Ganja	248	397 (1948)	150 (1932)			
Akstafa	359	567 (1915)	253 (1925)			

Figure 1-3 Mean annual precipitation map for Azerbaijan (Source: Agroclimate Atlas of Azerbaijan, 1993)

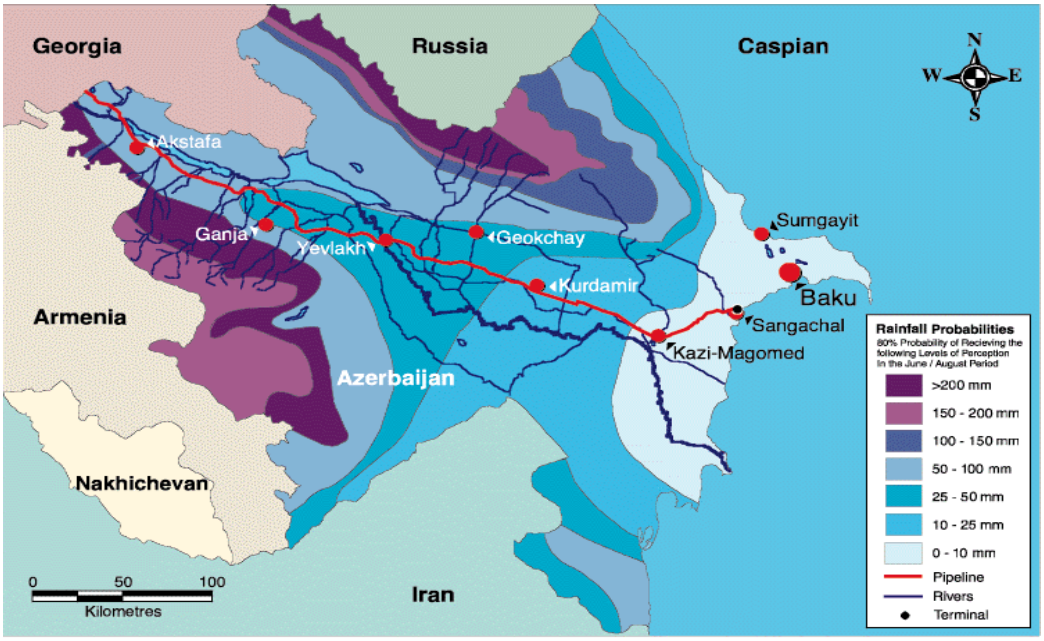
Figure 1-4 Monthly precipitation distribution for Baku, Yevlakh and Sheki



Hadiyev (1996) indicated that over the last 100 years, at selected sites in Trans-Caucasia, annual rainfall totals were decreasing, except over large cities. However, in a simple analysis of patterns over the last 60 years, done specifically for the EIA for the WREP, it has emerged that there has been a significant increase in annual rainfall in recent decades. The number of annual totals greater than 300mm tripled at both Baku and Ganja over the 28 year period between 1963 and 1990 compared with the previous 28 years. Similar precipitation increases have been found by Mumladze (1991) at Poti on the Georgian Black Sea coast.

Seasonal distribution of precipitation is not especially pronounced in the region, although there are subtle differences along the proposed pipeline corridor (see Table 1-2). Most of the precipitation falls between September and April. Figure 1-4 demonstrates that two seasonal peaks are evident, one in the March to May period, and a second in autumn/winter (October in Yevlakh, and December in Baku). The driest month is July throughout the proposed pipeline corridor, when the average rainfall is just 8mm in Baku (Darde, 1994), 2mm in Puta, and 32mm in Akstafa. Once again, however, year to year variability is high. For summer rainfall probabilities (June-August), there is a clear east/west gradient, west of Mingechaur, there is an 80% probability of receiving between 50 and 100mm precipitation, but this figure falls to less than 10mm in the Guzdek area (Figure 1-5). It is this relative security of summer rainfall supplies which helps to ensure the maintenance of the Karayazi wetland at the western end of the proposed pipeline corridor.

Figure 1-5 Rainfall probabilities in Azerbaijan for the June-August period



1.5.2 Rainfall event magnitudes and frequencies

Details of rainstorm frequencies are just as important as information on monthly averages, because large rainfalls can adversely affect pipeline construction working conditions. On average, rain falls on approximately 58 days a year in Baku, and 71 days in Kurdamir. The absolute maximum daily precipitation amounts received along the route vary from 65mm in Baku to 100mm in Kazi-Magomed, 97mm in Kurdamir, 77mm in Ganja, and 95mm in Akstafa. These extreme events occur mostly in summer, but they can also arrive in winter, especially near the coast. Eyubov (1996) states that such large daily rainfalls, in the 75 to 100mm range, may occur once every 100 years.

Precipitation is very often convective or frontal, when high-intensity rainfall results. While the local annual average numbers of daily rainfall events in excess of 30mm are not high (eg Alyat 0.3 per annum and Baku 0.2 per annum), they are probably more common in the mountains where flash floods are generated and transmitted downstream. Despite low annual precipitation receipts, intense rainstorms in such semi-arid environments have occurred, on average, every 2-4 years. Because of relatively large, steeply-sloping and poorly vegetated basins in the region, these events can lead to significant floods. These are associated with erosion and substantial sediment loads in the channel networks, which may be dry or at low flow for most of the year. This is especially true at the eastern end of the line. Mudflows may also be triggered by heavy rainstorms (see Volume 2, Part 7 in the Appendices check that this is still a valid cross-reference).

1.5.3 Snowfall and snowmelt

Precipitation occurs almost entirely as rain with only six days of snow per annum on average recorded at Baku and Kurdamir, increasing to 15-18 near the Georgian border. In Akstafa, for example, there is an 8% chance each winter of snow depth of between 60 and 200mm. However, heavy snow accumulations do occur in the Greater and Lesser Caucasus mountains every winter, which significantly affect the rivers crossed by the proposed pipeline route. The snows melt under strong, thermally driven ablation conditions each spring, and snowmelt can be augmented by rainstorms. Considerable quantities of meltwater can generate significant flooding downstream in the proposed pipeline corridor. For example, Figure 1-6 shows the relationship between the seasonal rise in air temperatures through the 0°C threshold, rainfall inputs, and the subsequent, relatively sudden, production of large river flows.

Figure 1-6 Seasonal variation in discharge in the Ganjachay River near Zurnobad (Western Azerbaijan) in relation to mean daily air temperature and daily precipitation

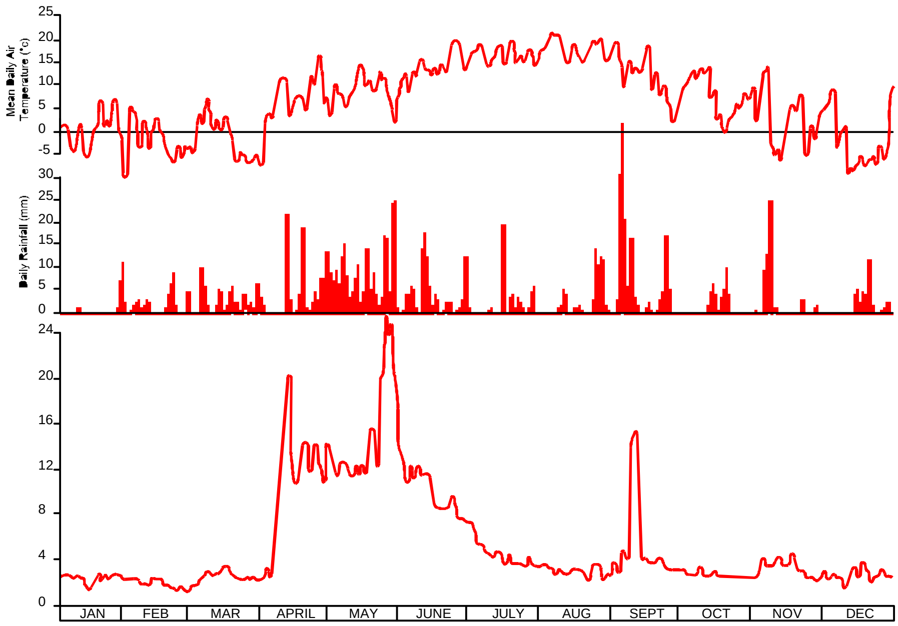


Figure 1-7 Average date of snow disappearance along the proposed pipeline

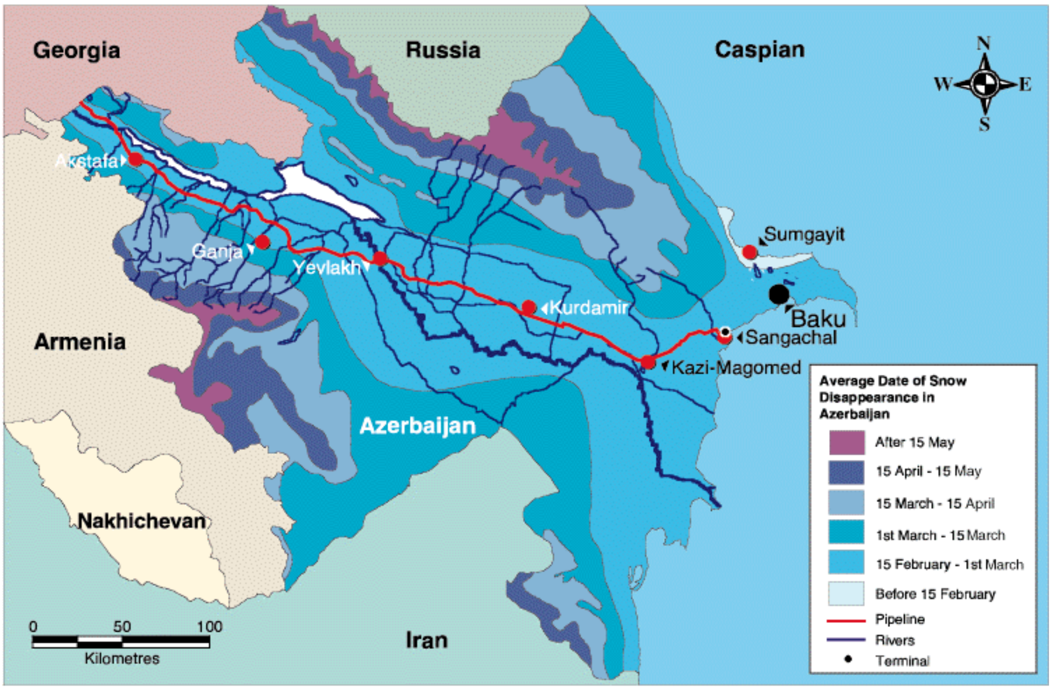
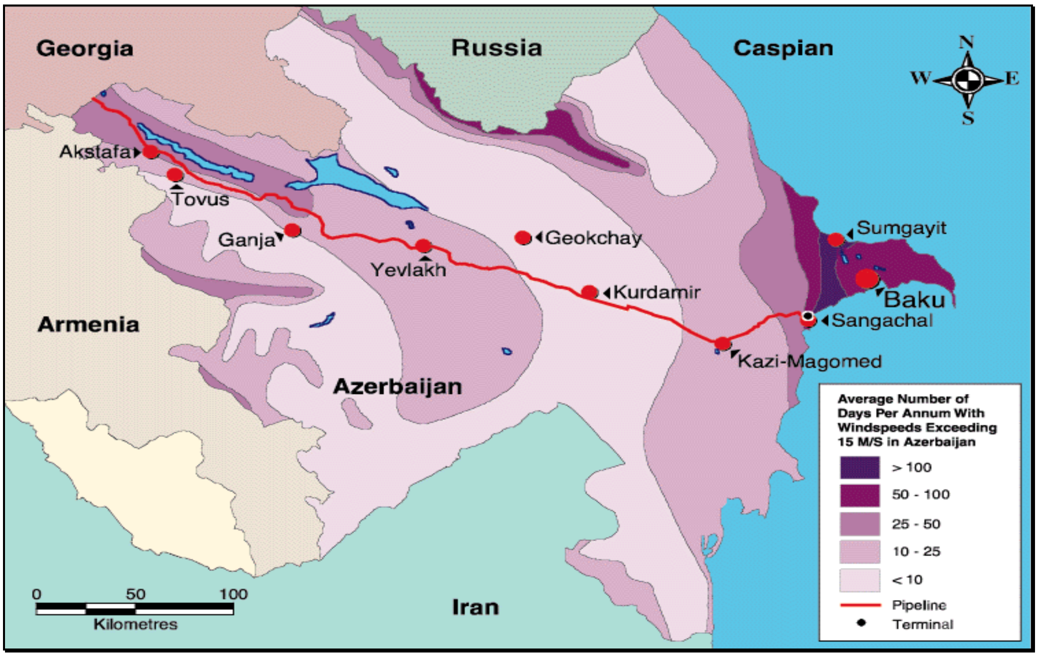


Figure 1-7 shows that snow has generally melted along the proposed pipeline corridor by the end of March. However, the isochrone map shows that snow usually persists in the mountain river source areas till the end of May/early June, and a risk of flooding downstream at proposed pipeline river crossings usually remains until late June. Most annual meltwater floods begin in March, peak in April or May, and are over by the end of June. Each specific basin has its own hydrometeorological controls and characteristics and it would be expected that snows on the south-facing slopes of the Greater Caucasus would melt slightly ahead of snowfields at the same altitude in the Lesser Caucasus, given the substantial aspect differences in net solar radiation receipts documented in the Caucasus by Borzenkova (1967, cited in Barry, 1992).

1.6 WIND SPEED AND DIRECTIONS

Mean annual wind speeds are very high near the eastern end of the proposed pipeline (6.7 m s^{-1} at Puta), decline toward the central part of the proposed corridor (2.3 m s^{-1} at Kurdamir), then rise again as the proposed pipeline begins to pass through the higher ground near the western end (3.3m s^{-1} at Ganja). Guzdek is located in the windiest part of Azerbaijan (see Figure 1-8). The increase in wind velocities relate to the relief and protrusion of the Apsheron peninsula into the Caspian, and Guzdek's location at the southern end of a north to south aligned topographic channel which funnels near-ground air flows, especially northerly airstreams. Puta experiences 114 days each year on average when wind speeds exceed 15m s^{-1}. This is more than seven times the number recorded at Kurdamir, and four times the frequency observed at Ganja. Stronger winds are especially common in August. Very high wind velocities (greater than 25m s^{-1}) also occur regularly throughout the Apsheron region. With wind erosion of the local dry and fine surface materials likely dust-storm events should be expected in the Guzdek area.

Figure 1-8 Average number of days per annum when windspeeds exceed 15 m s^{-1} in Azerbaijan



At the eastern end of the line, northerly, north-westerly and north-easterly winds dominate the directional regime (55% of the time), especially the strong north wind known locally as the "Hazri", which can, in winter, bring sudden reductions in temperature and occasionally snow. Southerly winds, called "Gilavar" may also be strong here. In central and western Azerbaijan, wind directions are dominated by easterly and westerly quadrants, reflecting the orientation of the enclosing Greater Caucasus and Lesser Caucasus mountain ranges. Westerly winds become increasingly common as one moves towards the Georgian border, especially in winter. Some katabatic winds from the mountains are also experienced (Eyubov, 1993b).

1.6.1 Dust storms

The eastern end of the proposed pipeline route is prone to much higher wind speeds than at the western end. This results in a high concentration of dust storms in this region. Typically, wind speeds of over 15m s^{-1} are recorded for 100 days or more annually.

HYDROLOGY AND WATER QUALITY

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1 HYDROLOGY AND WATER QUALITY

1.1 INTRODUCTION

The purpose of this report is to describe the baseline surface-water environments crossed or approached by the proposed pipeline route in Azerbaijan, and to identify key hydrological patterns, features, issues and areas. Water resources are especially valuable in this semi-arid part of Azerbaijan, and are intensively used for potable supplies, power generation, irrigation systems and livestock-watering. Water resources to be considered in the ESIA include major and minor river systems, reservoirs, wetlands and ecologically sensitive freshwater habitats.

The specific objectives of the report are to:

- Discuss the hydrological data-collection techniques employed in Azerbaijan and the quality and appropriateness of the information generated
- Identify the key hydrological and water resource features of the route
- Summarise the basic details and hydrological operation of the river systems in the vicinity of the pipeline corridor, including seasonality of processes
- Introduce information on river hydraulics and bank erosion problems
- Present information on water quality (both published and field data) for selected river systems
- Summarise details of known mudflows in this part of Azerbaijan

1.2 DATA SOURCES

This baseline report has been based on the following information sources:

- Literature Reviews by Azerbaijan scientists, including those of Professors Kashkay of the Institute of Geography at the Academy of Sciences in Baku and Professor Firdowsi Aliyev of the State Committee of Geology and Mineral Resources for the Azerbaijan Republic, produced in 1996, 1998 and 2000, and the State Committee of Geology (2001)
- Selected Azerbaijan Hydrometric Yearbooks
- Linewalk re-route information generated by AETC and ERM staff in 2000-2001
- Reconnaissance field data collected by D.M. Lawler on behalf of AIOC in November and December 1996
- Western Route Export Pipeline in Azerbaijan (WREPA) EIA, produced by AETC in April 1997
- Reports on Azerbaijan rivers, hazards, geomorphology and engineering and groundwater produced from 1998 - 2001, e.g. Fookes and Bettess (2000) and Banks (2001), made available by BP
- Published scientific papers on the hydrology of the Caucasus region (cited in References)

1.3 HYDROLOGICAL DATASETS AVAILABLE

A number of hydrological datasets exist in Azerbaijan, which are collected, maintained and processed by the State Committee for Hydrometeorology, the State Committee for Geology, and the Institutes of Geography and Geology at the Academy of Sciences in Baku. Hydrometric data have been collected for a number of the large river basins crossed by the pipeline route. Discharge values have been mainly computed from current meter observations on cableway systems. The long term records/datasets are believed to give a reasonably robust indication of average values.

1.4 LIMITATIONS OF THE DATA

The following limitations of the hydrological and hydrogeological datasets should be noted, because they have significant implications for the confidence that can be placed in the data and hydrological baseline established:

- Limited current data. The hydrometric network in Azerbaijan was severely curtailed after 1991/92, so few datasets exist for the last ten years. As such, quantification of current conditions is highly challenging. Early hydrological data, though useful, will not reflect subsequent climate variations, basin landuse changes, channel cross-sectional geometry shifts, canalisation projects, local river channel interference (e.g. gravel mining), new surface-water and groundwater abstractions, water resource development schemes and, for coastal stations, fluctuations in the level of the Caspian Sea
- Limited information on techniques. Generally, little information is readily available on the hydrological and monitoring techniques adopted, including sampling conditions, constraints, timing and frequency, analytical methods, precision limits and data collection problems, so it is difficult to place confidence limits on the published datasets
- Lack of route specific data. Flow measurement sites (river gauging stations) tend to be located in, or near the foot of, the Caucasus Mountains, mainly because this is considered to be the limit of significant runoff generation in these rivers. Therefore they are sometimes considerable distances upstream (or occasionally downstream) of the route. Some caution is warranted, therefore, in extrapolating data from the point of flow measurement to the pipeline crossing itself. Some rivers, as in many semi-arid environments, actually *lose* discharge in a downstream direction, because transmission, irrigation and abstraction losses outweigh runoff generation in the lower reaches
- Few data on extremes. The available data tends to be in the form of averages (means) and, though useful, provides limited information with respect to hydrological extremes (e.g. flood and drought magnitude and intensity)
- Limited published, peer-reviewed analyses. Little hydrological or hydrogeological data or analyses has been published for Azerbaijan in the international scientific literature

1.5 KEY HYDROLOGICAL FEATURES ON THE ROUTE

1.5.1 Introduction

The key hydrological features which the route crosses or approaches include:

- the main stem of the Kura River system, which runs close by, and parallel to, the pipeline in the western half of the route, and is crossed twice by it;
- Large Kura tributary rivers draining the Great Caucasus and Lesser Caucasus mountains
- Mingechaur Reservoir and dam
- Shamkir Reservoir and reserve
- Karayazi Wetland near the Georgian border
- Jandari Lake which straddles the Azeri-Georgian border
- Canal and pipe networks supplying drinking or irrigation water to villages and fields
- The dry Gobustan area in the east, including the channel of the Djerankechmes River

Linewalk data and the crossings list provided by the pipeline design team indicates that the route crosses 20 significant water courses between the Sangachal Terminal on the Caspian and the Azerbaijan/Georgian border (Table 1). In addition to the significant river systems the route crosses, a number of minor streams, numerous wadis and a variety of man made watercourses (canals, drainage ditches and irrigation systems) which are in various states of repair.

Table 1 River systems crossed by the proposed pipeline route

River	Crossing Point (Approx KP)	Key Characteristics at Crossing Point
Djerankechmes	9.3	Wide river bed with narrow stream flowing at time of survey. Sensitivity relates to overall species diversity within river system rather than aquatic fauna; many burrows were observed in banks. Bank stability is an issue due to the erodable nature of the bank materials and the level of vegetation. River flows highly seasonal (flow increases considerably during spring). Typically exhibits high sediment load
Pisgarat	42.1	Narrow canalised river with slow flow. High sediment load. Dredged within last 12 months.
Agsu Canal	111.2	Wide canalised river. High sediment load. Low apparent ecological sensitivity but has the potential to transport contaminants to more sensitive areas.
Geokchay	171.3	Narrow canalised river in deep cutting. Vegetation indicates wide fluctuations in water level. High sediment load. Diverse bank flora and bird life.
Turianchay	193.5	Incomplete survey because dense scrub precluded adequate access. Possible habitat for water voles.
Kura (east crossing)	223.6	Wide fast flowing river with extensive fishing and wildlife value. Reedbed downstream from crossing point is particularly valuable for birds. Given the high flow rate, the river has the potential to transport contaminants downstream rapidly.
Karabach Canal	245.1	Canalised river with marginal vegetation. Abstraction point for irrigation immediately upstream of crossing point. Low apparent ecological sensitivity but has the potential to transport contaminants to more sensitive areas
Goranchay	257.8	Small and dry (at the time of the survey)
Kurekchay	276.5	Wide braided channel – only narrow channels flowing. Mud cliffs have abundant holes. River well used by villagers for washing etc. Also used widely for watering livestock.
Korchay	292	Braided river with narrow flowing channels within extensive areas of marshy reedbeds. Ecologically diverse (habitat for terrapins and a wide range of birdlife). Also used widely for watering livestock.In the event of a spill, contaminant migration might be partially impeded by the reeds but could have significant local effects.Believed to have greater flow in Spring.
Ganjachay	296	Channel of variable width but negligible flow. Many burrows in cliffs. Dammed c.300m downstream from pipeline crossing point. It is probable that contaminant migration would be limited by the presence of the dam in the event of a pollution incident upstream of it,
Sarysu	316.1	Small stream with good species diversity.
Gashgarachay	316.7	Fast flowing with good species diversity. Also used widely for watering livestock.

Table 1 River systems crossed by the proposed pipeline route

River	Crossing Point (Approx KP)	Key Characteristics at Crossing Point
Karasu	320.9	Narrow watercourse within a wide channel, mainly vegetated by reeds Valuable bird habitat. In the event of a spill, contaminant migration might be partially impeded by the reeds but could have significant local effects
Shamkirchay	332	Wide but dry channel. Very low ecological value or sensitivity. The dry river bed has been extensively exploited for gravel extraction .
Zayamchay	357	Very low ecological sensitivity and almost no flowing channel.
Tovuzchay	377.1	Wide cobble river bed with narrow flowing channel. Main channel eutrophic. Flow may increase in spring and therefore introduce the risk of any pollution incident impacting downstream receptors.
Hasansu	397.8	Fast flowing clear 'mountain' stream. Ecological diverse and valuable habitat. Smallholding immediately downstream with livestock drinking from the river. Locals informed us that they regularly catch large trout in the river – thought to spawn locally. A pollution incident at the crossing point could have serious adverse impacts and could be carried considerable distance downstream.
Kura (west crossing)	411	Fast flowing and wide. Extensive fishing. Diverse birdlife (including Kingfishers). Wetland & islands used by birds just downstream from proposed crossing. Pollution incidents at the crossing point could lead to rapid migration of contaminants downstream.
Kuradera	422.3	Narrow flowing channel c. 0.1m deep at the time of the survey with sand/silt substrate. Cobbles/sand throughout dry portions of river bed. Sand cliffs downstream provide potential nesting habitat. Fly tipping including chemical bottles on bank. Karyazi wetland downstream increases sensitivity.

1.5.2 The Kura River

The route is dominated by the large Kura River system. The route crosses the Kura River twice. The lower, easterly crossing (Kura East) is near Yevlakh to the south-east of Mingechaur Reservoir (URS/Dames & Moore, 2000). It should be noted here that there are important sturgeon breeding areas downstream (Alekperov, 1983; Efendiyeva, 2000; Luk'yanenko *et al*., 1999). The westerly, crossing (Kura West) is at Polyu near the Georgian border, upstream of the important Shamkir and Mingechaur Reservoirs.

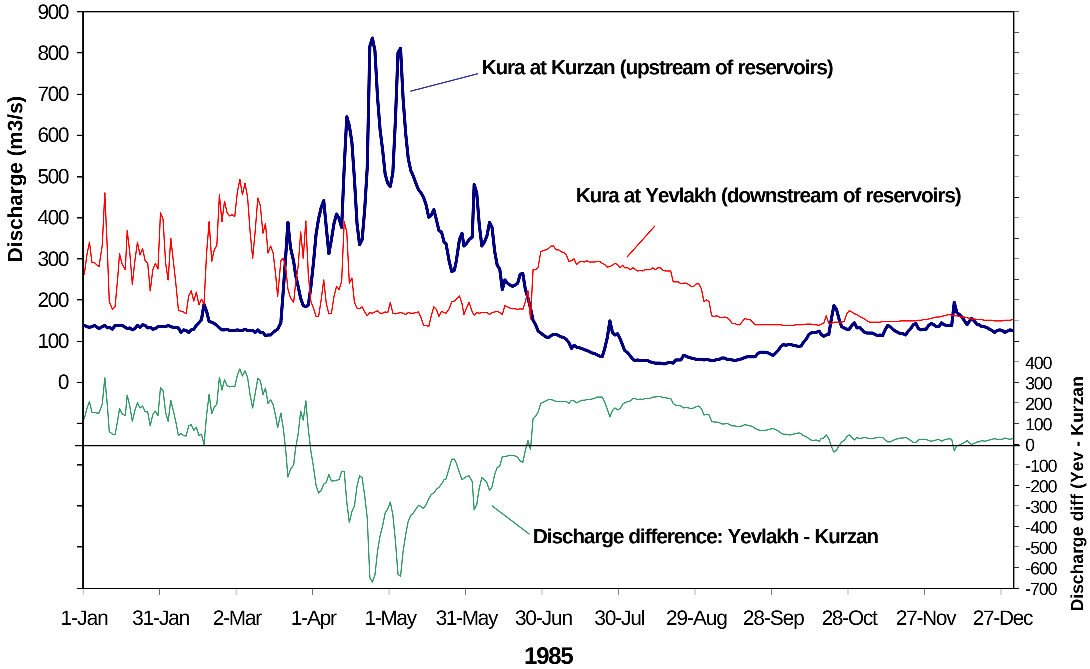
The Kura is the largest river system of the Caucasian region, originating in Turkey, then passing into Georgia before flowing into Azerbaijan near Polyu. Once in Azerbaijan, the Kura flows into Shamkir Reservoir and Mingechaur Reservoir, before crossing the Kura lowlands in the east and discharging into the Caspian. Its drainage basin area at Kurzan, near Polyu, is over 15000 km^2, and its mean annual discharge is 264 $m^3 s^{-1}$ (Table 2). Like its tributaries, the Kura has a strongly seasonal regime, with the main flow period concentrated between March and June, with a peak around the end of April (see Figure 1). This relates to the seasonal melting of snowpacks high up in the mountain runoff source areas of the Kura drainage basin in Turkey, Georgia and Azerbaijan.

Table 1a Hydrological and Hydraulic Information for the Main Rivers Crossed by the Proposed Pipeline Route (Figures in Brackets are Estimates)

River	Station	Average slope (m/m)	Minimum slope (m/m)	River discharge ($m^3\ s^{-1}$)			Stream power(W/m)	Estimated mean velocity ($m\ s^{-1}$)	Downstream Receptor	Receptor Distance from crossing (km)	Estimated average travel time (hours)	Estimated travel time in high flow** (hours)
				Mean annual	Maximum	Minimum						
Kura system in Azerbaijan												
Kura (u/s of Shamkir)	Kurzan	0.0034	0.000014	264	969	44.4	9.3	1.71	Shamkir Reservoir	7	1.1	1.0
Kura (d/s of Mingechaur)	Yevlakh	0.000831	N/A	313	1350	20	9.87	1.65	Sturgeon breeding grounds	200	33.7	27.8
Rivers of the Great Caucasus Southern Slopes												
Turianchay	Savalan	0.0205	0.00009	17.3	148	0.15	3497	0.28	Kura River	25	24.8	3.5
Geokchay	Geokchay	0.0175	0.00050	14.1	91	4.72	2433	0.55	Kura River	32.5	16.4	4.5
Girdemanchay	Garanour	0.0328	0.00200	7.7	(185)	1.36	2490	0.4	Karasu canal	1	0.7	0.1
Aksu	Aksu	0.0247	0.00170	1.96	(246)	(0.048)	477	0.4	Karasu canal	10	6.9	1.4
Pirsagat	Shosseyniy most	0.0682	0.01210	3.06	(287)	0.032	2058	0.29	Caspian Sea	32.5	31.1	4.5
Djeyrankechmes	Sangachal	0.0112	0.00371	0.16	(393)	0	18	N/A	Caspian Sea	16	N/A	2.2
Rivers of the Lesser Caucasus North-East slopes												
Akstafa	Krivoy Most	0.0210	0.00680	10.7	158	0.02	2216	N/A	N/A	N/A	N/A	N/A
Akhindjachay	Agdam	0.0236	0.01270	2.94	(47.6)	0.05	684	N/A	N/A	N/A	N/A	N/A
Tovuschay	Oysuzlu	0.0343	0.01410	0.91	31.4	0.01	308	0.3	Kura River	8.5	7.9	1.2
Dzegamchay	Yanihli	0.0210	0.01410	5.66	179	(0.090)	1172	1	Kura River	8	2.2	1.1
Shamkirchay	Barsum	0.0330	0.01400	8.56	(127)	0.95	2785	1.3	Kura River	10	2.1	1.4
Kushkarachay	Saritapa	0.0300	0.01390	1.35	(2.44)	0.49	399	0.63	Kura River	11	4.9	1.5
Ganjachay	Zurnabad	0.0277	0.01200	4.61	(95.5)	0.39	1259	0.8	Mingechaur	10	3.5	1.4
Kurakchay	Dozular	0.0245	0.00470	4.2	(168)	0.72	1015	0.66	Mingechaur	40	16.8	5.6
Goranchay	Agjakend	0.0380	0.00830	2.4	(45.2)	0.3	899	0.87	Mingechaur	27.5	8.8	3.8
** Assuming velocities in high-flow periods of $2\ m\ s^{-1}$ ($7.2\ km\ hr^{-1}$)												

The impact of water storage in the Mingechaur and Shamkir Reservoirs on the Kura flow regime is substantial. Note from Figure 1 that, despite similar *average* annual flows upstream and downstream of the reservoirs, the natural highly-peaked annual hydrograph of the Kura at Kurzan, upstream of the reservoirs, is strongly reduced at the outflow at Yevlakh. This is common in reservoired basins (e.g. Brandt, 2000). In contrast, low-flows in winter and summer are increased below the reservoirs (Figure 1). By smoothing out the strong seasonality in the Kura discharges, much more stable flows are achieved below the reservoir for irrigation purposes. Much river sediment is trapped in Mingechaur Reservoir also (Selivanov, 1996), and ERM (2000) have flagged up possible implications for dam failure due to loss of storage capacity and loading of the dam structure.

Figure 1 Impact of substantial flow regulation by the Mingechaur Reservoir on discharge peaks and seasonality of the Kura River: mean daily flow hydrographs for 1985 for Kurzan (upstream of Mingechaur and Shamkir reservoir) compared to Yevlakh (downstream of Mingechaur and Shamkir Reservoir)



1.5.3 Main Kura tributaries crossed by the route

Many of the Kura tributaries are high-energy mountain rivers, a number of which are laterally mobile within floodplain zones or incised into narrow gorges. The tributary rivers vary in mainstem length from the shortest, Tovuzchay (42km), to the longest, Turianchay (180km).

The rivers of the eastern half of the route flow south-west from the Great Caucasus. The Turianchay river is the most powerful. Most Great Caucasus rivers have floods generated both by snowmelt in spring/early summer and by rainstorms in the autumn. Rainstorm-generated floods can last up to 15 days.

In the west, the rivers generally flow in a north-easterly direction from the Lesser Caucasus mountains. Their regimes are dominated by the spring/early summer snowmelt flow period.

1.5.4 The Djeyrankechmes River

The Djeyrankechmes is a 20m wide wadi, which is often dry, incised into the Gobustan desert, flowing through the Gobustan Cultural Reserve for approximately 1km south of the pipeline crossing point. It is independent of the Kura River system and drains directly into the Caspian at Sangachal, approximately 9km downstream of the proposed pipeline crossing point. The river channel exhibits poor bank stability and is liable to flash flooding during periods of heavy rain. During periods of flow, it has a high sediment load.

1.5.5 Karayazi wetland

The route will pass close to the valuable Karayazi Wetland area between Polyu and the Georgian border. In this area at the western end of the corridor, there is an 80% probability of receiving between 50 and 100 mm precipitation during the summer months. It is this relative security of summer rainfall supplies which helps to ensure the viability of the wetland.

A site visit on 30 November 1996 confirmed that the groundwater table was at, or very near, the ground surface in the Karayazi Wetland, and standing water was visible. The wetland is, however, highly fragmented and heavily encroached upon by viticulture, drainage channels, pasture land and the main Baku-Tbilisi railway line.

Simple measurements of turbidity, pH and electrical conductivity on 30 November 1996 confirmed that Karayazi Wetland pool water was clear (turbidity 2.36 NTU), alkaline (pH 7.82) and not highly mineralised (electrical conductivity: 665 µS cm^{-1}). No contemporary hydrological or hydrogeological monitoring is thought to be going on in the area, but a 1:100,000 scale hydrogeological survey of the area was carried out in the late 1980s by the State Committee of Geology.

1.5.6 Canals

Numerous canals are crossed by the pipeline, particularly between Kurdamir and Yevlakh, where they are used extensively for irrigation purposes. Many of these are in disrepair. The main canal crossed by the pipeline is the Karabakh Canal (KP 245). The Karabakh Canal, which recharges from the Kura River at the Mingechevir Reservoir (Figure 2) carries significant amounts of water for many important uses including irrigation and industrial supply.

Figure 2 Karabakh canal

1.6 EAST-WEST HYDROLOGICAL DIFFERENCES ALONG THE ROUTE

Clear hydrological, fluvial and climatic differences can be identified along the pipeline route from east to west, from the Caspian Sea to the Georgian border, as follows:

- Average annual precipitation increases threefold from 150 to 500 mm per annum
- In the west, the climate becomes marginally cooler and less windy with lower potential evapotranspiration rates, as route altitudes rise to above 300 mamsl (metres above mean sea level)
- River flow seasonality becomes slightly more pronounced in the extreme west
- With one or two exceptions, there is a tendency for the seasonal flow peak to arrive earlier in the west (May rather than June)
- River suspended sediment concentration, turbidity, pH and TDS values tend to decrease towards the west

On the basis of these changes, four distinct regions along the route are identifiable:

- At its easterly end between Sangachal and Pirsagat, the route passes through very dry territory where average annual rainfall is less than 200 mm. The region is characterised by a number of semi-arid channel systems. These include two main rivers (the incised Djeyrankechmes and Pirsagat) and many ravines, gullies and wadis which carry flow for only a small part of the year but may experience flash floods. Transmission losses (through bed leakage and evaporation) are normally substantial in such rivers. The region is used as an over-wintering area for cattle, and small artificial reservoirs can also be found. These reservoirs and small, saline lakes contain water after rainstorms in autumn. Little intensive agriculture is practised. Water resources here are the scarcest in Azerbaijan, and the Djeyrankechmes basin delivers an average water yield of just $1.0 ls^{-1}km^{-2}$, decreasing to zero near the coast.
- Further inland, the line traverses the broad, flat, less arid Kura River lowland where the pipeline is largely isolated from the surrounding mountains (and their associated hazards) by a large alluvial plain. The route crosses four left-bank tributaries of the Kura River which are sourced in the Great Caucasus.
- Further west still, after crossing the Kura near Yevlakh, the route passes through the Ganja-Kazakh Plain. It runs alongside the Shamkir reservoir, and crosses seven sizeable, high-energy, right-bank tributaries of the Kura River which originate from the north-east slopes of the Lesser Caucasus mountains.
- Finally, the route re-crosses the Kura at Polyu and passes along the edge of the important Karayazi Wetland before crossing into Georgia.

The Great Caucasus, left-bank, tributaries of the Kura tend to generate higher average, maximum and minimum river discharges at the gauging stations, despite lower precipitation totals on the pipeline route itself. The annual average and extreme flows for the easterly rivers Turianchay, Geokchay, Girdemanchay, Aksu and Pirsagat typically exceed the westerly, Lesser Caucasus, rivers (see Table 2). This is partly because the mountain source areas for the easterly rivers tend to receive slightly higher precipitation inputs. It should be noted that flow data are lacking for many pipeline crossing locations and it is likely that, on the route itself, the westerly, Lesser Caucasus, rivers are more powerful. This underscores the need to analyse river systems in their drainage basin contexts, as well as at site- or reach-specific locations near pipeline crossing points.

1.7 SURFACE-WATER RUNOFF SYSTEMS

1.7.1 Hydroclimatic conditions

The climate of central and western Azerbaijan varies from semi-desert at the eastern end of the pipeline corridor to more humid and continental conditions near the Georgian border (see Part 9 of the Baseline Reports). Average annual precipitation increases from approximately 150 mm near Guzdek in the east to around 500 mm in the Karayazi Wetland near the Georgian border. Mean annual potential evapotranspiration rates are very high all along the pipeline route: in the April - October period (the main evapotranspiration season), rates exceed 800 mm in eastern Azerbaijan and 600 mm in the west (Eyubov, 1993). These rates are far greater than rainfall inputs for the corresponding areas.

High evapotranspiration rates have several hydrological and geomorphological implications:

- Significant problems of soil salinisation in many places
- Creation of substantial water resource shortages and the need for irrigation systems to support intensive agriculture. Irrigation systems designed to replenish evaporated and transpired soil moisture to sustain agricultural activity are extensive in the central parts of the corridor (Wolfson and Daniell, 1995). Irrigation may be seasonal: for example, water is used to irrigate maize in August and September;
- Generation of semi-arid hydrological systems and landscapes, with sparse vegetation cover and severe soil erosion and gullying problems related to intense rainstorms, fine erodible soils, little vegetative protection and flash flooding, especially in the eastern part of the route
- River runoff which decreases with distance from the mountain source areas. River discharges, after first increasing within the headwater zone, often then reduce downstream. This trend is exacerbated by increasing abstraction and irrigation in lowland agricultural areas and by transmission losses through permeable gravel river beds

Figure 3 Relief map of central Azerbaijan

River runoff is generated mainly by spring/early summer snowmelt in the Caucasus mountains and by rainstorms, especially in autumn. Many of the tributary rivers crossed by the route are sourced at high altitude (1900 - 3680 m) in either the Great Caucasus (Kura left-bank tributaries in the east) or the Lesser Caucasus (Kura right-bank tributaries in the west) (see Table 3 and Figure 3). Average annual precipitation totals rise to approximately 1000 mm per annum in the Great Caucasus and to around 800 mm per annum in the Lesser Caucasus. At high altitudes, much precipitation principally arrives in the form of snow.

Despite low annual precipitation receipts, intense rainstorms occur, on average, every two to four years. Because of relatively large, steeply-sloping and poorly vegetated basins in the region, these rainstorms can result in significant floods downstream. High flows tend to lead to bank erosion and increased sediment loads in the channel networks (which may be dry or at low flow for much of the year). This is especially true at the drier, eastern end of the line.

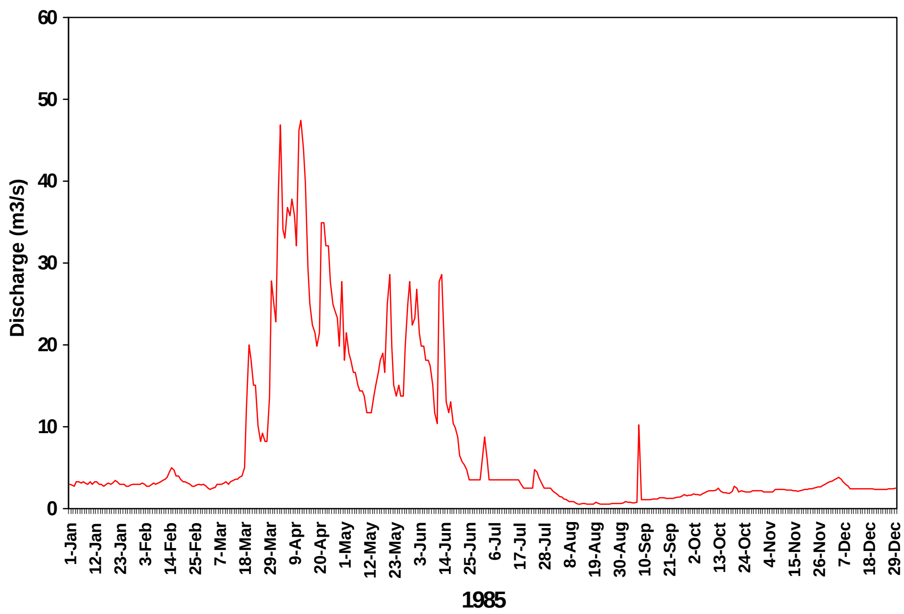
Table 2 Basic hydrological data for the main drainage basins crossed by the proposed pipeline route

River	Station	Length of record (years)	Station altitude (m)	Distance from confluence (km)	Length of river (km)	Source height (m)
Kura system in Azerbaijan						
Kura	Kurzan	20	149.3	739	1364	2,770
Kura	Yevlakh	42	5.23	566	1364	2,770
Rivers of the Great Caucasus Southern Slopes						
Turianchay	Savalan	53	118	106	180	3,680
Geokchay	Geokchay	47	89	37	115	1,980
Girdemanchay	Garanour	29	751.5	50	88	2,900
Aksu	Aksu	26	N/A	48	85	2,100
Pirsagat	Shosseyni y most	14	N/A	144	119	2,400
Djeyrankechmes	Sangachal	N/A	-28	1	88	N/A
Rivers of the Lesser Caucasus North-East slopes						
Akstafa	Krivoy Most	28	527.12	42	133	3,000
Akhindjachay	Agdam	33	529.6	30	76	1,950
Tovuschay	Oysuzlu	9	554.47	7	42	1,900
Dzegamchay	Yanihli	N/A	641.52	37	90	2,020
Shamkirchay	Barsum	53	688.73	42	95	3,220
Kushkarachay	Saritapa	25	N/A	32	76	2,360
Ganjachay	Zurnabad	60	872.48	58	99	2,814
Kurakchay	Dozular	49	617.64	87	126	3,100
Goranchay	Agjakend	51	1210.5	60	81	3,100

1.7.2 Snowmelt influence on river flows

Little snow falls on the pipeline route itself. There is an average of only 6 days of snow per annum at Baku and Kurdamir, for example, increasing to 15 - 18 near the Georgian border. However, heavy snowpacks do accumulate in the Great and Lesser Caucasus in winter which affect the rivers sourced in those zones and which are crossed by the pipeline. Ablation of the snowfields occurs in the spring as radiation receipts and air temperatures rise, and this is assisted by rainstorms. The considerable quantities of liberated meltwater can then generate significant flooding downstream. The clear dominance of the spring/early summer melt-season high-flow period can be seen for the Akstafachay River (which flows into the Kura River close to the Kura West crossing, but is not crossed by the pipeline route) in Figure 4. The striking relation between spring river flow peaks and the seasonal rise in air temperatures through the 0^{o}C ablation threshold and sporadic rainfall inputs can be seen for the Ganjachay in Figure 5.

Figure 4 Annual river flow hydrograph for Akstafachay, 1985



Although any snow disappears from the pipeline corridor at the end of March, snowpacks persist in the mountain river source areas until the end of May/early June (see Figure 6). A risk of flooding at pipeline river crossings can remain until late June. The annual meltwater flow increase lasts 2-3 months, generally beginning in March, peaking in April or May, and finishing by the end of June. However, each specific basin has its own key hydrometeorological controls and characteristics, including slope aspect. Snow on the south-facing slopes of the Great Caucasus should melt slightly ahead of snowfields at the same altitude in the north-east facing slopes of the Lesser Caucasus, given the substantial differences slope aspects these cause in net radiation receipts in the region (Borzenkova, 1967; cited in Barry, 1992).

Figure 5 Annual hydrograph for the Ganjachay River. Note the relationship between the seasonal rise in air temperatures through the 0 °C threshold, rainfall inputs and the strongly seasonal generation of river flows

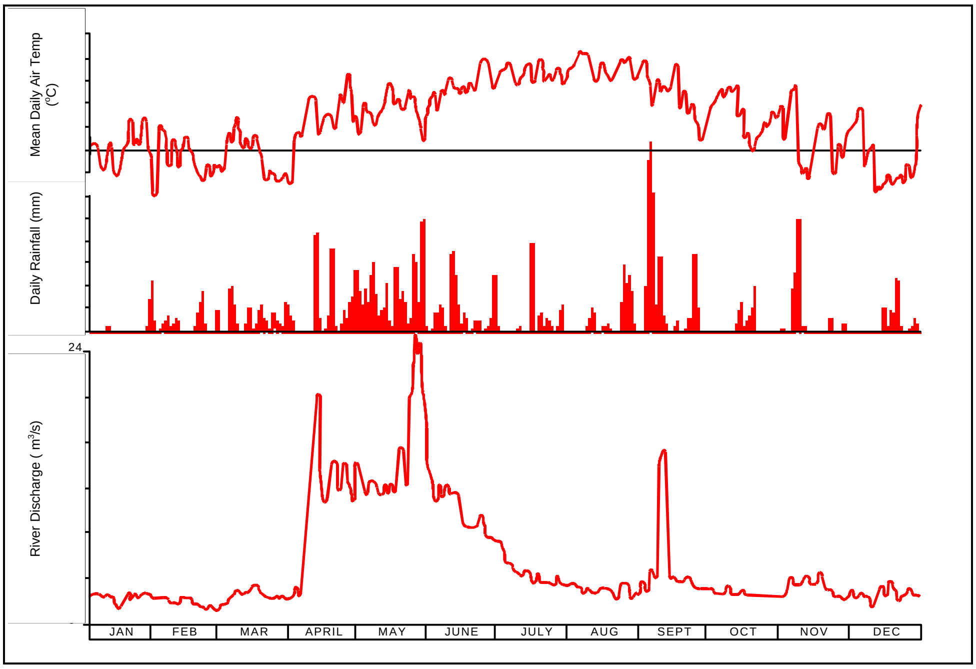
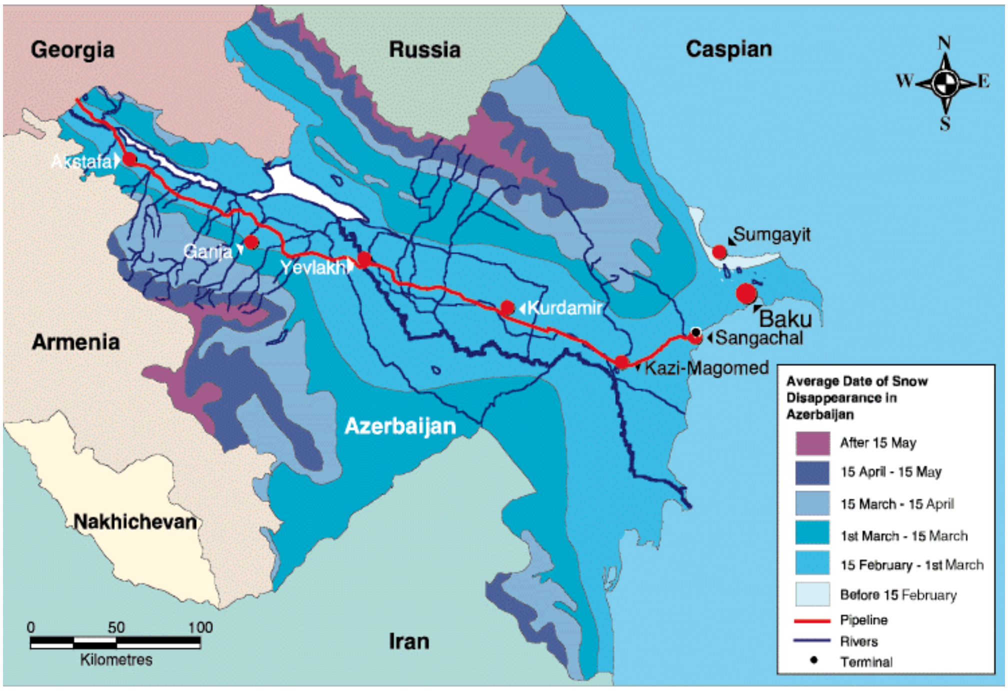


Figure 6 Map showing the average dates of snow disappearance across Azerbaijan (Eyubov, 1993)

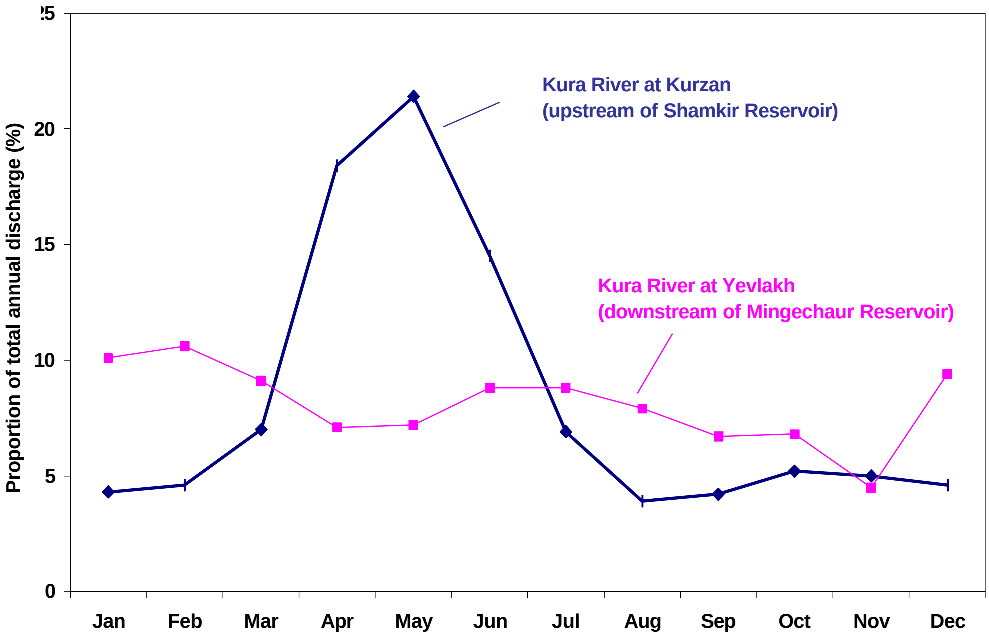


1.7.3 River flow seasonality

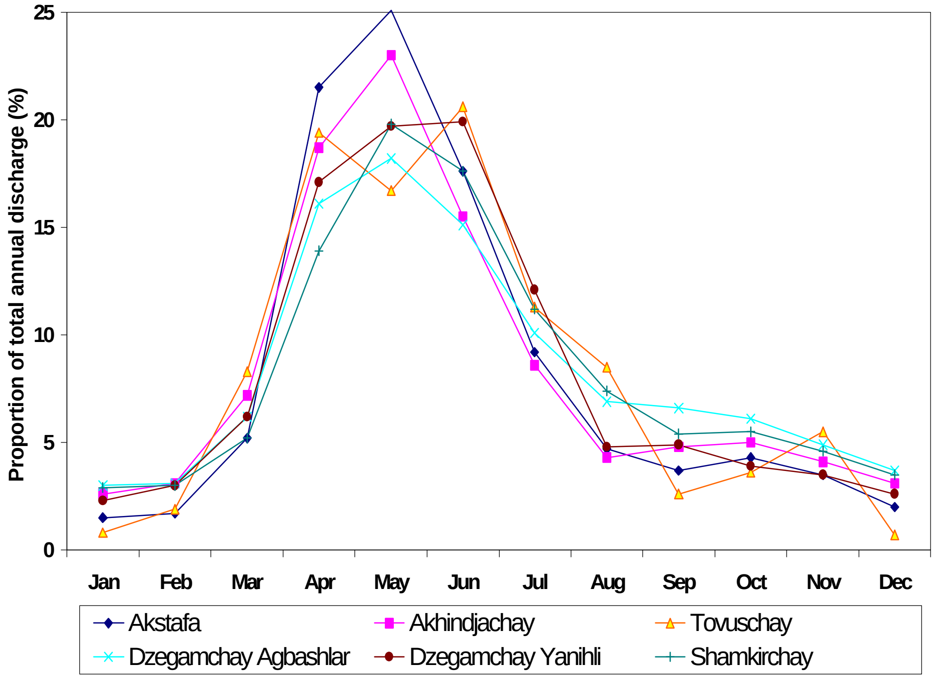
All rivers crossed by the route have highly seasonal regimes. Peak flows typically occur between April and June on average, with the low-flow period from September to February (see Figure 7). Around March and April, significant mountain snowmelt and rainfall begins to increase discharges for most rivers, and peak flows are reached in May or June (see Figure 7). Around 15-25% of total annual flow takes place in May alone (see Table 4). For half of the rivers, more than 50% of total annual discharge occurs in a three-month period, April - June (see Table 4).

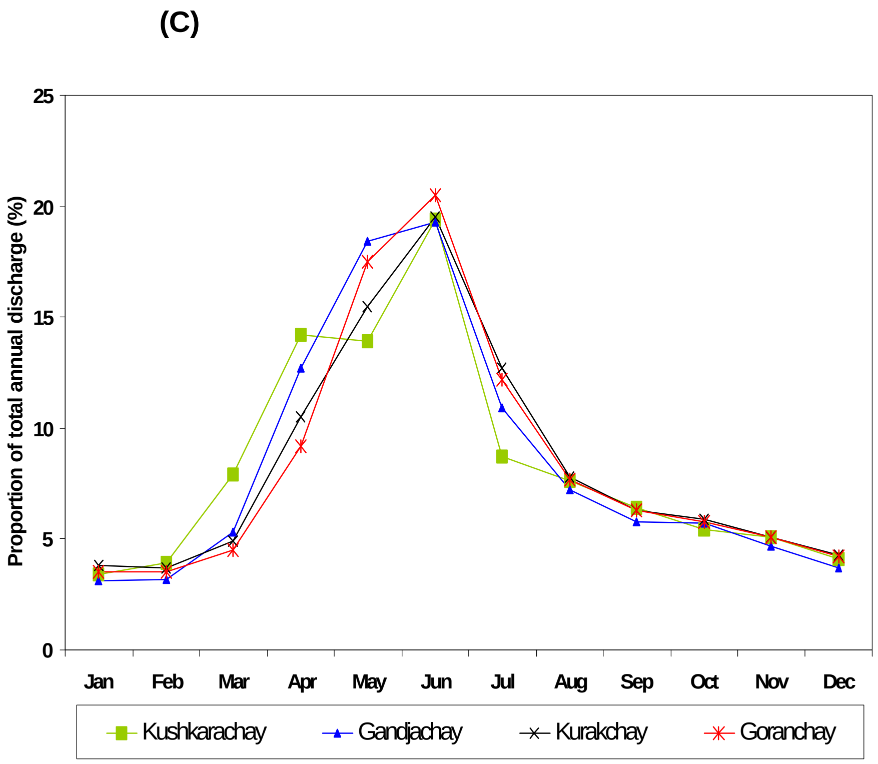
Apart from the Aksu and Girdemanchay rivers in the east (which peak in April), there is a tendency for the month of peak flow to shift from May to June as one moves east (see Figure 7). This is probably because most easterly rivers are sourced at higher altitudes in the Great Caucasus mountains, at around 3000 m (the Djeyrankechmes, at 800 m, is an exception). Snowmelt onset is delayed until May or June in these high altitude basins, in contrast to April/May for the Lesser Caucasus catchments in the west. The easterly rivers also tend to have a subsidiary flow peak in the September - October period, driven by autumn rainfall receipts.

(A)


Kura River at Kurzan
(upstream of Shamkir Reservoir)
Kura River at Yevlakh
(downstream of Mingechaur Reservoir)
Proportion of total annual discharge (%)
0
5
10
15
20
25
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

(B)


Proportion of total annual discharge (%)
0
5
10
15
20
25
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Akstafa
Akhindjachay
Tovuschay
Dzegamchay Agbashlar
Dzegamchay Yanihli
Shamkirchay



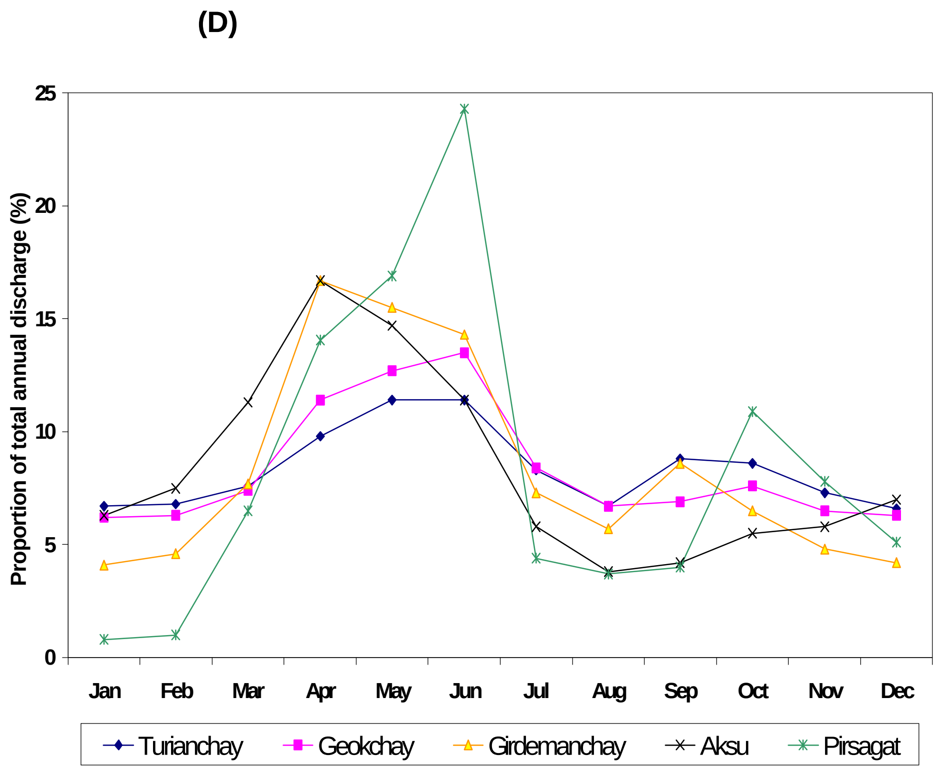


Figure 7 Seasonal distribution of flows for the main rivers crossed by the route: (A) Kura River at Kurzan and Yevlakh; (B) westerly Rivers of the Lesser Caucasus; (C) west-central Rivers of the Lesser Caucasus; (D) Rivers of the Great Caucasus.

Table 2 Average monthly distribution of river discharges (%), showing high flow seasonality

River	Station	Months													Proportion of flow in April – June (%)
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL	
Kura system in Azerbaijan															
Kura	Kurzan	4.3	4.6	7.0	18.4	21.4	14.5	6.9	3.9	4.2	5.2	5.0	4.6	100.0	54.3
Kura	Yevlakh	10.1	10.6	9.1	7.1	7.2	8.8	8.8	7.9	6.7	6.8	4.5	9.4	97.0	23.1
Rivers of the Great Caucasus Southern Slopes															
Turianchay	Savalan	6.7	6.8	7.6	9.8	11.4	11.4	8.3	6.7	8.8	8.6	7.3	6.6	100.0	32.6
Geokchay	Geokchay	6.2	6.3	7.4	11.4	12.7	13.5	8.4	6.7	6.9	7.6	6.5	6.3	99.9	37.6
Girdemanchay	Garanour	4.1	4.6	7.7	16.7	15.5	14.3	7.3	5.7	8.6	6.5	4.8	4.2	100.0	46.5
Aksu	Aksu	6.3	7.5	11.3	16.7	14.7	11.4	5.8	3.8	4.2	5.5	5.8	7.0	100.0	42.8
Pirsagat	Shosseyni y most	0.8	1.0	6.5	14.1	16.9	24.3	4.4	3.7	4.0	10.9	7.8	5.1	99.5	55.3
Rivers of the Lesser Caucasus North-East slopes															
Westerly rivers															
Akstafa	Krivoy Most	1.5	1.7	5.2	21.5	25.1	17.6	9.2	4.7	3.7	4.3	3.5	2.0	100.0	64.2
Akhindjachay	Agdam	2.6	3.1	7.2	18.7	23.0	15.5	8.6	4.3	4.8	5.0	4.1	3.1	100.0	57.2
Tovuschay	Oysuzlu	0.8	1.9	8.3	19.4	16.7	20.6	11.3	8.5	2.6	3.6	5.5	0.7	99.9	56.7
Dzegamchay	Agbashlar	3.0	3.1	6.2	16.1	18.2	15.1	10.1	6.9	6.6	6.1	4.9	3.7	100.0	49.4
Dzegamchay	Yanihli	2.3	3.0	6.2	17.1	19.7	19.9	12.1	4.8	4.9	3.9	3.5	2.6	100.0	56.7
Shamkirchay	Barsum	2.9	3.0	5.2	13.9	19.8	17.6	11.2	7.4	5.4	5.5	4.6	3.5	100.0	51.3
West-central rivers															
Kushkarachay	Saritapa	3.4	3.9	7.9	14.2	13.9	19.4	8.7	7.6	6.4	5.4	5.1	4.1	100.0	47.5
Gandjachay	Zurnabad	3.1	3.2	5.3	12.7	18.4	19.3	10.9	7.2	5.8	5.7	4.7	3.7	100.0	50.4
Kurakchay	Dozular	3.8	3.7	4.9	10.5	15.5	19.5	12.7	7.8	6.3	5.9	5.1	4.3	100.0	45.5
Goranchay	Agjakend	3.5	3.5	4.5	9.2	17.5	20.5	12.2	7.7	6.3	5.8	5.1	4.2	100.0	47.2

Table 3 Mean monthly suspended sediment concentration (SSC, mg l^{-1}), load (SSL, kg s^{-1}) and discharge (Q, m^3s^{-1}) for selected rivers crossed by the route

River and Gauging Station	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average annual
Turianchay at Savalan	SSL	0.1	0.5	3.5	85.5	147	133	61	17	79.5	79	6.8	2.5	51.3
	Q	12.3	12.6	13.9	18.5	23.8	22.6	13.4	12.5	18	19.9	15.2	13.4	16.4
	SSC	8	40	152	4629	6177	5850	3729	1365	4419	4404	447	186	3128
Geokchay at Geokchay	SSL	0.55	5.97	8	92.2	184	179	46.1	33.2	35.6	78.7	13.6	4.4	56.8
	Q	7.97	8.2	11	17	21.1	17.3	9.85	6.95	8.28	14.4	10.9	8.68	11.8
	SSC	70	729	726	5250	8730	10330	4670	4780	4300	5460	1246	507	4810
Girdemanchay at Kululu	SSL	0.12	0.55	1.76	11.7	70.4	37.3	0.78	1.82	0.6	1.76	0.042	0.068	10.6
	Q	0.84	0.9	1.31	3.75	8.03	4.99	1.08	0.6	0.3	1.69	0.32	0.48	2.03
	SSC	143	612	1312	3119	8760	7560	722	3036	2000	1041	131	142	5220
Aksu at Aksu	SSL	1.1	1.8	10	7.8	8.8	6.9	3.55	1.25	2.2	2.4	2.8	1.5	4.17
	Q	1.33	1.53	2.53	3.48	3.78	1.92	1.37	0.91	1.14	1.74	1.84	1.42	1.92
	SSC	827	11.76	3952	2241	2329	3594	2591	1365	1930	1380	1521	1056	2172
Pirsagat	SSL	0.1	0.9	2.46	2.18	5.51	0.66	0.6	0.004	0.6	0.2	0.057	0.03	1.11
	Q	0.62	1.42	2.99	2.8	2.62	1.66	0.85	0.18	0.53	1.45	1.35	0.57	1.42
	SSC	161	633	823	779	2100	397	705	22	1030	138	42	53	768
Akstafachay at Krivoy Most (Crooked Bridge)	SSL	0.05	0.1	0.85	13.8	18.8	7.8	2.1	0.8	0.35	0.55	0.38	0.12	3.82
	Q	2.12	2.51	6.03	23	26.2	17.3	9.28	5.92	4.13	5.03	4.26	2.7	9.04
	SSC	24	40	141	602	718	450	232	135	85	109	89	44	423
Akhindjachay at Agdam	SSL	0.005	0.012	0.24	0.46	0.65	1.95	0.14	0.008	0.004	0.012	0.002	0.002	0.3
	Q	1.29	1.95	4.22	7.92	10	8.92	2.86	0.62	0.7	0.93	0.7	0.28	3.36
	SSC	3.9	6.2	57	58	65	219	49	13	5.7	13	2.9	7.2	89
Tovuschay at Oysuzlu	SSL	0.002	0.017	0.027	0.02	0.038	0.095	0.09	0	0.001	0.003	0	0	0.024
	Q	0.21	0.7	0.84	1.45	1.54	1.2	0.64	0.091	0.89	0.19	0.16	0.084	0.6
	SSC	9.9	24	32	14	25	79	141	0	11	16	0	0	40
Dzegamchay at Yanihli	SSL	0.019	0.016	0.14	0.65	1.64	2.36	1.24	0.38	0.072	0.025	0.025	0.041	0.58
	Q	1.33	1.43	3.51	9.43	8.57	8.01	6.87	3.71	2.26	2.15	2.15	1.49	4.33
	SSC	14	11	40	69	191	295	180	102	32	12	12	27	134

Table 3 Mean monthly suspended sediment concentration (SSC, mg l^{-1}), load (SSL, kg s^{-1}) and discharge (Q, m^3s^{-1}) for selected rivers crossed by the route

River and Gauging Station	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average annual
Shamkirchay at Barsum	SSL	0.15	0.15	0.52	7.55	19	16.5	8.35	4.55	0.37	0.4	0.2	0.1	4.84
	Q	3.02	3.12	5.51	14.5	20.4	18.4	11.6	7.41	5.6	5.82	4.92	3.68	8.66
	SSC	50	48	58	521	932	897	720	614	66	69	41	27	560
Koshkarchay at Dashkesan	SSL	0.002	0.004	0.046	0.19	0.16	0.14	0.11	0.031	0.009	0.006	0.003	0.001	0.058
	Q	0.34	0.36	0.81	1.78	1.17	2	1.11	0.36	0.28	0.46	0.5	0.31	0.78
	SSC	5.9	11	57	107	137	70	99	86	32	13	6	3.2	75
Ganjachay at Zurnabad	SSL	0.01	0.01	0.05	0.6	1.55	1.19	0.48	0.34	0.23	0.33	0.05	0.02	0.4
	Q	1.49	1.6	2.4	6.49	9.39	9.82	5.77	3.58	2.84	3.53	2.34	1.78	4.25
	SSC	7	6	21	93	165	121	83	95	81	94	21	11	94
Kurakchay at Dozular	SSL	0.05	0.05	0.06	1.12	2.6	4.25	3.35	0.55	0.25	0.17	0.1	0.06	1.22
	Q	1.69	1.62	2.02	4.91	7.12	9.17	6.36	3.74	2.96	2.72	2.29	1.96	3.88
	SSC													
Goranchay at Agdjakend	SSL	0.01	0.02	0.01	0.08	0.23	0.3	0.16	0.06	0.04	0.04	0.03	0.02	0.08
	Q	0.86	1.12	0.98	2.15	4.2	5.01	3.34	1.96	1.57	1.49	1.28	1.04	2.08
	SSC	12	18	10	37	55	60	48	31	26	27	24	19	39

1.7.4 Hydrological extremes

Hydrological extremes (flood/drought intensity/frequency/duration) are probably more important than flow averages when assessing pipeline security and environmental impacts. Therefore, Values for flow minima and maxima are shown in Table 2. Substantial flows have been recorded at some time for most rivers. Once again, the data suggest that the easterly, Great Caucasus, rivers have produced the region's highest discharges. The extreme flow events of $246m^3s^{-1}$, $287m^3s^{-1}$ and $393m^3s^{-1}$ estimated respectively for Aksu, Pirsagat and Djeyrankechmes (Table 2) probably represent flash floods produced as a result of infrequent but intense rainstorms within the catchment area.

For flow minima there is no clear east-west spatial patterning, although the two rivers sourced at high altitude in the Great Caucasus (Geokchay and Girdemanchay) have reliable flows which have never dropped below $4.7m^3s^{-1}$ or $1.3m^3s^{-1}$ respectively (Table 2). Discharges of the Pirsagat and Djeyrankechmes rivers, in the dry easterly zone, can decrease to zero in summer.

1.8 RIVER HYDRAULICS

1.8.1 Introduction

Information on river hydraulic conditions, such as velocity, stream power, shear stress and energy slope information, is important in pipeline EIAs and subsequent pipeline construction, hydrotesting and operation. This is especially true in the following impact areas:

- River channel instability issues at river crossings, including bank erosion, bed scour, bedload transport and suspended sediment fluxes, which might threaten the integrity of pipeline or supporting structures, and influence location, design and management of river crossings (see Part 7 of the Baseline Reports)
- Direct fluid abrasion or corrosion effects on exposed pipelines, sleeving materials or supporting structures at river crossing sites
- Estimates of time-of-travel and dispersal patterns for contaminants introduced into rivers. Typical pollutants include fuel, lubrication oil or wastewater leakages from pipeline construction plant or pumping station operations, as well as crude oil spillages arising loss of integrity of pipelines
- Freshwater ecohydrology, especially hydraulic conditions vital to habitats and populations of invertebrates, fish and aquatic flora, via their influence on organism stress levels, dissolved oxygen concentrations, sediment-flushing processes, suspended sediment concentrations and light penetration in the water column
- Formulation of Emergency Response Plans and Oil Spill Response Plans, including boom design

1.8.2 Hydraulic data and pilot desk studies

For any rigorous channel stability analysis for the purposes of estimating setback distances or burial depths at pipeline crossings, strong, quantitative, datasets on river hydraulics, fluvial processes, sediment transport conditions and boundary material characteristics, collected at key sites during high-flow conditions, would be required.

Few meaningful hydraulic data of a suitable type, however, collected during key periods at appropriate river locations, are readily available in Azerbaijan. However, basic flow information is available for the gauging stations on the main rivers crossed by the route (see Table 2). Note that these stations may be some distance upstream (and occasionally downstream) of pipeline crossings and they may not fully reflect conditions at the crossing points.

River gradients on the mountain rivers are steep, ranging up to 0.034 (Table 2). Table 2 shows that channel slopes in the vicinity of the pipeline are generally higher for the Lesser Caucasus rivers in the west. This means that, despite rough gravel beds and relatively shallow depths, flow velocities are generally likely to be substantial at higher flows. The achievable velocities are probably sufficient to mobilise the gravel bed material and to create potential channel instability. Gross stream power values have also been calculated in Table 2 according to the formula:

$$\Omega = \rho g Q S \qquad (1)$$

where Ω is gross stream power per unit length of channel (Wm^{-1}), ρ is water density ($1000kgm^{-3}$), g is gravitational acceleration ($9.81ms^{-2}$), Q is discharge (m^3s^{-1}) and S is channel slope (mm^{-1}), normally the water-surface slope, but technically the energy slope. Stream power is an energy measure increasingly used as a more sensitive estimate of a river's ability to perform erosive work, and is often used to help estimate channel instability and sediment transport. Average stream powers here are high by global standards, reflecting the high discharges and slopes of their montane character.

1.8.3 Time-of-travel for contaminant releases in rivers

Accidental release of contaminants into a river or other water resource is a possibility during construction or operation of an oil pipeline. In the case of the proposed route, the potential release scenarios include:

- Spillages of construction or operation plant fuel, diesel, lubrication oil
- Discharge of oily effluent from cooling water blow-down, engine/parts wash-down
- Discharge of wastewater and rainwater from containment areas and AGIs
- Oil spillages during a pipeline breach

An important question, therefore, is how long after introduction into a river would a contaminant take to propagate downstream to other systems or sensitive sites such as public water supplies, reservoirs, ecologically valuable wetlands, coastal habitats or aquifers. Such information is useful as an input to an Environmental Management Plan or Oil Spill Response Plan. For the proposed pipeline route, the key potential downstream receptors for contaminants include the watercourses themselves, the Shamkir Reservoir, the Mingechaur Reservoir, the Karayazi Wetland, various aquifers, water abstraction points, agricultural lands and settlements.

The velocity data of Table 2 can be used to simply estimate approximate travel times for introduced crude, lubrication oil or fuel slugs (although they do not account for behavioural/density differences between fuel/oil and water, or seasonal changes in flow). It is clear that, especially under high-flow conditions in late spring/early summer (April-June), oil introduced at the upper Kura near Kurzan is likely to reach Shamkir Reservoir (7 km downstream) in around 1 hour (see Table 2). Similarly, any spillage directly into one of the right-bank, Lesser Caucasus tributaries would tend to reach the main Kura River in less than 6 hours. A spill into Ganjachay, 10 km from Mingechaur Reservoir, could reach the reservoir in less than 4 hours.

Clearly, plume migration times will vary with river flow conditions. In the early-summer flow peak, river discharges and velocities will be higher and plume migration speeds increased. Under low-flow conditions (September - February), however, velocities will be much lower and travel times much longer, but less dilution of the injected pollutant will take place and contaminant concentrations may therefore be higher. This means that ecologically undesirable effects may also be highly significant at low flow conditions, though they are more likely to be more localised at these times.

The simple scenarios provided above may be useful when designing crossings, timetabling refurbishment tasks to avoid high-flow periods when velocities and dispersion potentials are maximised, planning protection measures, and establishing environmental management plans and emergency response plans.

1.9 RIVER CHANNEL INSTABILITY

1.9.1 Introduction

Many of the fluvial systems examined near or on the route are active, dynamic and meandering or braided, especially in the west where the pipeline approaches the foothills of the Lesser Caucasus (see Part 7 of the Baseline Reports). Such braided systems are normally characterised by large channel width-depth ratios, high energy flows, high bedload transport rates, a quickly-responding discharge regime (i.e. one prone to flash floods) and active lateral channel instability. Braided systems tend to occur on steeply-sloping valley floors, where large quantities of coarse sediment are frequently mobilised to build the braid bars, and copious but variable flows are available to reorganise the bed materials frequently and erode the banks relatively effectively. The steep slopes and seasonally concentrated meltwater regimes of the Azerbaijan rivers generate exactly these high-energy conditions. Necessary sediment supplies appear to be generated by mountain landslides, gullying, bank erosion, deformation of upstream channels, and occasional mudflows and sheetwash events.

On field examination, river bed gravels appear fresh, with limited algal growth, and are likely to be mobile during parts of the high-flow season, March - June. Bank materials are relatively fine-grained in the lowland river reaches, but are coarser in the mountain rivers, especially in the west. Anthropogenic disturbance of bed fabrics through gravel extraction is important in some rivers (eg Shamkirchay), and may have the potential to impact pipelines in the area.

The timing at which highly seasonal river systems are inspected in the field is crucial. It is easy to form the impression of limited activity if these rivers are visited in the autumn and winter low-flow season, when only one or two small divided channels, if any, are occupied by water. The linewalk visits between September and October 1996, and the December 1996 and August 2000 water quality monitoring site visits, for example, found many watercourses to be dry or at low-flow. To appreciate fully the power of the rivers crossed by the route, it is necessary to visit during the March - June period when river flows are rising or peaking.

1.9.2 Indicators of channel dynamism along the route

Dynamic channels result from the interaction of high river energy levels with erodible boundary materials. Strong indicators of channel dynamism are apparent in the major Kura tributaries crossed by the pipeline, especially in the west. These indicators include:

- Velocities and stream power levels high enough to set typical bed materials in motion (see Table 2), especially during the early summer melt season
- The evidence of sparse vegetation on the braid bars, and an absence of algae on the gravel bed material (normally indicating recent particle transport);
- Extensive and severe bank erosion at many of the sites visited, including around existing pipelines and structures;

- Data over recent decades showing high suspended sediment concentrations and loads (see Table 5).

1.9.3 Bank and bed erosion

Bank erosion problems should always be viewed in a drainage basin context, because:

river flows responsible for erosion are generated by ablation of snowpacks or precipitation falls in upstream headwater zones;
(a) coarse sediments derived from *upstream* alter *local* cross-section geometry, thereby changing velocity, shear stress fields, bed scour and bank erosion rates near pipelines; and
(b) instability zones can migrate downstream over pipeline engineering design timescales.

Linewalks have revealed widespread lateral channel activity along the proposed pipeline route, indicating regional-scale instability. Bank erosion scars are quite numerous, and affect many crossings. The Azerbaijan authorities have already implemented bank protection schemes in some areas. These protection schemes indicate indicates awareness by the authorities of previous problems. Some rivers (eg Aksu and Girdemanchay in the east) have been canalised for long stretches to stabilise flows and reduce erosion problems.

Little evidence of severe and widespread bed scour was found during the linewalk, but this is to be expected in braided rivers which are classically dominated by lateral, not vertical, activity.

1.10 RIVER WATER QUALITY

1.10.1 Introduction

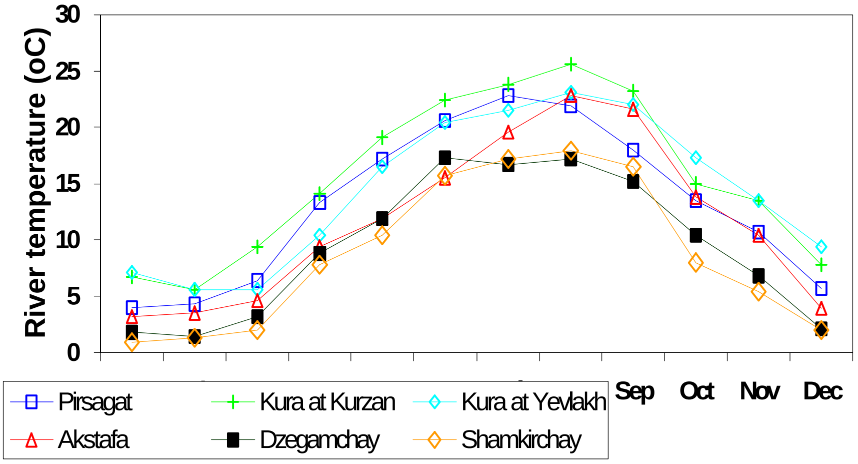
Data on water quality of the rivers and other hydrological features crossed or approached is important in a pipeline EIA for the following reasons:

- High suspended sediment concentrations or bedload discharges can lead to problems of in-channel abrasion of pipelines, sleeves or other structures if positioned directly in the river
- High levels of suspended sediment transport can be indicative of more general problems of upstream soil erosion, land degradation, channel or hillslope instability. Such problems have the potential to propagate downstream and impact on pipeline stability;
- River water is often used for pipeline hydrotesting purposes, and there may be quality requirements involved;
- Water quality data provide baseline information when considering the disposal and behaviour of effluents arising during construction, hydrostatic testing or subsequent operation of the pipeline or AGIs. This includes complex binding of contaminants to suspended sediment (e.g. Horowitz, 1991) and changing behaviour of fuel or other pollutants in waters of different temperature, suspended sediment concentration, viscosity, chemistry or pH;
- Water quality influences habitat quality, especially freshwater species diversity and abundance and Azerbaijan water bodies have important freshwater biota.

1.10.2 Water temperatures

River temperatures vary seasonally from around 2-7°C in winter to 17-25°C in the summer months (see Figure 8). Warmest river temperatures are in August, except for Pirsagat which peaks in July (see Figure 8). Lowest river water temperatures are attained between December and March, with minima in January or February (see Figure 8). The published mean early-winter values are consistent with direct field measurements of the temperature of selected river systems made in November and December 1996. River temperatures have strong freshwater ecological implications, and also affect behaviour of contaminant plumes.

Figure 8 Monthly river temperatures for selected rivers crossed by the route, 1985



1.10.3 Suspended sediment transport

1.10.3.1 Suspended sediment concentrations

Simple mean monthly water quality data for recent decades on suspended sediment concentration and total dissolved solids concentration (Kashkay 1996; 2000) for the rivers crossed by the proposed pipeline route are summarised in (Table 5). The longer-term mean datasets can underestimate total and mean loads, depending on the nature of sampling and calculation, but they can usefully augment data from hydrograph dynamics in such temporally variable systems. Average suspended sediment concentrations will vary considerably with river and season, and they will also fluctuate at the event timescale, but no data are available with respect to such conditions. It should, however, be noted that flood-peak suspended sediment concentrations can typically be many orders of magnitude higher than mean values.

Average concentrations and loads are high by world standards, and approximate those of other glacial/snowmelt rivers. Annual mean suspended sediment concentrations for the Great Caucasus rivers exceed by an order of magnitude those for the Lesser Caucasus systems. The rivers Girdemanchay (5,220 mg l-1) and Geokchay (4,810 mg l-1), both of which drain from the Great Caucasus, have the highest annual mean values (see Table 5). Girdemanchay (8,760 mg l-1; May) and Geokchay (10,330 mg l-1; June) also achieve the maximum monthly values of all rivers reported. Suspended sediment transport is highly seasonal, and for most rivers highest suspended sediment concentrations occur around the month of the highest flow between March and June, with a secondary peak in autumn (see Table 5).

1.10.3.2 Suspended sediment loads

The Great Caucasus rivers also boast the higher suspended sediment loads (i.e. mass flux per unit time). Geokchay again emerges with the highest sediment fluxes and, during May, it exports from its catchment an average of 184 kg s^{-1} of sediment (see Table 5). Turianchay, Geokchay and Girdemanchay are right at the heart of the region of dynamic left bank Kura tributaries which drain the vigorously eroding Great Caucasus Mountains.

High sediment transport rates relate to high soil erosion rates driven by steep slopes, intense rainstorms, highly seasonal snowmelt-driven flows, flash floods, likely freeze-thaw processes in the mountain zones, fine erodible soils and limited vegetation cover. In fact, the rivers of the Great Caucasus carry more suspended sediment than almost any other region in the FSU (Bobrovitskaya, 1996). Erodible soils are a particular issue. For example, Kuznetsov et al. (1998) found that for pre-mountain cinnamonic steppe-like soils, chestnut soils and light-chestnut soils on the surface of the south-eastern slope of the Great Caucasus, average scouring velocities required for a flow 2 cm deep varied from 0.20 - 0.24 m s-1. Erosion scars are visible in many places on the existing WREPA ROW (URS/Dames & Moore, 2000), e.g. rivers Korchay and Shamkirchay. High soil erosion and sediment transport problems are likely to emerge as a key issue in pipeline engineering and integrity in Azerbaijan (URS/Dames & Moore, 2000). Soils are easily eroded once vegetation is removed and surface sediments disturbed (e.g. during pipeline or AGI construction).

Mingechaur Reservoir was built in 1953 but has rapidly silted up (capacity in 1953 = 16 km^3; 1982 = 14.5 km^3) with accumulation of suspended sediment. The reservoir removes around 70% of the sediment discharge from the Kura river (Selivanov, 1996).

1.10.4 Total dissolved solids (tds) concentrations

The few data from Kashkay (1996) on TDS levels in rivers crossed by the WREPA route are relevant to the proposed pipeline route and are presented in Table 6. Sampling, analytical and calculation methodologies are unknown, however. TDS values tend to be higher for the easterly, Great Caucasus, rivers, where average TDS concentrations range from 274 - 1812 mg l^{-1} (see Table 6). This may reflect slower runoff in the lowland reaches and therefore greater solute acquisition opportunities (Trudgill, 1996), and contributions from solute-rich agricultural runoff. There is also a switch as one moves east from hydrocarbonate and carbonate river hydrochemistry in the west to a sulphate-dominated chemistry in easterly rivers. This may reflect increased geothermal contributions in the east (see Table 6). This is clearly shown for the Djeyrankechmes river, where the few analyses available indicate that SO_4^{2-} dominates the chemistry, accounting for between 40% and 56% of the total dissolved solids. Next dominant amongst the anions is HCO_3^- and, occasionally, Cl^- (Kashkay, 1996). The cationic proportions are reported as follows: $Ca^{2+} > Na^+ > K^+ > Mg^{2+}$.

Table 4 Total dissolved solids (TDS) concentrations in Azerbaijan Rivers (from Kashkay, 1996)

River	Average TDS Concentration mg L^{-1}	Minimum TDS Concentration mg L^{-1}	Maximum TDS Concentration mg L^{-1}	Hydro-chemical type	Dominant Cation
Lesser Caucasus Rivers	198 – 313	200	500	Hydrocarbonate	Ca or Na+K
Great Caucasus Rivers					
Turianchay	466	351	685	Carbonate	Ca
Geokchay	274			Hydrocarbonate	NA
Girdemanchay	563	510	1110	Sulphate	NA
Pirsagat	*N/A*	410	1278	Sulphate-Sodium	NA
Djeyrankechmes	1812			Sulphate	Ca

N/A = Data not available

1.10.5 Field reconnaissance survey data

A brief water quality measurement and sampling reconnaissance exercise was undertaken for selected rivers on the route on 30 November 1996 and 1 December 1996. This work was undertaken to obtain unique and/or up-to-date information on turbidity, water temperature, pH and electrical conductivity values for selected rivers and the key wetland zone crossed by the pipeline route at a time when almost all rivers were flowing (though at low flow). electrical conductivity (EC) can be used as a surrogate measure of total dissolved solids concentration. Seven sample sites were selected, in two spatial clusters. The first cluster included sites from Tovuschay westwards, and incorporated the upper Kura crossing and the Karayazi wetland (see Figure 9). The second cluster was a group of rivers east of the Mingechaur Reservoir, and included the lower Kura crossing near Yevlakh and the two river systems with the highest suspended sediment fluxes - the Geokchay and Turianchay.

Instruments used included a fully temperature-compensated RS Components Temperature and Conductivity Meter (RS 180-7127) and a temperature-compensated RS 610-540 pH meter, reading to an accuracy of 0.03 pH units. Turbidity values (in Nephelometric Turbidity Units, NTU) were determined in the field on 15-ml subsamples to an accuracy of +/- 2% using a Hach 2100P Turbidimeter. Samples were drawn from surface stream water at the channel edge. It is stressed that these values probably underestimate mean suspended sediment concentrations because concentrations tend to increase towards the bed in all but the most turbulent rivers. As is normal, all water quality measurements must be considered to be representative only of conditions at that time of sampling, especially in such highly temporally variable river systems as those crossed by the pipeline route.

Figure 9 Karayazi wetland region

Results for the 1996 survey are presented in Table 7. River temperatures were moderate, and varied from 9.7 to 12.7 °C. (cf. the published means plotted in Figure 8). All river waters were alkaline, with pH values between 7.82 and 8.20, and easterly rivers showed a tendency for higher pH values (see Table 7). These values are consistent with a limestone-dominated geology in the mountain source areas. Buffering ability for pollution is fairly good. Turbidity values were generally low (the Kura at Polyu was found to be very clear), consistent with the low-flow conditions sampled. However, turbidity increased towards the east and, confirming the average suspended sediment concentration data, the highest values were found for Turianchay, Geokchay and Girdemanchay.

A second water quality reconnaissance survey of river pH, electrical conductivity, nitrite and nitrate was undertaken by ERM (2000) in August 2000, and the pH and EC values have been added to Table 7. These later values are broadly consistent with the 1996 results of the reconnaissance survey.

1.10.6 River water contaminants

Only limited data is available with respect to baseline pollutant levels in the Azerbaijan water sources crossed or approached by the proposed pipeline route. However, many water bodies in neighbouring Caucasus and FSU republics suffer from significant problems with highly persistent pesticides (e.g. DDT; Richardson, 1998), nutrients and eutrophication (e.g. Hovhanissian and Gabrielyan, 2000), heavy metals, hydrocarbon contamination, and toxic defoliants used in the production of cotton. It is likely therefore that at least some water resources in Azerbaijan will be affected by measurable concentrations of these pollutants. Aliev (1995) considers the waters of the Kura River downstream of Mingechaur Reservoir to be polluted by heavy metals beyond the normal standards, and only usable for irrigation and industrial activities.

The results of water quality analyses conducted during the baseline assessment of the proposed pipeline route during 2001 are presented in Tables 8, 9 and 10 below.

Table 5 Results of reconnaissance water quality surveys of selected rivers and water bodies in Azerbaijan crossed by the route: (A) survey of 30 November and 1 December 1996; (B) survey of August 2000 by ERM (2000)

River/water body	Site location	Date	Local time	Temperature (°C)	Electrical Conductivity (us cm^{-1})	pH	Turbidity (NTU)
(A) Water quality survey: November/December 1996, west-east order							
Karayazay	Wetland pool	30-Nov-96	14:40	10.7	665	7.82	2.4
Kura	Polyu	30-Nov-96	16:40	10.9	646	7.98	5.8
Tovuzchay	Road bridge	30-Nov-96	17:49	10.8	1368	8.03	2.4
Kura	Yevlakh	1-Dec-96	10:33	12.7	630	8.12	14.7
Turianchay	Lyaki	1-Dec-96	11:45	10.0	660	8.16	72.1
Geokchay	Uzhary	1-Dec-96	12:30	10.5	609	8.20	62.7
Aksu	Karrar	1-Dec-96	16:50	12.0	4080	8.15	560.0
(B) Water quality survey, August 2000, west-east order							
Kura	Nr Akstafa	August 2000	N/A	N/A	750	8.4	N/A
Hassan Su	?	August 2000	N/A	N/A	800	8.4	N/A
Tauz	(main)?	August 2000	N/A	N/A	970	8.4	N/A
Karasu	?	August 2000	N/A	N/A	1960	8.2	N/A
Gushgara	?	August 2000	N/A	N/A	1300	8.2	N/A
Ganja	?	August 2000	N/A	N/A	1610	8.2	N/A
Karabach canal	?	August 2000	N/A	N/A	980	7.9	N/A
Kura	Nr Yevlakh	August 2000	N/A	N/A	740	8.6	N/A
Girdiman	?	August 2000	N/A	N/A	558	8.3	N/A
Pirsagat	?	August 2000	N/A	N/A	1710	8.1	N/A

Table 6 Results of 2001 Water Quality Survey of Selected Waterbodies Along the Pipeline Route - Metals

Water Source	Approximate KP	Date Sampled	Metals (mg/L)						
			Barium	Calcium	Chromium	Copper	Manganese	Nickel	Lead
NATURAL WATERBODIES									
Kura River	South of 82	20-Nov-01	0.046	140	0.009	0.020	0.310	0.025	0.030
Kura River	223	13-Nov-01	0.037	80	0.008	0.013	0.031	0.018	<0.01
Kura River	227	13-Nov-01	0.048	NA	0.005	0.008	0.028	0.010	0.012
Kura River	410	15-Nov-01	0.066	NA	0.007	0.078	0.081	< 0.005	0.019
Kura River	310	14-Nov-01	0.059	120	0.005	0.065	0.070	0.009	<0.01
River adjacent to former WREP camp	410	15-Nov-01	0.085	NA	0.005	0.009	0.017	0.008	0.025
Lake 4 km to NE of route	440	15-Nov-01	0.034	NA	< 0.005	0.007	0.021	0.005	<0.01
ARTIFICIAL WATERBODIES									
Irrigation canal 2 km S of Mugan	63	11-Nov-01	0.036	NA	0.012	0.013	0.120	0.028	0.025
Local irrigation canal	129	19-Nov-01	0.056	NA	0.005	0.011	0.049	< 0.005	<0.01
Local irrigation channel	176	19-Nov-01	0.064	NA	0.040	0.014	0.180	0.036	0.011
Irrigation canal	200	20-Nov-01	0.037	NA	0.005	0.010	0.100	0.018	0.020
Main canal in Yevlak	227	13-Nov-01	0.035	NA	0.006	0.005	0.036	0.056	0.012
Local irrigation canal	227	13-Nov-01	0.033	NA	0.006	0.006	0.071	0.010	<0.01
Irrigation canal to the north of Gandja	298	12-Nov-01	0.012	NA	0.005	0.015	0.019	< 0.005	0.013
Irrigation channels	298	14-Nov-01	0.039	NA	< 0.005	0.005	0.013	0.013	<0.01
Local irrigation channels	440	15-Nov-01	0.040	NA	< 0.005	0.006	0.029	0.011	0.017
Chohranli settlement (irrigation canal)	124	19-Nov-01	0.061	NA	0.005	0.010	0.010	0.014	<0.01
Agsu Canal	111	20-Nov-01	0.027	1900	0.010	0.021	0.040	0.007	0.031
Upper Karabakh Canal	244	13-Nov-01	0.047	100	0.006	0.055	0.013	0.006	0.085

Notes:

NA Not analysed

All samples were also analysed for Arsenic, Cadmium and Mercury, however these metals were not found to be present at concentrations in excess of the laboratory's detection limits (0.005mg/L, 0.001mg/L and 0/0002mg/L respectively)

Table 7 Results of 2001 Water Quality Survey of Selected Waterbodies Along the Pipeline Route - Bacteriological Parameters

Water Source	Approximate KP	Date Sampled	Coliforms (Yes/No)	E. Coli (Yes/No)	Sulphate-reducing bacteria (CFU/mL)	Anaerobic bacteria (MPN/mL)	Heterotrophic bacteria (MPN/mL)
NATURAL WATERBODIES							
Kura River	South of 82	20-Nov-01	Y	N	25	2.4E+06	2.7E+04
Kura River	223	13-Nov-01	Y	N	5.9	1.9E+06	9.4E+04
Kura River	227	13-Nov-01	Y	Y	NA	NA	NA
Kura River	410	15-Nov-01	Y	Y	NA	NA	NA
Kura River	310	14-Nov-01	Y	N	0.36	1.9E+06	5.2E+04
River adjacent to former WREP camp	410	15-Nov-01	Y	Y	NA	NA	NA
Lake 4 km to NE of route	440	15-Nov-01	Y	Y	NA	NA	NA
ARTIFICIAL WATERBODIES							
Irrigation canal 2 km S of Mugan	63	11-Nov-01	Y	N	NA	NA	NA
Local irrigation canal	129	19-Nov-01	Y	Y	NA	NA	NA
Local irrigation channel	176	19-Nov-01	Y	Y	NA	NA	NA
Irrigation canal	200	20-Nov-01	Y	Y	NA	NA	NA
Main canal in Yevlak	227	13-Nov-01	Y	Y	NA	NA	NA
Local irrigation canal	227	13-Nov-01	Y	Y	NA	NA	NA
Irrigation canal to the north of Gandja	298	12-Nov-01	Y	N	NA	NA	NA
Irrigation channels	298	14-Nov-01	Y	Y	NA	NA	NA
Local irrigation channels	440	15-Nov-01	Y	Y	NA	NA	NA
Chohranli settlement (irrigation canal)	124	19-Nov-01	Y	Y	NA	NA	NA
Agsu Canal	111	20-Nov-01	Y	Y	180	1.7E+06	2.4E+06
Upper Karabakh Canal	244	13-Nov-01	Y	N	6.9	2.4E+06	3.0E+05

Notes:
NA - Not analysed

Table 8 Table 1-2 Results of 2001 Water Quality Survey of Selected Waterbodies Along the Pipeline Route - Other Analytes and Parameters

Water Source	Approximate KP	Date Sampled	Chemical Oxygen Demand	Temperature	Electrical Conductivity	Dissolved oxygen	pH	Salinity	Turbidity	Chlorine demand	5 Day Biological Oxygen Demand (BOD-5) (max)	Sulphate	Chloride	Ammonia	Bicarbonate	Hardness (as Ca)
			mg/L	°C	mS/cm	mg/L	-	%	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
NATURAL WATERBODIES																
Kura River	South of 82	20-Nov-01	110	12.1	0.09	9.6	7.3	0.04	139	1.8	0.63	190	51	0.4	220	110
Kura River	223	13-Nov-01	200	16.6	0.64	9.1	7.9	0.02	14	1.8	0.68	130	110	0.3	110	85
Kura River (1)	227	13-Nov-01	170	16.6	0.64	9.0	7.8	0.02	14	NA	NA	NA	NA	NA	NA	NA
Kura River (1)	410	15-Nov-01	230	12.8	0.67	10.3	7.7	0.02	24	NA	NA	NA	NA	NA	NA	NA
Kura River	310	14-Nov-01	50	12.8	0.67	10.3	7.7	0.02	24	2.0	1.1	140	110	< 0.2	135	85
River adjacent to former WREP camp (1)	410	15-Nov-01	130	14.1	0.12	13.4	7.9	0.05	1.4	NA	NA	NA	NA	NA	NA	NA
Lake 4 km to NE of route (1)	440	15-Nov-01	140	10.3	0.47	10.5	7.9	0.01	31	NA	NA	NA	NA	NA	NA	NA
ARTIFICIAL WATERBODIES																
Irrigation canal 2 km S of Mugan (1)	63	11-Nov-01	320	15.9	0.39	9.0	8.8	0.19	50	NA	NA	NA	NA	NA	NA	NA
Local irrigation canal (1)	129	19-Nov-01	170	10.8	0.83	10.0	7.7	0.03	71	NA	NA	NA	NA	NA	NA	NA
Local irrigation channel (1)	176	19-Nov-01	150	10.7	0.60	11.3	7.8	0.02	211	NA	NA	NA	NA	NA	NA	NA
Irrigation canal (1)	200	20-Nov-01	170	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Main canal in Yevlak (1)	227	13-Nov-01	60	15.0	0.30	8.4	8.0	0.14	51	NA	NA	NA	NA	NA	NA	NA
Local irrigation canal (1)	227	13-Nov-01	150	14.7	0.16	10.5	7.9	0.07	28	NA	NA	NA	NA	NA	NA	NA
Irrigation canal to the north of Gandja (1)	298	12-Nov-01	110	11.7	0.42	9.8	7.9	0.01	9.6	NA	NA	NA	NA	NA	NA	NA
Irrigation channels (1)	298	14-Nov-01	200	12.6	0.63	9.2	7.9	0.02	2.2	NA	NA	NA	NA	NA	NA	NA
Local irrigation channels (1)	440	15-Nov-01	200	11.0	0.46	9.2	7.9	0.01	5	NA	NA	NA	NA	NA	NA	NA
Chohranli settlement (irrigation canal) (1)	124	19-Nov-01	250	11.2	0.15	6.2	7.7		3.8	NA	NA	NA	NA	NA	NA	NA
Agsu Canal	111	20-Nov-01	130	7.9	0.32	11.2	7.2	0.15	7.6	2.8	0.67	1100	120	0.4	270	330
Upper Karabakh Canal	244	13-Nov-01	210	19.7	0.55	7.8	7.9	0.02	5.2	3.0	0.47	100	65	< 0.2	140	110

Notes:

NA - Not analysed

(1) - Samples also analysed for diesel range organic compounds, polynuclear aromatic hydrocarbons, polychlorinated biphenyls and a range of pesticides. None of these materials were detected at concentrations in excess of the laboratory's detection limits in any of the samples.

A more recent field water quality survey for the pipeline project was carried out by ERT Caspian (2001) between 9 and 20 November 2001 (see Tables 8, 9 and 10). In conjunction with a BP/Kvaerner team, sample sites were selected along the proposed route, and included irrigation canals and a selected rivers, including the Kura, with a view to assessing water quality. This was a 'one-off- survey, so could not take into account any seasonal variations in river water quality, which are known to be considerable (see above), but aimed to provide a snapshot background picture. Local residents were also interviewed for information on, for example, the reliability of their water supplies and recollections of any pollution incidents. The survey was not designed to determine sources of any contamination found in samples.

Samples were analysed for a range of metals, organics and coliforms used by water and health agencies to assess appropriateness of waters for drinking purposes. A small number of samples meet existing UK/EU water quality guidelines but would fail to meet the required standards due to be enforced in 2003 (ERT Caspian, 2001). Also, many samples pass water quality tests *individual* determinand, but would fail *overall* when assessed against a range of collectively-important water quality variables.

All samples fell within the international limits for PAH, Arsenic, Barium, Cadmium, Chromium, Copper, Mercury, pH, electrical conductivity (EC) and Ammonia. For lead, all sites passed except the upper Karabakh canal. A number of sites exceeded the manganese limits, especially the Kura River north of Mugan. In terms of nickel concentrations, several sites exceeded EU limits. Turbidity limits were exceeded in a number of rivers and canals, as would be expected. Allowable sulphate and calcium concentrations are exceeded in the Agsu canal.

One of the key determinands for human health, however, is coliform count. It is stressed that most waters sampled exceeded UK and EU limits, though a few samples were analysed after lengthy storage and results for these sites cannot be considered reliable (ERT Caspian, 2001).

Table 9 Recorded mudflow events in the basins crossed by the proposed pipeline route

River	Date	Mudflow duration (hrs)	Triggering factor		Altitude zone of Occurrence (m)	Results of mudflow occurrence						
			Snow melt	Rainstorm		Flood damage	Building damage	Road damage	Bridge damage	Railway damage	Canal damage	Fatalities
Turianchay	Aug 1905			✓	1800-2400	✓	✓					
Turianchay	01-Sep-30	8		✓	1800-2400	✓						
Turianchay	29-May-37	20	✓	✓	600-2600	✓					✓	
Turianchay	26-Jun-52	15		✓	1800-2400	✓	✓					
Turianchay	26-Jun-56	20	✓	✓	600-2600	✓	✓					
Turianchay	05-Sep-60	24			600-2600							
Turianchay	11-Jun-63	30	✓	✓	600-2600	✓					✓	
Turianchay	23-Jul-74	10		✓	1800-2400	✓	✓					
Bumchay (trib of)	May 1927	3		✓	1000-2500	✓	✓	✓				
Turianchay)	13-Aug-45	8		✓	1000-2500	✓	✓					40
Bumchay	20-Jul-06	10		✓	600-1800	✓	✓			✓		
Bumchay	20-May-16	1		✓	600-1000	✓	✓	✓				
Bumchay	13-Jun-35	6		✓	600-1800	✓	✓					
Bumchay	30-May-49	2	✓	✓	1000-1800	✓						
Bumchay	30-Jul-55	2		✓	600-1800	✓						
Bumchay	02-Jul-57	6		✓	600-1800	✓					✓	
Bumchay	07-Jul-63	8		✓	1000-1800	✓					✓	
Bumchay	30-May-72	2		✓	1000-1800	✓	✓	✓	✓			
Bumchay	06-Jun-72	1.5		✓	1000-1800	✓						
Girdemanchay	27-Jul-15	2		✓	1500-2000	✓		✓				
Girdemanchay	18-Oct-51	2		✓	1500-3000			✓				
Girdemanchay	03-Jul-57	2-7		✓	1500-2000			✓				
Girdemanchay	07-Jul-57	2-7		✓	1500-2000			✓				
Girdemanchay	12-Jul-57	2-7		✓	1500-2000			✓				
Girdemanchay	19-Jul-57	2-7		✓	1500-2000			✓				
Girdemanchay	06-May-72	4		✓	1500-2000	✓		✓				
Girdemanchay	24-Jun-75	2		✓	1500-2000	✓		✓				

Table 9 Recorded mudflow events in the basins crossed by the proposed pipeline route

River	Date	Mudflow duration (hrs)	Triggering factor		Altitude zone of Occurrence (m)	Results of mudflow occurrence						
			Snow melt	Rainstorm		Flood damage	Building damage	Road damage	Bridge damage	Railway damage	Canal damage	Fatalities
Aksu	15-Jul-47	3		✓	1200-1500	✓			✓			
Aksu	09-Jun-62	2		✓	1200-1500	✓			✓			
Aksu	02-May-64	1		✓	1200-1500	✓						
Aksu	06-Jun-68	4		✓	1200-1500	✓		✓	✓			
Aksu	06-May-72	6		✓	1200-1500	✓		✓				
Aksu	24-Jun-75	5		✓	1200-1500	✓			✓			
Aksu	27-Jun-59	5		✓	1200-2000	✓		✓				
Aksu	16-May-66	4		✓	1400-2200	✓		✓				
Akhindjachay	25-Jun-52	3		✓	500-1500			✓				
Akhindjachay	08-Jul-72	5		✓	500-1500	✓		✓				
Tovuzchay	24-Jul-63	5		✓	500-1500	✓		✓				
Tovuzchay	08-Jul-72	3		✓	500-1500	✓						
Gandjachay	10-Jul-06	4		✓	1000-2500	✓		✓	✓		✓	
Gandjachay	26-Aug-31	3		✓	1000-1500	✓	✓	✓				
Gandjachay	11-Jul-65	6		✓	1000-1500	✓		✓				

1.11 MUDFLOWS

Mudflows are significant events that have affected at least seven of the rivers crossed by the pipeline (Kashkay 1996). Of the 41 documented events, 34 occurred in the four main Great Caucasus river basins (Turianchay, Geokchay, Girdemanchay and Aksu), where damage was also greatest. This is further evidence of the hydrogeomorphological dynamism of the region, though contemporary data is unfortunately lacking. Up to one million cubic metres of material can be moved down-catchment in a few hours during such events, causing infrastructural damage and fatalities (e.g. 40 people died in Upper Kamervan in the upper Turianchay basin on 13 August 1945). Damage to communications has been severe and frequent in the past, including near the pipeline route. Mudflows are highly seasonal events, typically taking place between April and October, but with a clear peak frequency in May, June and July. The most damaging recorded mudflow events are listed in Table 11.

Catastrophic 'mudflows' have affected the Djeyrankechmes basin, even as far downstream as Sangachal. Between 1941 and 1972 at least eight mudflows occurred on the Djeyrankechmes at an average interval of around 2-5 years. Most occurred in the May-July period and they were mainly generated at altitudes of 300-800 metres above mean sea level. Such events are likely to have been generated during intense rainstorms by the release of mobile materials as a result of slope erosion or failure. Eroded materials then develop into a thick sediment-water slurry which moves quickly downslope and into river channels. Boulders up to 0.4 - 0.7 m in diameter can be carried in the water-sediment mixture.

1.12 ENVIRONMENTAL CHANGE AND PIPELINE CORRIDOR HYDROLOGY

Significant environmental and hydrological changes (especially in temperature, precipitation, groundwater, land use, industrial activity and sea levels) have taken place throughout the Azerbaijan area in recent times. For example, Hadiyev (1996) has argued that mean air temperatures have risen significantly in the Transcaucasian region over the last 100 years. Furthermore, Hadiyev (1996) found that, at selected sites in the Transcaucasian region, annual rainfall totals *decreased* over the last 100 years, except over large cities. However, in a simple analysis of patterns over the last 60 years, Lawler (1997) discovered that there was a significant *increase* in annual rainfall totals in recent decades in Azerbaijan. At Baku and Ganja, Lawler (1997) found that the frequency of annual totals greater than 300 mm over the 28-year period, 1963-1990, was three times that of the 1935-1962 period. Mumladze (1991) described similar recent precipitation increases at Poti on the Black Sea coast of Georgia.

The level of the Caspian Sea has been rising since 1978 (Efendiyeva, 2000) at a rate of approximately 11cm per annum, leading to more than 2 m of sea-level rise between 1978 and 1996. This may have repercussions for groundwater levels, quality and flow directions in the coastal part of the proposed pipeline route.

Given these significant past changes over the last century in the Caucasus region, and predictions of future climates by General Circulation Models (GCMs), there exists the distinct possibility of future environmental changes along the proposed pipeline route. These include changes in climate (precipitation and temperature), land use and agricultural activities, groundwater levels and flow directions, and Caspian Sea level. These changes may alter hydrological regimes and water quality, and affect future flood intervals, river and soil erosion and contamination risks over the design life of the pipeline. In particular, future economic development in Azerbaijan may well generate significant agricultural land-use changes in the pipeline route that could alter river flows and surface-water and groundwater quality.

SOCIO-ECONOMIC BASELINE

TABLE OF KNOWN PIPELINE AFFECTED COMMUNITIES AND CHARACTERISTICS

GARADAG						
	Settlement	**Population**	**KP Ref**	**Community expectations & concerns**	**Infrastructure & Utilities**	**Requests / Possible Social Investment**
	Sangachal also includes Azimkend	4010	KP 2	☺ - Local employment ☹- Noise - Traffic - Roads deterioration	**Water:** Always **Electricity:** Always **Gas:** Always **Telephones:** Always **Roads:** Fair	Use of BP's machinery Roads repair Basic sewage
HADGIQABUL						
	Randjbar	2850	KP 40	☺ - Local employment - Roads repair - Indirect employment ☹ - No compensation for land -Safety of the pipeline	**Water:** Shortage for irrigation (drinking in summer) **Electricity:** Often interruptions **Gas:** Partial supply (piped) **Telephones:** Some (communal point) **Roads:** Partially asphalted	Digging of a sewage ditch Roads repair Drilling the artesian well for water Inform on the commencement of construction
	Pirsagat	852	KP 45	*	**Water:** Always **Electricity:** Interrupted **Gas:** Permanent, canisters **Telephones:** At communal points **Roads:** Poor	*
	Kazi-Magomed	22279	KP 51-55	☺ - Local employment + indirect employment	**Water:** Enough for all purposes but low quality	Roads repair Sewage system cleanup

				- Improvement of a gas supply ☹ - Possible explosions	**Electricity:** Supplied with intervals **Gas:** Supplied with intervals (gas line) **Telephones:** Most households **Roads:** poor	Establish a micro credit program for SMEs
	Mugan	4000	KP 63	☺ - Local employment + indirect - Roads repair - School refurbishment ☹ - Possible explosion - Gas leakage	**Water:** Always have water **Electricity:** Supplied with intervals **Gas:** Gas canisters **Telephones:** Mobile + most households **Roads:** poor	More information about pipeline Upgrade of the medical centre Refurbishment of a school building Digging sewage canals Roads repair Upgrade of a power transformer
	Qarasu	2266	KP 79	☺ - Local employment - Roads repair - Water channel repair ☹ None	**Water:** Almost always **Electricity:** Supplied with intervals **Gas:** Gas line supply **Telephones:** Most have mobiles **Roads:** Poor	Digging of a sewage ditch Helping build a hospital Roads repair Building a village culture club
	Padar	752	KP 91	☺ - Local employment - Improved electricity supply - Gas supply ☹ - None	**Water:** Buy from trucks **Electricity:** With long intervals **Gas:** Gas canisters (2 a month) **Telephones:** local and mobile **Roads:** Poor	Drilling of artesian well for water School building refurbishment Using the old pipe to delivery water from the nearby channel to the village Gas supply
Kurdemir						
	Kurdemir Town	17676	KP 128-132	☺ - Local employment - Improve infrastructure	**Water:** Some **Electricity:** Irregular	Receive information from BP Use of BP's machinery for

				- Improve electricity and gas supply ☹ - None	**Gas:** Some use gas canisters **Telephones:** Mobile + households **Roads:** Fair	improvement of a water supply network Investment in local diary factory Support for carpet-weaving industry
	Sigirly	5403	KP 105	☺ - Local employment - Gas supply ☹ - In case of explosion damage to environment - Misbehaviour of construction workers	**Water:** Irrigation comes from canal, drinking bought **Electricity:** 7 hours a day **Gas:** None **Telephones:** Some home lines + mobiles **Roads:** Very bad	More info on the project Roads repair Water source upgrade Digging of a sewage canals
	Karrar	2196	KP 110	☺ - Local employment - Receive compensation - Gas supply - Road maintenance ☹ - Pipeline might lay through good and fertile land - Noise	**Water:** Not sufficient supply **Electricity:** With intervals and scheduled **Gas:** Containers **Telephones:** local and mobile **Roads:** Poor	Refurbishment of a school building Upgrade of a water system Roads repair
	Karrar Station	1390	KP 119	☺ - Local employment - Gas supply - Receive compensation ☹ - Damage to land - Gas explosion - Damage to roads	**Water:** Canal water for drinking **Electricity:** Irregular **Gas:** Containers **Telephones:** Mobile and local **Roads:** Poor	Treatment of drinking water Establishment of medical facility Rehabilitation of wine factory
	Chokhranly	1118	KP 123	☺ - Local employment - Use of BP's equipment - Trade links ☹ - None	**Water:** Very little **Electricity:** 4-5 hours a day **Gas:** Containers **Telephones:** Mobile and local **Roads:** Fair	More information about pipeline Establishment of a medical care facility School building refurbishment Extension of a water pipe

	Yeni Shiximly	215		*	**Water:** No communal supply, canals **Electricity:** Interrupted **Gas:** No supply, canisters too expensive **Telephones:** No **Roads:** Fair	*
	Arshaly	652		*	**Water:** No communal supply, stored water **Electricity:** Interrupted **Gas:** No communal supply, ,canisters **Telephones:** Most households **Roads:** Poor	*
Ujar						
	Taza Shilyan	2800	KP 150	☺ - Local employment - Gas supply - Improvement of a water supply ☹ - Possible explosions - Environment - Damage to roads - Resettlement	**Water:** Insufficient especially for agro use **Electricity:** Interrupted **Gas:** Containers **Telephones:** Some local and mobile **Roads:** Poor	Roads repair Upgrade of the hospital Water system upgrade
	Chiyny	511	KP 159	☺ - Local employment - Credits allocations for business - Improve electricity supplies ☹ - Damage to water canals	**Water:** Bad quality, shortage in summer **Gas:** Some containers **Electricity:** Irregular **Telephones:** Some local and mobile **Roads:** Poor	New school building Establishment of medical facility Local water treatment Establishment of micro credit program
	Anver Memmedhanly	216	KP 163	☺ - Local employment - Roads improved ☹ - Environmental - Damage to roads and lands - Damage to canals	**Water:** Bad quality **Gas:** Containers **Electricity:** Seldom **Telephones:** Some local and mobile **Roads:** Poor	Potable water treatment New school building (or renovation of the old one) Establishment of a medical facility Refurbishment of a mosque
	Gulabend	1120	KP 170	☺ - Local employment	**Water:** Spring	More information about

				- Receive compensation - Roads maintenance ☹ - Disturb landuse	**Electricity:** Scheduled **Gas:** Containers **Telephones:** Some local and mobile **Roads:** Poor	pipeline New school building Help in refurbishment of a water system Roads repair
	Garaberk	3500	KP 175	☺ - Local employment - Receive compensation ☹ - Noise - Damage to land, roads and water canals - Fire - Resettlement	**Water:** Use canal water **Gas:** Containers **Electricity:** Permanent **Telephones:** Some local and mobile **Roads:** Poor	Upgrade of a medical centre Provision of a fishing gear
	Ujar Town	15483	KP 178	☺ - Local employment - Receive compensation in form of dug wells ☹ - Roads deterioration - Increased traffic	**Water:** Not sufficient, have to carry from long distances **Electricity:** With often interruptions **Gas:** Some containers **Telephones:** Mobile and local **Roads:** Poor	Digging artesian wells for water More information about pipeline Improve electricity supplies Improve roads
	Alpout	3270	KP 180	☺ - Local employment - Piped gas available - Roads maintenance ☹ - Damage to land - Resettlement - Damage to roads	**Water:** Canals **Gas:** Containers **Electricity:** Irregular **Telephones:** Some local and mobile **Roads:** Poor	School building refurbishment Roads repair More info from BP's reps
	Karadagly	2265	KP 182	☺ - Local employment - Gas supply - Receive compensation ☹ - Damage to land - No compensation for land - Gas leakage	**Water:** Bad quality for drinking, not enough for irrigation **Gas:** Containers **Electricity:** With interruptions **Telephones:** Some local and mobile **Roads:** Poor	School upgrade Hospital upgrade Water system upgrade
	Alikend	700	KP 189	☺ - Local employment	**Water:** Canals	Treatment of a respiratory

				- Improved electricity supplies ☹ -None	**Gas:** Containers **Electricity:** Irregular **Telephones:** Some local and mobile **Roads:** Poor	diseases School upgrade Help in revitalization of cotton production
	Ramal	720	KP 190	☺ - Local employment - Improve electricity supply ☹ - Possible explosion - Possible resettlement - Damage to roads - Damage to land	**Water:** Use water from canal, shortage in summer **Electricity:** Irregular **Gas:** Containers **Telephones:** Some local **Roads:** Poor	Potable water treatment facility Roads repair
	Shahliq	1400	KP 190	☺ - Local employment - Gas supply - Roads repaired ☹ - Noise - Possible resettlement - Land taken away - Possible explosion	**Water:** Almost always **Electricity:** Irregular **Gas:** Containers **Telephones:** Some local **Roads:** Poor	Improve electricity supplies Improve roads
Agdash						
	Asagy Leky	1454	KP 198	☺ - Local employment - Receive compensation - improve infrastructure ☹ - Possible explosion	**Water:** Problem especially in summer **Electricity:** Irregular **Gas:** Containers **Telephones:** Local lines and some mobile **Roads:** Poor	School repair + provision of basic supplies Help revitalize cotton production + live stock Cleaning of the water channels

	Hanitlu	518	KP 198	☺ - Local employment - New wells - Indirect employment ☹ - Possible explosion - Damage to roads - Damage to water canals - Dust	**Water:** Little **Electricity:** 1-2 hours a day **Gas:** None **Telephones:** local and mobile **Roads:** Poor	Improve health centre facility Clean the potable water source Roads repair Digging artesian wells More information about pipeline
	Leki	3854	KP 205	☺ - Local employment - Use of BP's equipment ☹ - Damage to roads	**Water:** Insufficient **Electricity:** With interruptions **Gas:** Containers **Telephones:** local and mobile **Roads:** Poor	Digging basic sewerage gutters Use of BP's machinery for the village needs More info on the project
	Guvekend	1443	KP 205	☺ - Local employment - Use of BP's equipment ☹ - Damage to roads	**Water:** Insufficient **Electricity:** With interruptions **Gas:** Containers **Telephones:** local and mobile **Roads:** Poor	Digging basic sewerage gutters Use of BP's machinery for the village needs More info on the project
	Amirarh	1014	KP 205	☺ - Local employment - Improvement of social infrastructure - Water supply - Improved power supply ☹ - Unfair compensation for land	**Water:** Rare **Electricity:** 3 hours a day **Gas:** Some containers **Telephones:** local and mobile **Roads:** Poor	New school (no at present) Drill artesian wells
	Agdjaqovak	110	KP 217	☺ - Local employment - Sell products - Construction of school and a kindergarten - Receive compensation ☹ - Possible damage to water canals and roads	**Water:** Some **Electricity:** Very seldom **Gas:** Containers **Telephones:** local and mobile **Roads:** Poor	New school and kindergarten (none at present) Basic medical equipment to health centre Help develop cotton and wheat production
Yevlakh						

	Duzdak	446	KP 237	*	*	*
	Ashagy Garhun	1211	KP 220	☺ - Local employment - Gas supply ☹ - Damage to arable land	**Water:** Sufficient **Electricity:** 5-6 hours a day **Gas:** Some containers **Telephones:** Some local and mobile **Roads:** Fair	Medical centre upgrade School building renovation More info through meetings
	Yevlakh town	51952	KP 231	☺ - Local employment -Sewerage system fixed - Development of town's infrastructure ☹ - Dust - Noise	**Water:** Some **Electricity:** 8-10 hours a day **Gas:** Some **Telephones:** Local lines and mobile **Roads:** Fair	Digging of a basic sewage gutters
	Narimanabad	1573	KP 235	☺ - Local employment - Use of BP's equipment - Roads maintenance - School repair ☹ - Gas going to Turkey rather than for village use	**Water:** Little **Electricity:** 1-2 hours a day **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair Establishment of a medical facility School building renovation More info through meetings
	Sametobad	1161	KP 237	☺ - Local employment - Gas supply ☹ - None	**Water:** Some (bad quality) **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair
	Neymatabad	1295	KP 238	☺ - Local employment - Gas supply ☹ - None	**Water:** Little **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair Micro credit program

	Yaldily	1226	KP 242	☺ - Local employment - Gas supply ☹ - None	**Water:** Some (bad quality) **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair Upgrade of the medical centre Renovation of a school building
	Aran	6694	KP 242	☺ - Local employment - Gas supply - Trade links ☹ - Gas leakage - Accidents	**Water:** Little **Electricity:** 10 hours a day **Gas:** Some containers **Telephones:** Some local and mobile **Roads:** Poor	Drilling of artesian wells Roads repair Micro credit program More information about the project
Ganja						
	Ganja town	299000	KP 297-302	☺ - Local employment - Improved business ☹ - None	**Water:** Always **Electricity**: Almost always **Gas:** Almost always **Telephones:** Local and mobile **Roads:** Fair	

GERANBOY

Map Ref.	**Settlement**	**Population**	**Attitude to Pipeline**	**Expectations**	**Specific Characteristics**	**Requests / Possible Social Investment**
	Kazambulak	720	KP 272	*	*	*
	Yaharchi Gazahlar	850 e	KP 287	*	*	*
	Alpout	948	KP 291	*	*	*
	Eyvazlilar	509	KP 251	☺ - Local employment	**Water:** Very little	Drilling artesian wells for water

				- Receive compensation - Gas supply ☹ - Damage to the land	**Electricity:** 1-2 hours a day **Gas:** Containers **Telephones:** Few local lines **Roads:** Poor	Roads repair New school New medical center
	Jinli Boluslu	1230	KP 253	☺ - Local employment ☹ - None	**Water:** Some **Electricity:** With interruptions **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair Upgrade of medical centre School building renovation Drilling additional wells for water
	Erevanly	214	KP 256	☺ - Local employment - Gas supply - Trade links - Economic development ☹ - Damage to land - Damage to roads - Taking land away	**Water:** Very little **Electricity:** 5-6 hours a day **Gas:** Firewood used instead **Telephones:** Few local **Roads:** Poor	More information about the project Roads repair Establishment of a medical centre Drilling artesian wells for water
	Nadirkend	1380	KP 256	☺ - Local employment - Receive compensation for land - Gas supply ☹ - None	**Water:** Some **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** More or less fair	Upgrade of a medical centre School building renovation
	Borsunlu	3460	KP 272	☺ - Local employment - Gas supply ☹ - None	**Water:** Little **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair School buildings renovation Upgrade of a medical centre
	Azizbeyov	690	KP 280	☺ - Local employment - Gas supply ☹ - None	**Water:** Little (bad quality) **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Building a new road Improve electricity supply Provide gas

	Muzdurlar	1272	KP 281	☺ - Local employment - Gas supply ☹ - None	**Water:** Little **Electricity:** Irregular **Gas:** Containers **Telephones:** local and mobile **Roads:** Poor	Roads improvement School building renovation Medical centre upgrade
	Yolpak	590	KP 282	☺ - Local employment - Gas supply ☹ - Noise - Possible explosion - Possible removal of trees	**Water:** Little **Electricity:** With interruptions **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Finish the school building Artesian wells upgrade More info on the project
	Bashirly	428	KP 283	☺ - Local employment - Increased state budget ☹ - Land loss - Damage to houses and water canals - Damage to roads	**Water:** Located in far distance **Electricity:** Irregular **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Drilling artesian wells Medical centre upgrade More info about the project Improve electricity supply
	Sarov	850	KP 285	☺ - Local employment - Benefit to state budget - Gas supply - Improved power supply ☹ - Damage to land	**Water:** Some **Electricity:** Interrupted **Gas:** Piped gas **Telephones:** Local and mobile **Roads:** Poor	Establishment of medical centre Roads repair More information about the project
	Fahraly	2500	KP 288	☺ - Local employment - Gas supply - Economic development ☹ - None	**Water:** Some (bad quality0 **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Digging artesian wells for water School refurbishment
	Gurbanzade	580	KP 289	☺ - Local employment - Gas supply ☹ - Safety	**Water:** Rare **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Drilling of artesian wells for water Upgrade of a medical centre Roads repair

SAMUKH

Map Ref.	Settlement	Population	Attitude to Pipeline	Expectations	Specific Characteristics	Requests / Possible Social Investment
	Lyak	1096	KP 298	*	*	*
	Kadily	451	KP 316	*	*	*
	Ashagy Agasybeyli	447	KP 293	☺ - Local employment - Sell products - Gas supply ☹ - Damage to land - Land loss	**Water:** Some **Electricity:** With interruptions **Gas:** Some containers **Telephones:** local and mobile **Roads:** Poor	Roads repair Restoration of a medical centre New school More info on the project
	Aly Bayramly	816	KP 294	☺ - Local employment - Economic development ☹ - Damage to land - Damage to bridge	**Water:** None **Electricity:** 1-2 hours a day **Gas:** None (firewood instead) **Telephones:** local and mobile **Roads:** Poor	Transformer repair Drilling artesian wells Roads repair School building renovation Micro credit program More info on the project through meetings
	Hodjaly	1098	KP 302	☺ - Local employment - Receive compensation ☹ - None	**Water:** Almost always but not everywhere **Electricity:** Often **Gas:** Containers **Telephones:** Mobile **Roads:** Poor	Roads repair Medical centre upgrade School building repair Improvement of a water situation
	Seyidlyar	538	KP 316	☺ - Local employment - Gas supply - Receive compensation - Trade	**Water:** Always **Electricity:** 2 hours a day **Gas:** Some containers	Medical centre upgrade Improved power supply

				- Improved power supply ☹ - Safety -Damage to land	**Telephones:** Local and mobile **Roads:** Fair	
	Garaarh	495	KP 320	☺ - Local employment - Trade - Accommodations lease - Gas supply ☹ - Damage to land	**Water:** Always **Electricity:** 2-3 hours a day **Gas:** Some containers **Telephones:** Mobile **Roads:** Poor	Roads repair School building repair Establishment of a medical centre Restoration of the irrigation canals More info about the project
SHAMKIR						
Map Ref.	**Settlement**	**Population**	**Attitude to Pipeline**	**Expectations**	**Specific Characteristics**	**Requests / Possible Social Investment**
	Chaparhy	1510	KP 336	*	*	*
	Talish	562	KP 318	☺ - Local employment - New well - Gas supply - Power supply ☹ - Safety - Damage to land	**Water:** Always **Electricity:** 2-3 hours a day **Gas:** Some containers **Telephones:** Local **Roads:** Poor	Roads repair Medical centre upgrade New school building
	Garagemirly	5300	KP 326	☺ - Local employment - Gas supply - Lease of accommodation ☹ - Safety	**Water:** Some **Electricity:** Seldom **Gas:** Containers **Telephones:** Local and mobile **Roads:** More less fair	Schools renovation Repair of artesian wells
	Mahmudlu	3165	KP 330	☺ - Local employment - Gas supply - Lease of premises	**Water:** Some (bad quality) **Electricity:** 8 hours a day **Gas:** Some containers **Telephones:** Local and mobile	Water system upgrade Kindergarten renovation More info about the project Improved power supply

				☹ - Damage to land - Damage to road	**Roads:** Fair	
	Kechily	5600	KP 332	☺ - Local employment - Gas supply ☹ - None	**Water:** Some **Electricity:** Irregular **Gas:** Piped gas **Telephones:** Local and mobile **Roads:** Poor	Roads repair Medical centre upgrade Improvement of school conditions
	Dellercirdaxan	2540	KP 338	☺ - Local employment - Gas supply ☹ - None	**Water:** Almost always **Electricity:** With interruptions **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair School building renovation
	Deller	4169	KP 340	☺ - Local employment - Support for village schools ☹ - Damage to roads - Possible conflicts with workers	**Water:** Some **Electricity:** Rare **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Basic school supplies to local school + its repair Improvement of a water supply Improvement in medical care Improvement of power lines Roads repair
	Dallyar Djeir	4857	KP 342	☺ - Local employment - Benefit to state budget - Receive compensation - Gas supply ☹ - Safety - Loss of land - Loss of houses	**Water:** Some **Electricity:** With interruptions **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Medical centre upgrade School building renovation Roads repair
	Dallyar Dashbulak	2061	KP 343	☺ - Local employment - Receive compensation - Trade - Gas supply - Assistance in improvement of water and power supply	**Water:** Some **Electricity:** With interruptions **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair Medical centre upgrade School building renovation

				☹ - Safety		
	Sary Tepe	510	KP 350	☺ - Local employment ☹ - Disturb land - Noise - Dust - Explosion	**Water:** Some **Electricity:** 3-4 hours a day **Gas:** Containers **Telephones:** Mobile **Roads:** Poor	More info about the project Vegetable processing workshop Digging of artesian wells Roads repair
	Bayramly	2670	KP 352	☺ - Local employment - Gas supply ☹ - None	**Water:** Some **Electricity:** With interruptions **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Medical centre upgrade School building renovation
	Zeyem	7225	KP 354	☺ - Local employment - Improved water supply ☹ - Damage to roads	**Water:** Little **Electricity:** Irregular **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Drilling artesian wells for water Roads repair School building refurbishment Digging basic sewage gutters More info about the project
TOVUZ						
	Khatinly	2774	KP 382	☺ - Local employment - Gas supply - Provision of goods and services ☹ - Possible explosion - Damage to land	**Water:** Some **Electricity:** 5-6 hours a day **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair School renovation School supplies Digging of artesian wells
	Ashagi Mulkulu	2200	KP 384	*	**Water:** No communal supply, stored water **Electricity:** Interrupted **Gas:** No communal supply, ,canisters **Telephones:** NA **Roads:** Poor	*
AKSTAFA						

	Ashagy Kesamanly	2560	KP 400	☺ - Local employment - Receive compensation ☹ - Loss of land - Damage to land - Damage to roads - Noise	**Water:** Some **Electricity:** 2-3 hours a day **Gas:** None **Telephones:** Local and mobile **Roads:** Poor	Roads repair Medical centre upgrade School renovation
	Zelimhan	1145	KP 401	☺ - Local employment - Gas supply ☹ - Safety - Land loss	**Water:** Some **Electricity:** Irregular **Gas:** Some containers **Telephones:** Local and mobile **Roads:** Poor	Roads repair Water system upgrade
	Poylu	1255	KP 410	☺ - Local employment ☹ - None	**Water:** Little **Electricity:** Sometimes **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	Improvement of medical care services Textbooks supply for school needs Micro crediting program Use of construction machinery to improve water supply More info on about the project
	Saloglu	1300	KP 420	☺ - Local employment ☹ - Damage to the land	**Water:** Always **Electricity:** Often **Gas:** Containers **Telephones:** Local and mobile **Roads:** Poor	School repair
	Soyuk Bulak	640	KP 429	*	*	*
	Kechvely	1100	KP 432	*	*	*
	Boyuk Kesik	1300	KP 440	☺ - Local employment - Receive compensation	**Water:** Some **Electricity:** Irregular	Roads repair Water situation improvement

				☹ - Damage to the land	**Gas:** None **Telephones:** Local and mobile **Roads:** Poor	(use of BP's equipment) More info about the project

- Information not collected

COMMUNITIES SURVEYED FOR COMPILATION OF BASELINE

- Agdjaqovak
- Alikend
- Alpout
- Aly Bayramly
- Amirarh
- Anver Memmedhanly
- Aran
- Asagy Leky
- Ashagy Agasybeyli
- Ashagy Garhun
- Ashagy Kesamanly
- Azizbeyov
- Bashirly
- Bayramly
- Borsunlu
- Boyuk Kesik
- Chiyny
- Chokhranly
- Dalimamedli
- Dallyar Dashbulak
- Dallyar Djeir
- Deller
- Dellercirdaxan
- Erevanly
- Eyvazlilar
- Fahraly
- Ganja
- Garaarh
- Garaberk
- Garagemirly
- Gulabend
- Gurbanzade
- Guvekend
- Kazi-Magomed
- Hanitlu
- Hodjaly
- Jinli Boluslu
- Karadagly
- Karadjally
- Karrar
- Karrar .Station
- Kazyan
- Kechily
- Khatinly
- Kirah Kesaman
- Kurdemir
- Leki
- Mahmudlu
- Mugan
- Muzdurlar
- Nadirkend
- Narimanabad
- Neymatabad
- Padar
- Poylu
- Qarasu
- Ramal
- Randjbar
- Saloglu
- Sametobad
- Sangachal
- Sarov
- Sary Tepe
- Seyidlyar
- Shahliq
- Sigirly

- Talish
- Taza Shilyan
- Ujar
- Yaldily
- Yevlakh
- Yolpak
- Zelimhan
- Zeyem

BASELINE AIR QUALITY REPORT FOR PUMP STATION

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1 BASELINE AIR QUALITY REPORT FOR PUMP STATION

1.1 INTRODUCTION

As part of the process of environmental baseline data collection for the ESIA, an air quality sampling survey was undertaken at the proposed site of pump station A2 (PS-A2), at KP 243.5. The aim of the survey was to provide an indication of the current levels of certain air pollutants in the vicinity of the site and enable assessment of background air quality.

1.2 SCOPE OF THE SURVEY

1.2.1 Pollutants

The following pollutants were surveyed:

- Oxides of nitrogen (NOx) – comprising nitrogen dioxide (NO_2) and nitrogen monoxide (NO)
- Sulphur dioxide
- Hydrocarbons (HC):
  - Benzene
  - Toluene
  - Ethylbenzene
  - Xylene (*m*- and *p*- isomers together, *o*- separately)
  - Total measurable hydrocarbons (THC)
- Particulate matter (dust)

The aromatic compounds benzene, toluene, ethylbenzene and xylene are commonly abbreviated together as BTEX.

1.2.2 Locations

At the time of the survey two possible sites for the pumping station (one to the north of the proposed BTC pipeline route and one to the south) were still under consideration. Sampling was carried out at eight locations – one near each of the corners of the two potential sites. The site to the south was subsequently selected as the preferred option for the pump station. The sampling locations are shown on a plan of the area, Figure 1-1 and summarised in Table 1-1 overleaf.

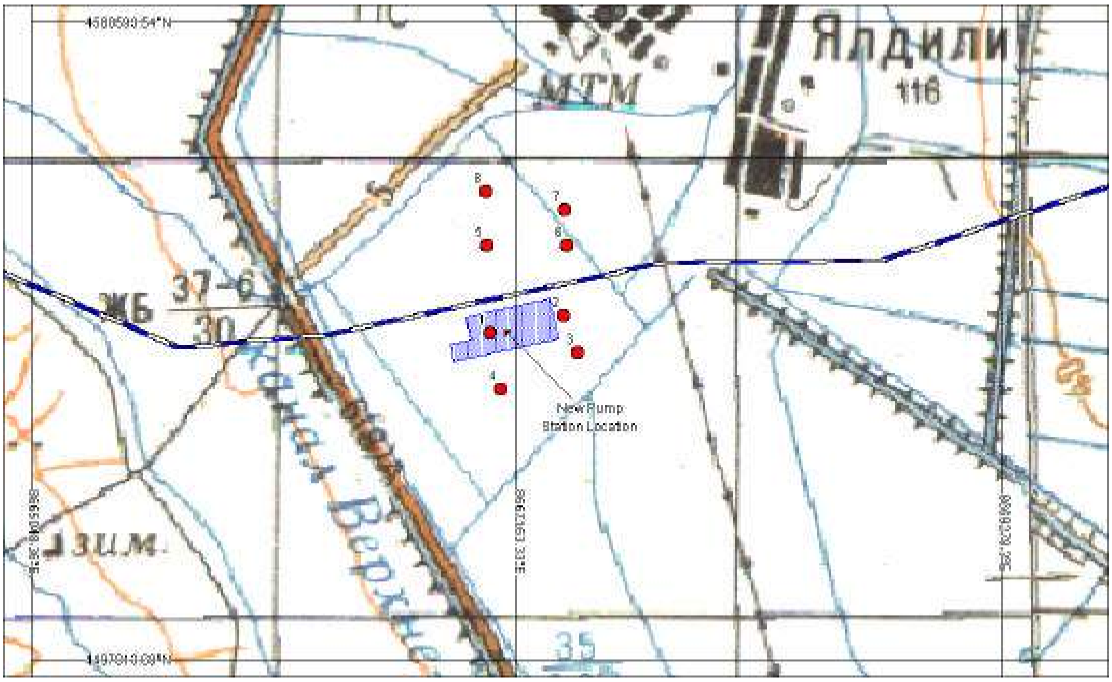

Figure 1-1: Sampling locations

Table 1-1: Sampling locations

LOCATION NO.	PUMP STATION SITE	CORNER	GRID REFERENCE	
			E	N
1	South	NW	8667049	4499242
2		NE	8667367	4499319
3		SE	8667429	4499159
4		SW	8667097	4499000
5	North	SW	8667036	4499627
6		SE	8667383	4499626
7		NE	8667375	4499779
8		NW	8667030	4499862

1.3 SAMPLING METHODS

1.3.1 Diffusion Tubes

Oxides of nitrogen, sulphur dioxide and hydrocarbons were sampled using diffusion tubes. The principle of diffusion tubes is that the tubes are left exposed to air for a measured time period. The pollutant vapour migrates along the tube by diffusion and is absorbed onto an absorbent material, which varies according to the pollutant being measured. The tubes are then sealed at the end of the exposure period and sent to a laboratory for analysis.

All diffusion tubes were fixed to wooden posts at approximately head height and exposed for 20 days (2 – 22 November 2001) then replaced by identical sets, which were exposed for 13 days (22 November – 5 December 2001) or 14 days (to 6 December) in the case of location 8 only).

Handling, storage, deployment and all other aspects of use were carried out in accordance with the recommendations of the tube supplier.

1.3.1.1 Oxides of nitrogen

Two tubes were deployed concurrently at each sampling location. One tube was the standard NO_2 diffusion tube and the other incorporated granules of an oxidising agent in the tube entrance. The standard tube measures NO_2 only, whereas the oxidising tube also oxidises all NO present to form NO_2 and therefore provides a measurement of total NO_x (as NO_2).

After collection, the tubes were sent to Gradko International Ltd, a UKAS accredited laboratory, where NO_2, absorbed as nitrite by triethanolamine, was determined by ultra-violet/visible spectrophotometry at 540nm.

1.3.1.2 Sulphur dioxide

The sulphur dioxide diffusion tubes were analysed by Gradko using Ion Chromatography, which determines the mass of sulphur absorbed. This is then converted to a concentration of sulphur dioxide using constants derived from coefficients of diffusion and uptake rates.

1.3.1.3 Hydrocarbons

The hydrocarbon tubes absorb most organic compounds (as a rough guide, Gradko suggest those less volatile than C_4 are absorbed). During analysis, the organic vapours are thermally desorbed and transferred to a gas chromatography system. The measured peaks are identified and the concentrations derived from the area of the peak and calibration data. This analysis method is in accordance with the UK standard method MDHS 80 (HSL, 1999).

1.3.2 Particulate matter

Particulate matter was sampled using adhesive strip directional dust gauges supplied and analysed by TES Bretby Ltd, a UKAS accredited laboratory. The gauges consist of an adhesive strip, approximately $100cm^2$ in area, to which particulate matter sticks. The strips were fastened to a wooden board, flat in the horizontal plane, which was then fastened to the top of a wooden post at approximately head height.

Analysis of the dust gauges is performed by the measurement of reflectance by a smoke stain reflectometer. The fraction of the light absorbed is divided by the number of days of exposure and results are reported in Effective Area Covered per Day ($EACd^{-1}$, %). Although this is not comparable to air quality guidelines or standards, TES Bretby advises that results of less than 2% $EACd^{-1}$ would not generally be expected to give rise to complaints.

1.4 RESULTS

1.4.1 Oxides of nitrogen and sulphur dioxide

Table 1-2: Results for oxides of nitrogen and sulphur dioxide

LOCATION NO.	NO_X AS NO_2 (mg/m^3)			NO_2 (mg/m^3)			SO_2 (mg/m^3)		
	SET 1	SET 2	MEAN	SET 1	SET 2	MEAN	SET 1	SET 2	MEAN
1	13.1	3.7	8.4	4.1	2.5	3.3	4.5	7.4	5.9
2	VOID(2)	3.7	3.7	4.1	2.5	3.3	1.8	3.1	2.4
3	4.1	2.5	3.3	2.5	2.5	2.5	4.8	2.3	3.6
4	VOID(2)	6.2	6.2	2.5	1.2	1.8	3.5	1.9	2.7
5	11.6	11.0	11.3	2.5	2.5	2.5	3.3	1.9	2.6
6	8.2	3.7	6.0	2.5	0.0	1.2	2.5	1.2	1.9
7	5.0	4.9	5.0	5.0	2.5	3.7	4.6	4.7	4.6
8	4.9	5.8	5.4	3.3	1.2	2.2	3.0	4.4	3.7
Mean	7.8	5.2	6.5	3.3	1.8	2.6	3.5	3.4	3.4

Set 1 = 2 – 22 November 2001, Set 2 = 22 November – 5/6 December 2001.
Void results are due to oxidation cap not being present on collection

1.4.2 Hydrocarbons

Table 1-3: Results for hydrocarbons

LOCATION NO.	BENZENE (mg/m3)			TOLUENE (mg/m3)			ETHYLBENZENE (mg/m3)		
	SET 1	SET 2	MEAN	SET 1	SET 2	MEAN	SET 1	SET 2	MEAN
1	0.4	0.0	0.2	0.1	<LOD	0.1	0.0	<LOD	0.0
2	2.7	3.4	3.0	2.9	3.6	3.3	0.5	0.8	0.6
3	2.6	2.7	2.7	4.0	2.4	3.2	1.3	1.3	1.3
4	2.9	3.3	3.1	3.7	2.4	3.0	0.7	0.4	0.5
5	2.2	2.1	2.2	30.4	2.3	16.3	1.1	0.9	1.0
6	1.5	2.6	2.0	1.3	1.7	1.5	2.4	0.8	1.6
7	3.1	2.7	2.9	1.6	9.2	5.4	0.9	1.7	1.3
8	3.1	1.9	2.5	4.1	2.2	3.1	1.5	0.9	1.2
Mean	2.3	2.3	2.3	6.0	3.4	4.7	1.1	1.0	1.0

LOCATION NO.	*M- / P-* XYLENE (mg/m^3)			*O-* XYLENE (mg/m^3)			THC (mg/m^3)		
	SET 1	SET 2	MEAN	SET 1	SET 2	MEAN	SET 1	SET 2	MEAN
1	0.0	<LOD	0.0	0.0	<LOD	0.0	9.0	13.1	11.0
2	0.8	1.2	1.0	0.0	0.2	0.1	131.3	54.0	92.6
3	1.2	1.1	1.1	0.7	0.3	0.5	39.4	53.3	46.3
4	1.3	1.1	1.2	0.7	0.1	0.4	30.7	47.6	39.1
5	8.1	0.7	4.4	1.1	0.7	0.9	49.7	169.1	109.4
6	3.3	0.3	1.8	8.1	0.1	4.1	747.2	81.0	414.1
7	1.2	1.3	1.3	0.5	1.0	0.8	64.4	35.5	50.0
8	1.2	1.1	1.1	1.2	0.4	0.8	29.4	187.3	108.4
Mean	2.1	1.0	1.5	1.6	0.4	1.0	137.6	80.1	108.9

<LOD: Below Limit of Detection

1.4.3 Particulate matter

Table 1-4: Results for particulate matter

LOCATION NO.	EFFECTIVE AREA COVERED PER DAY (%)		
	SET 1	SET 2	MEAN
1	0.5	VOID	0.5
2	VOID	0.3	0.3
3	0.4	0.3	0.4
4	0.4	0.3	0.4
5	0.4	0.4	0.4
6	0.4	0.3	0.4
7	0.4	0.9	0.7
8	0.5	0.5	0.5
Mean	0.4	0.4	0.4

Void results are due to dust gauge not being present on collection.

1.4.4 Summary of Results

Table 1-5: Summary of baseline air quality results

SUBSTANCE	AVERAGE CONCENTRATION (μg/m3)
Oxides of nitrogen (total NOx as NO_2)	6.5
Nitrogen dioxide	2.6
Sulphur dioxide	3.4
Benzene	2.3
Toluene	4.7
Ethylbenzene	1.0
Xylene (all isomers)	2.5
Total hydrocarbons	108.9

The average level of particulate matter was 0.4% Effective Area Covered per Day.

1.5 SUMMARY AND CONCLUSIONS

The results indicate that air quality in the area of the proposed pumping station is good. No pollutant levels approach the ambient standards and limits discussed in Section 10 of the ESIA, although the results of this survey are not directly comparable with the limits owing to differences in averaging periods and allowances for exceedences.

The survey has provided an indication of levels of air pollutants in the area. This information can be used in conjunction with modelling results to predict pollutant concentrations resulting from the proposed BTC pipeline development.

BACKGROUND NOISE SURVEY FOR PUMP STATION

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1. BACKGROUND NOISE SURVEY FOR PUMP STATION

Postscript: *An alternative location for the pump station is currently being assessed. The new location is a parcel of municipal land to the west of the site discussed in this report, and to the east of the road that runs parallel to the Karabakh Canal. It is likely that the environmental factors associated with the alternative location will be similar to, or less than, those assessed for the current location. However, specific environmental assessments will be conducted for the new site should the engineering studies indicate that re-siting would constitute a preferable option. One of the key reasons for assessing the possibility of locating the pump station in the area of municipal land is to reduce impacts on agricultural land in the vicinity of the current location.*

1.1 INTRODUCTION

The BTC pipeline will require a pump station approximately 80km to the east of Ganja in the centre of the Azerbaijan section of the pipeline, at KP243.5.

The site proposed is in relatively close proximity to the medium sized village of Yardili. Noise emissions from the pump station will need to be controlled to minimise the impact on local residents both during the day and at night.

This report forms part of a study to assess the likely noise impacts due to the construction and operation of the proposed pump station PS-A2 facility.

An integral part of an environmental noise impact assessment of a proposed development is an understanding of the noise environment which exists in the area potentially affected by the development. It is therefore accepted practice to undertake background noise measurements at locations surrounding the site of the proposed development which may be sensitive to noise. These are usually dwellings in the immediate vicinity of the site.

This report presents the results of a series of noise surveys carried out by Alan Saunders Associates on and around the proposed pump station site.

All sound pressure levels in this report are in dB or dB(A) reference 20mPa..

1.2 BACKGROUND

At the time of the survey (November 2001), two locations were being considered for the pump station, on either side (north and south) of the proposed BTC pipeline[1]. Additional engineering constraints are imposed by the existence of the Western Route Export Pipeline (WREP) alongside which the BTC pipeline will run. Of the two options, the northern version

[1] Subsequent to completion of this study, the southern location has been selected for the pump station.

would bring the pump station in closer proximity to the nearby dwellings. The two location positions are shown on Figure 1-1.

The construction of the complex will create noise which, if unmitigated, could cause annoyance to local residents. However, of greater potential concern is the operational noise that would be associated with the project. Although little or no operational noise from the BTC pipeline is expected, the pump station is likely to generate noise of an ‘industrial’ nature. Experience shows that flaring is likely to be the most audible operation at nearby houses, although this is not a standard procedure and is used in extreme conditions only.

The local environment is typical of rural conditions in this central area of Azerbaijan. A medium sized village is relatively close to the proposed site, as is a refugee camp. The Karabakh Canal runs to the west of the site, beyond which is a rocky outcrop. The remainder of the area comprises featureless plains, with occasional areas of scrub and irrigation channels.

1.3 NOISE CONTROL CRITERIA

The criteria to be used for the pump station noise control design are under investigation. No Azerbaijan legislation or standards are understood to apply, with noise at work and industrial deafness protection being the only published requirements.

To comply with requirements applied routinely elsewhere in the world, an appreciation of background noise conditions is required, against which to determine the impact of proposed boundary noise levels. This is the basis for assessment under the British Standard BS4142: ‘Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas’, 1997.

This document and other standards will be reviewed and discussed with the relevant interested parties to establish design levels on the basis of the survey results contained within this report.

1.4 BASELINE NOISE SURVEY

Baseline noise measurements were made at eight locations during a survey visit between 31/10/01 and 03/11/01. Due to safety restrictions, manual observations were not possible at night. To gain an appreciation of the overnight noise climate, automated noise monitoring equipment was set to run continuously over 15 minute sample periods for a typical 24 hour cycle. Measurements of L_{Aeq}, L_{A90}, L_{A10}, and L_{Amax} were logged in this way, with remote data communications enabling night-time noise survey data to be accessed. A description of the acoustical terms used in this report is given in Appendix A of this report. Noise measurements were made using the following equipment:

1. Norsonic Type 116 Type 1 Precision sound level meter (4 off)

2. GRAS Type 41 AL Environmental Microphone (4 off)
3. Norsonic Type 1251 Acoustic calibrator
4. Seimens M20 T Data Phone Modem
5. Nokia 5110 Mobile Telephone
6. Dell Inspiron 7000 Laptop Computer

The meters were calibrated before and after the measurement period and no signal drift was found to have occurred.

All equipment holds current manufacturer's calibration certificates and conforms to relevant parts of IEC: 651: 1979 (equivalent to BS 5969: 1981) for the requirements of type 1 acoustic accuracy. Additionally, the equipment conforms to specifications contained within IEC 804: 1985 (equivalent to BS 6698: 1986) for integrating Sound Level Meters. Fast meter response and freefield settings were used for all measurements carried out during the survey.

Measurements were made generally in accordance with BS 7445:1991 'Description and measurement of environmental noise' Part 2: 'Acquisition of data pertinent to land use'.

At all locations the microphone was either mounted on a stake approximately 1.5 metres above ground level or operated by hand at the same height.

Environmental windshields were used at all times throughout the survey. Weather conditions were dry throughout the measurement period, although windspeeds varied. In general, weather conditions became progressively better throughout the survey. The representative 24 hour period selected contained the most calm wind conditions to provide the closest measurement of underlying ambient noise climate conditions. The following measurement positions were used, of which locations 1 and 2 were the automated monitors, and locations 3 to 8 were used for comparative satellite measurements.

Location 1: In the centre of the site area, at KP243.5 as identified by handheld GPS.

Location 2: At nearest residential property to the north-west of the site. The location was at a bearing of 322E from KP243.5.

Location 3: 25m to the east of the electrical sub-station located by the point at which the existing western export pipeline crosses the Karabakh Canal.

Location 4: At the roadside edge of the small track running parallel to the Karabakh Canal, level with the refugee camp to the east.

Location 5: At 10m to the south of the main road crossing of the Karabakh Canal.

Location 6: At KP257 of the existing WREP, representative of background noise levels close to the residential properties to the east.

Location 7: South of KP243.5, at the margin of the field in which the development is proposed.

Location 8: North of KP243.5, close to the northernmost point of the proposed pump station site (northern option).

1.5 RESULTS

The results of the overnight monitoring survey are shown in Figures 1-2 and 1-3. Manual measurements are tabulated in Table 1.

Table 1 Manual noise measurements

Time	Position	L_{Aeq}, dB	$L_{A\ Fmax}$, dB	L_{A10}, dB	L_{A90}, dB
13:09	3	61.2	67.7	62	60.2
13:25	4	56.8	76.3	58	35.9
13:54	5	61.2	74.6	65.5	46.7
14:18	8	29.6	45.2	32.2	25.9
14:34	6	41.2	65.5	42.4	36.2
14:36	6	50.3	68.7	53.3	37
14:54	7	38.5	64.3	39.6	32.7
15:11	6	41.5	56.2	43.8	35.5
15:14	6	46.1	71.3	50.6	34.9

From these measurements, and from the detailed daytime satellite measurements at measurement positions 3 to 8, the following daytime and night-time background noise minima have been derived

For the purposes of this report, a 24 hour period has been divided into daytime (07:00- 23:00) and night-time (23:00-07:00). The results are summarised in Table 2.

Table 2 Summary of measured noise levels

Location	Daytime	Night time	Comment
	L_{A90}, dB	L_{A90}, dB	
1	32	22	
2	36	31	
3	60	60	Electricity Substation Noise
4	34	31	
5	39	35	
6	34	34	Irrigation Channel Noise
7	29	22	

Location	Daytime	Night time	Comment
	L_{A90}, dB	L_{A90}, dB	
8	31	25	

The above measurements represent minimum measured background levels at positions 1 and 2 only. The data presented for positions 3 to 8 give an approximate indication of minimum levels, particularly at night, due to the lack of site access.

1.5.1 Daytime

During the daytime period the noise environment at all locations (except 3) was dominated by local activity, agricultural machinery and at positions close to roads, by individual traffic movements. Traffic along the main east-west road running through Yardili was generally sporadic, with occasional busy periods. Traffic noise levels were relatively high, however, due to the poor road surface and poorly maintained, noisy vehicles (particularly HGVs).

Noise levels at position 3 were entirely dominated by the neighbouring electricity sub-station. It should be noted that a family residence is located immediately adjacent to this noise source.

1.5.2 Night-time

Measured background L_{A90} noise levels during the survey period were in the range 22 to 30 dB(A) at the monitoring locations. These background noise levels were considered to be typical of a rural/agricultural area during the night.

From preliminary noise propagation calculations, it has also been established that noise levels at all sensitive receptors around the site will be maintained above at least 20 dB(A) due to the continuous operation of the electrical sub-station at location 3.

1.6 CONCLUSIONS

An extensive background noise survey has been carried out in the region of the proposed pump station site at KP243.5.

Noise levels were relatively low, being consistent with the rural nature of the local environment. The night-time noise climate, however, was affected by the continuous operation of an electrical sub-station / transformer house close to KP259 of the WREP.

Site noise emissions criteria will be defined on the basis of these survey results, for the assessment and control of noise impact due to both construction and operational phases of the development.

APPENDIX A - ACOUSTIC TERMINOLOGY & HUMAN RESPONSE TO BROADBAND NOISE

Acoustic Terminology

The annoyance produced by noise is dependent upon many complex interrelated factors such as `loudness', its frequency (or pitch) and any variations in its level. In order to have some objective measure of the annoyance, scales have been derived to allow for these subjective factors.

dB (A): The human ear is more susceptible to mid-frequency noise than the high and low frequencies. To take account of this when measuring noise, the `A' weighting scale is used so that the measured noise corresponds roughly to the overall level of noise that is discerned by the average human. It is also possible to calculate the `A' weighted noise level by applying certain corrections to an un-weighted spectrum. The measured or calculated `A' weighted noise level is known as the dB(A) level.

L_{10} & L_{90}: If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time, hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the `average maximum level'. Similarly, L_{90} is the average minimum level and is often used to describe the background noise.

It is common practice to use the L_{10} index to describe traffic noise, as being a high average, it takes into account the increased annoyance that results from the non-steady nature of traffic noise.

L_{eq}: The concept of L_{eq} (equivalent continuous sound level) has up to recently been primarily used in assessing noise in industry but seems now to be finding use in defining many other types of noise, such as aircraft noise, environmental noise and construction noise.

L_{eq} is defined as a notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (e.g. 1 hour).

The use of digital technology in sound level meters now makes the measurement of L_{eq} very straightforward.

Because L_{eq} is effectively a summation of a number of noise events, it does not in itself limit the magnitude of any individual event, and this is frequently used in conjunction with an absolute noise limit.

L_{max}: L_{max} is the maximum sound pressure level recorded over the period stated. L_{max} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the L_{eq} noise level.

Octave Band Frequencies

In order to determine the way in which the energy of sound is distributed across the frequency range, the International Standards Organisation have agreed on ‘preferred’ bands of frequency for sound measurement and analysis. The widest and most commonly used band for frequency measurement and analysis is the Octave Band. In these bands, the upper frequency limit is twice the lower frequency limit, with the band being described by its ‘centre frequency’ which is the average (geometric mean) of the upper and lower limits, eg. 250 Hz octave band runs from 176 Hz to 353 Hz. The most commonly used bands are 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz.

Earth Bunds and Barriers - Effective Screen Height

When considering the reduction in noise level of a source provided by a barrier, it is necessary to establish the ‘effective screen height’. For example if a 3 metre high barrier exists between a noise source and a listener, with the barrier close to the listener, the listener will perceive the noise source is louder, if he climbs up a ladder (and is closer to the top of the barrier) than if he were standing at ground level. Equally if he sat on the ground the noise source would seem quieter than it was if he were standing. This may be explained by the fact that the ‘effective screen height’ is changing with the three cases above, the greater the effective screen height, in general, the greater the reduction in noise level.

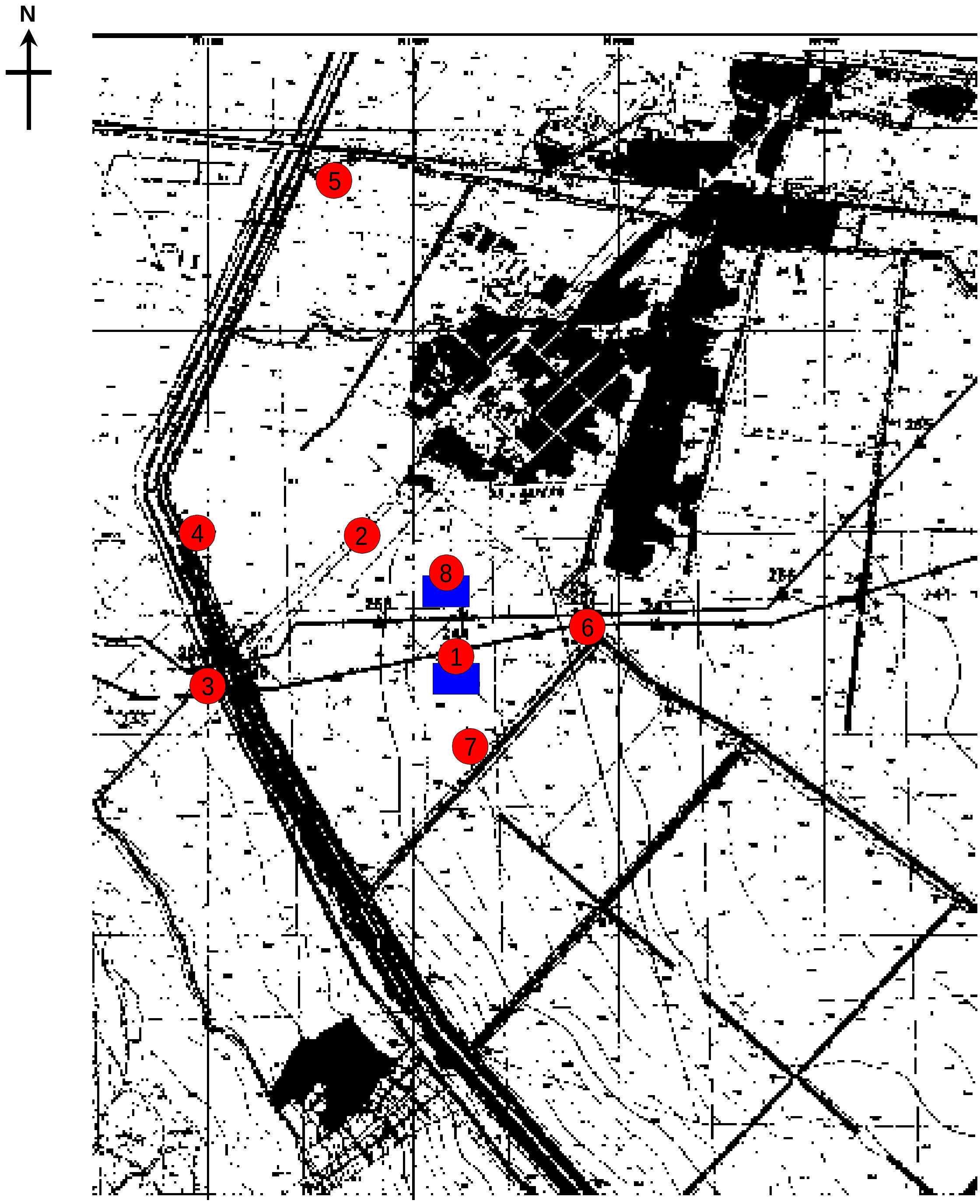
Where the noise sources are various roads, the attenuation provided by a fixed barrier at a specific property will be greater for roads close to the barrier than for roads further away.

Human Perception of Broadband Noise

Because of the logarithmic nature of the decibel scale, it should be borne in mind that noise levels in dB(A) do not have a simple linear relationship. For example, 100dB(A) is not twice as loud as 50 dB(A) sound level. It has been found experimentally that changes in the average level of fluctuating sound, such as traffic noise, need to be of the order of 3 dB(A) before becoming definitely perceptible to the human ear. Data from other experiments have indicated that a change in sound level of 10 dB(A) is perceived by the average listener as a doubling or halving of loudness. Using this information, a guide to the subjective interpretation of changes in traffic noise level can be given as shown in Table 3.

Table 3 Subjective interpretation of traffic noise levels

Change in Sound level dB(A)	Subjective Impression	Human Response to noise
0 to 2	Imperceptible change in loudness	Marginal
3 to 5	Perceptible change in loudness	Noticeable
6 to 10	Up to a doubling or halving of loudness	Significant
11 to 15	More than a doubling or halving of loudness	Substantial
16 to 20	Up to quadrupling or quartering of loudness	Substantial
21 or more	More than a quadrupling or quartering of loudness	Very Substantial



Approximate locations of proposed pumping station

ALAN SAUNDERS ASSOCIATES
Consultants in Acoustics, Noise & Vibration
Westgate House
39-41 Romsey Rd.
Winchester
SO22 5BE
t: 01962 872 130
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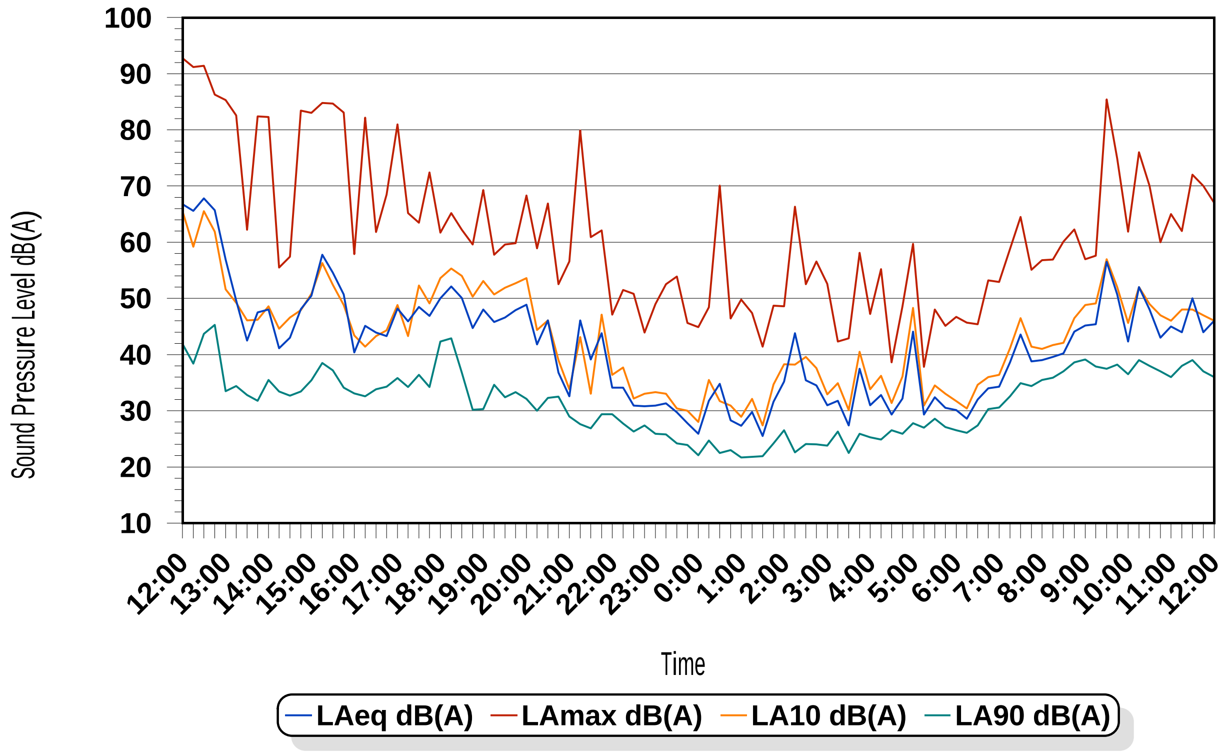
Title: Site plan showing approximate location of noise measurement positions.

Project: BTC Pipeline Pumping Station at KP244, Azerbaijan.	Date: 14/11/2001 Scale: NTS	Figure No: 1-1

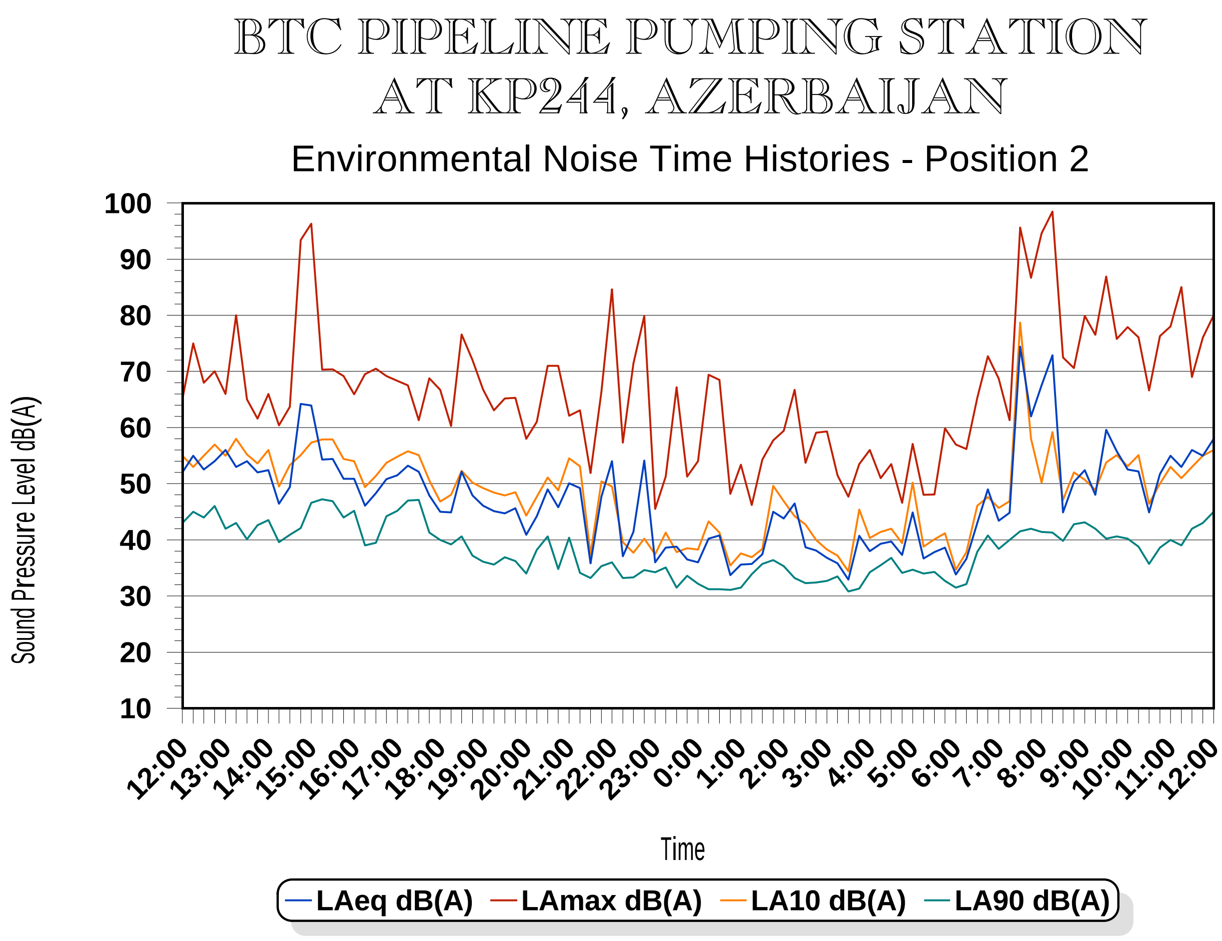
BTC PIPELINE PUMPING STATION AT KP244, AZERBAIJAN

Environmental Noise Time Histories - Position 1



Thursday 1st to Friday 2nd November 2001

Figure 1-2



Thursday 1st to Friday 2nd November 2001

Figure 1-3

NOISE MODELLING

1 NOISE MODELLING

1.1 POSTSCRIPT:

1. *An alternative location for the pump station is currently being assessed. The new location is a parcel of municipal land to the west of the site discussed in this report, and to the east of the road that runs parallel to the Karabakh Canal. It is likely that the environmental factors associated with the alternative location will be similar to, or less than, those assessed for the current location. However, specific environmental assessments will be conducted for the new site should the engineering studies indicate that re-siting would constitute a preferable option. One of the key reasons for assessing the possibility of locating the pump station in the area of municipal land is to reduce impacts on agricultural land in the vicinity of the current location.*
2. *This modelling was undertaken in November 2001 using the design data available at that time. Some design changes have subsequently been carried out to reduce noise emissions and boundary limits have been adjusted to reduce the risk of disturbance. These changes are reflected in the text of the ESIA and further modelling is proposed.*

1.2 SUMMARY

Alan Saunders Associates has been commissioned by AETC to undertake a noise assessment of the proposed PS-A2 pump station at KP442 on the proposed BTC pipeline in Azerbaijan. The pump station is situated approximately 1 kilometre from the medium sized village of Yardili.

A background noise survey has established the current noise climate in the area surrounding the pump station. Relatively low background noise levels indicate that a 30dB(A) noise emissions criterion would be desirable, although background levels are higher in some locations. A level 35dB(A) should be considered as the upper limit of acceptability for noise emissions to the community, considering the advice given in BS 4142 [1].

Pump station proposals available at the time of writing suggest that a 60dB(A) boundary limit will be imposed at the perimeter of the site, based originally on the limited guidance available for impact on wildlife and incorporated into the project specification. A noise propagation model has been created based on the assumption that this level is achieved at the boundary fence by generic point noise sources distributed throughout the pump station footprint.

The results of the model show that compliance with the boundary limit is unlikely to provide sufficient mitigation to the nearest residents, although the majority of the village of Yardili falls outside the 35dB(A) upper limit contour.

A noise reduction in the order of 5dB(A) is required, therefore, to bring the majority of the surrounding area below 30dB(A), with a small number of properties exposed to levels in the marginal range of 30 to 35dB(A). A site boundary limit of 55dB(A) could be used to achieve this, although more detailed modelling of the actual plant proposed would provide for more pragmatic plant noise control options.

[1] BS4142: '*Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas*', 1997

Engineering noise control measures on noisier items of equipment would be enhanced by means of additional air path attenuation, local plant lagging and enclosure, plus plant buildings as appropriate. Some inherent screening is likely to also be provided by buildings and installations, more details of which will become available as the pump station design evolves.

1.3 NOISE EMISSIONS CRITERIA

The World Health Organisation [2] recognises that adverse health affects due to community noise levels occur above about 45dB(A). In otherwise quiet environments, however, noise levels below this threshold can be intrusive and are often the cause of complaints. This is particularly evident when noise sources are not 'anonymous' or transient, like traffic, but are clearly identifiable as the result of a neighbouring activity.
At very low noise levels, however, even in comparison with lower background conditions, the lower extent of the human dynamic hearing range is approached and the benefit of further reductions becomes increasingly marginal.

This is recognised in the British Standard BS4142 which states in it's scope that *'..background noise levels below about 30dB and rating levels below about 35dB are considered to be very low'*.

1.4 NOISE PROPAGATION

In assessing noise propagation to the atmosphere, meteorological affects only become significant at distances greater than approximately 200 metres. Atmospheric temperature and pressure have a relatively minor influence in that they have an influence on the nature of sound absorption in the air. This is a more significant phenomenon at higher frequency. Low frequency noise propagates more efficiently over distance, being less influenced by both air and ground absorption and by topographical screening affects.

Wind speed and direction can have a significant influence, however, since the medium through which noise is travelling is itself moving. The difference in received noise levels between upwind and downwind propagation in modest wind conditions can result in a modification of the received level in calm conditions by ±5dB(A). The affects of stronger wind conditions (significantly greater than 5m/s) are not generally of great concern, since otherwise prevailing background noise levels in such conditions tend to be significantly elevated.

An exception is in the context of very high noise level emissions, wherein comparisons with background conditions are less important than absolute levels, and in extreme cases the potential for noise induced hearing loss.

1.5 MODEL DETAILS

The noise model of the pump station has been produced using the SiteNoise2000 module of NoiseMap2000 prediction software. SiteNoise2000 is based on the methodology of BS5228 [3].

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[2] *'Guidelines for Community Noise'*: World Health Organisation, 1999.
[3] BS5228: *'Noise and Vibration Control on Construction and Open Sites: Part 1. Code of practice for basic information and procedures for noise and vibration control'*, 1997

The model is further enhanced by the inclusion of CONCAWE [4] soft ground attenuation and detailed frequency barrier attenuation calculations (NB no noise barriers are assumed in the Yardili model).

The model has been based on a notional sound pressure level L_{Aeq} 60dB at the site boundary generated by an array of generic point sources distributed across the pump station site. This is a worst case scenario as all boundaries of the site are unlikely to be exposed to 60dB(A) under normal operational conditions.

Operational noise levels emitted from the pump station are likely to be relatively constant with the majority of plant items running continuously. Some items that run intermittently will contribute less to the overall noise levels, but are more likely to attract attention during start up and shut down. All such plant items are assumed to run continuously to account for this effect, by allowing for their cumulative contribution during periods when they may be inactive.

A plot of results from the noise modelling exercise is shown in the attached figure. The contours shown are at a height of four metres above local ground level to represent noise levels at first floor window height and to minimise ground absorption effects. All source heights were assumed to be at this level also. The model assumes worst case meteorological effects in all directions. The noise contours plotted represent free field L_{Aeq} noise levels, with no allowance for building reflections.

[4] CONCAWE Report 4,81 *'The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighbouring Communities'*

LANDSCAPE AND VISUAL IMPACT - PUMP STATION PS-A2

List of Tables

List of Figures

1. LANDSCAPE AND VISUAL IMPACT OF PUMP STATION PS-A2

Postscript: *An alternative location for the pump station is currently being assessed. The new location is a parcel of municipal land to the west of the site discussed in this report, and to the east of the road that runs parallel to the Karabakh Canal. It is likely that the environmental factors associated with the alternative location will be similar to, or less than, those assessed for the current location. However, specific environmental assessments will be conducted for the new site should the engineering studies indicate that re-siting would constitute a preferable option. One of the key reasons for assessing the possibility of locating the pump station in the area of municipal land is to reduce impacts on agricultural land in the vicinity of the current location.*

1.1 Introduction

The overall landscape character of the proposed pumping station site PS-A2, and its surroundings is determined by the relationship between landform, landcover, landscape elements and climate.

Landscape is never static and is in a constant state of change. Change results from both natural processes and human activities. All landscapes have a relative sensitivity to change that is known as ‘landscape capacity’. The introduction of a new feature into an existing landscape, whether it be a commercial, agricultural, industrial or residential development, public open space or recreational uses, inevitably brings about change.

The capacity of the landscape to accommodate change, without deterioration or loss of its essential landscape character and quality, is as varied as the range of different landscape types present. Assessing the impacts of such change requires a clear understanding of the landscape character of the study area and its surrounding landscape.

The existing landscape character of the site and its environs is central to the issue of identifying whether or not a particular landscape can accommodate the proposed development without detriment.

1.2 Study Methodology

A landscape and visual assessment of the proposed pumping station site forms an integral part of the environmental impact assessment of the proposed development.

The landscape and visual impact assessment assesses the following:

1. Landscape impacts, including:

- Direct impacts upon specific landscape elements within and adjacent to the site
- Effects on the overall pattern of the landscape elements which give rise to the landscape character of the site and it’s surroundings
- Impacts upon any special interests in and around the site

2. Visual impacts:

- Direct impacts of the development upon views in the landscape

- Overall impact on visual amenity

As a matter of best practice the assessment has been undertaken in accordance with the advisory guidelines set out in the document - 'Guidelines for Landscape & Visual Impact Assessment', published by The Landscape Institute and Institute of Environmental Assessment (1995). Both the landscape and visual assessments include baseline studies which describe, classify and evaluate the existing landscape and visual resources, focusing on their sensitivity and ability to accommodate change.

The assessments were undertaken by AETC in October 2001.

Information was gathered from the following;

- Consultations with BP and the BTC design team regarding the development proposals
- Site visits and fieldwork to confirm data derived from available mapping and to identify and assess potential impacts

In conjunction with the landscape survey and assessment of the study area, a visual survey was undertaken to assess the potential visual impact of the proposed development. If the landscape is to absorb the development successfully, it must be integrated in a way that protects and, where possible, enhances the visual appearance of the landscape.

The potential visibility of the pump station site is dependent upon a range of factors, including location of viewpoint, angle of the sun, time of year and weather conditions. Of equal importance is whether the development is seen completely, or in part, above or below the skyline, where land provides a backdrop and where there is a complex foreground or an expansive landscape surrounding the view. In addition, the aspect of dwellings and whether the pump station is seen as a main view, or as an oblique view from a secondary window is also a consideration, as is direction or speed of vehicular and pedestrian travel.

In order to identify any critical viewpoints of the site, whether in the immediate locality or further afield, all principal and most minor roads within the surrounding the area were visited. Particular attention was paid to existing residential properties and public open spaces.

From information obtained during the survey of the site, it was possible to determine a number of viewpoints where the proposed pump station could cause a perceived visual impact. The viewpoints are summarised within Table 1.

Photomontage images were prepared for three of the viewpoints identified and these are presented as Figures 4 to 6. A visual impact schedule (Table 2) has been prepared, which summarises the results of the visual assessment survey, together with conclusions drawn from the photomontage study.

1.3 Baseline Conditions

The site of the proposed pump station is located approximately 0.75km to the south west of the village of Yardili, and approximately 2.78km south of the Baku-Tbilisi road crossing of the Karabakh Canal.

The area in which the proposed pump station will be situated is essentially an open, rural agricultural landscape. The landscape is characterised by predominantly flat topography with low lying open fields (arable and pasture) and large expanses of unmanaged grassland (see Figure 1).

A regular pattern of large rectilinear fields is defined by an extensive irrigation system of channels and linear spoil banks. Many of the irrigation channels support reeds and other marginal vegetation.

The settlement pattern of the area is of small, scattered villages linked to the major Baku – Tbilisi road. The villages, such as Yardili which is located a short distance from the proposed pump station site, are based on a grid system of minor, unmade roads, and are therefore often linear in nature. The villages feature a distinctive architecture of houses built from local, sandy-buff coloured stone, and corrugated sheet metalled roofs often with ornate details.

The majority of mature trees and vegetation within this landscape are within or close to the fringes of the villages; the trees are often fruit bearing, providing a valuable food source. In the wider context the vegetation and trees of the village have the effect of softening the hard lines of the built form and integrate the villages into the landscape (see Figure 1).

Figure 1 Landscape Character of the pump station site. View looking NE towards Yardili village across the flat, open, cultivated agricultural land.

The major Baku to Tbilisi road crosses the landscape in a generally east–west direction, north of the pump station site. The road is elevated as it crosses the Karabakh Canal, allowing road users extensive views towards the pump station site.

The Karabakh Canal is a major linear feature, approximately 1km to the west of the proposed pump station site, and crosses the landscape in a generally north-south direction. It is defined by large, wide embankments, which carry unmade tracks and overhead power lines, and elevate the canal in the landscape. This allows users to gain extensive views across the lower lying adjacent land.

Distant views may be gained in many directions across the flat open landscape, with views only occasionally interrupted by variations in topography such as the embankments of elevated road sections and canal banks, and the linear mounds associated with the irrigation system. The flat relief and the lack of any well-vegetated field boundaries contribute to the openness of the landscape. Views to the southwest are restricted, and are dominated by a line of hills that form a distinctive ridgeline of hummocks approximately 4km from the proposed pump station site (see Figure 2).

Figure 2 Landscape character of the pump station site. View looking W towards prominent hills across the flat, open, cultivated and pastoral agricultural land.

1.4 Characteristics of the Proposed Development

The proposed pump station site will have an area of approximately 71,571 m^2.

The development will comprise the following principal elements, which are each considered as part of the visual impact assessment (all heights are approximate):

- Pump driver stack – height approximately 25m
- Pump shelter - 10m
- Pump shelter building - 10m
- Sub-station building - 7m
- Warehouse and maintenance building - 6m
- Strainers maintenance shelter building - 5m
- Pig launcher/receiver shelters building - 5m
- Pump station control building - 5m
- Fire water pump house building - 5m
- Accommodation building - 4m
- Gatehouse building - 4m

Other features of the development include:

- Main access road from Yardili village, internal circulation roads, security fencing and a 3m high security wall
- A temporary construction and lay down facility area adjacent to the site
- Car parking
- Areas of hard standing for tankers for loading and off loading of fuel

1.5 Potential Impact of the Proposed Development

The greatest potential for visual impact as a result of the proposed development is the introduction of industrial type facilities into an essentially rural landscape. The pump station includes a small number of tall features in excess of 20m high, which will be visible as they protrude above the proposed security wall. The security wall will screen the majority of low-level facilities and associated structures.

1.6 Predicted Impact of the Proposed Development

Landscape and visual impacts will arise during both the construction and operational phases. The construction impacts will be temporary whereas the operational impacts will be long-term and relate to the various permanent structures associated with the pump station development. Impacts may result from the following aspects:

During construction

- Construction activities, including presence of large plant (particularly cranes), earthworks, temporary accommodation and storage areas

During operation

- Permanent features introduced as part of the pump station, including buildings and stacks
- Operational features, such as visible emissions, lighting
- Height above ordnance datum (AOD) of tall features

Potential impacts on the landscape resource were identified by considering the following issues:

- Aesthetic value of the landscape setting and its sensitivity to change
- Nature and value of any landscape resources likely to be lost due to development
- Visual relationship between the site and its setting

1.7 Landscape Character Impacts

The site and surrounding landscape is sensitive to change as a result of the proposed development. Sensitivity to change is based upon the combination of the areas individual character, aesthetic quality, and visual environment.

The impact on landscape character as a result of the pump station development is primarily a result of a change in land use from managed agricultural land, to that of an industrial complex, in an area which has no major industrial sites of any scale, and no significantly sized structures.

1.8 Visual Impacts

1.8.1 Visual Assessment Surveys

A number of viewpoints and sensitive receptors that may be affected by the development have been identified. Based on guidance referenced above, a sensitive receptor is defined as '*a viewer group that will experience impact*' .

As a result of the assessment of the visual survey, a total of 14 viewpoint locations have been selected. These are listed in Table 1, which also provides a grid reference and indicates the distance of the viewpoint from the centre of the site. The locations are depicted on Figure 3. The photographs of viewpoints 1-4, 6-9, and 10-13 are included in Appendix A of this report.

Table 1 Viewpoint locations

Viewpoint Number	Title	Easting	Northing	Distance from site (m)
1	View looking W from track at edge of village	8672507	4499643	5378
2	View looking SSE from track adjacent irrigation channel and mounds at edge of village	8666804	4500031	840
3	View looking S from periphery of field adjacent village	8667017	4500168	914
4	View looking SW from track at edge of village	8667897	4499769	909
*5	View looking SW from track at edge of village	8667749	4499713	756
6	View looking S from periphery of field adjacent irrigation channel at edge of village	8667335	4500040	801
7	View looking SSE from road/track on western embankment of Karabakh Canal	8666093	4501076	2095
8	View looking E from road/track on western embankment of Karabakh Canal	8666093	4499268	1049
*9	View looking NNE from minor road on western bank of Karabakh Canal	8666717	4498163	1178
10	View looking SE from minor road/residential properties at edge of village/refugee camp	8666481	4499809	858
11	View looking SSE from track adjacent irrigation channel and mounds at edge of village	8666891	4500132	905
12	View looking S from periphery of field adjacent village	8667124	4500182	920
13	View looking W from track at edge of village	8672397	4499202	5255
*14	View looking SSE from road, W of Karabakh Canal	8666407	4501945	2782

***** DENOTES PHOTOMONTAGE VIEWPOINT

1.8.2 Assessment of Impact

On completion of the detailed site survey and photographic study a visual impact was compiled (Table 2). The schedule provides a description of the existing view and assesses and quantifies the potential magnitude of the visual impact on the differing types of sensitive visual receptors.

1.8.3 Impact Magnitude and Receptor Sensitivity

In considering the visual impacts of the proposed pump station, it is important to take into account, in a systematic way, a combination of factors in order to draw consistent conclusions about impact significance. In accordance with the guidelines, impact significance can be defined as **'***a function of the sensitivity of the affected landscape and visual receptors and the magnitude of change that they will experience***'.**

Differences in receptor type correspond to variations in their susceptibility to visual impact. This is largely a function of their presumed sensitivity to the visual environment. Nearby residents are usually classified as the most sensitive receptor group as, if affected, they will see the site regularly.

1.8.4 Night-time Visual Impact

At night, the local landscape in the vicinity of the pump station is almost completely dark, with only very limited sources of light visible, primarily from the residential properties in the nearby village of Yardili. The local roads are unlit, with car headlights providing a temporary light source.

Once operational, elements of the pump station site will be lit at night, essentially for safety purposes. The potential for night time light pollution will be minimised by, for example, the use downlighters and/or cowls.

Figure 3 Photomontage and Photographic Viewpoint Locations

Table 2 Visual impact schedule pump station PS-A2

View Point No.	Location Easting, Northing, Elevation	Distance From Centre Of Site	Direction Of View/ Description	Receptor Type	Receptor Sensitivity	Magnitude Of Impact		
						High	Med	Low
1	8672507E 4499643N 62m + 1.6m**	5380m	View looking W from track at edge of village across flat, open expansive landscape of low-lying agricultural fields with few features.	Residential/ Minor Road	High			*
2	8666804E 4500031N 59m + 1.6m**	840m	View looking SSE from track adjacent to irrigation channel and mounds at edge of village across flat, open expansive landscape of low-lying agricultural fields with few features.	Footpath/ Track	High	*		
3	8667017E 4500168N 59m + 1.6m**	914m	View looking S from periphery of field adjacent village across flat, open expansive landscape of low-lying agricultural fields with few features.	Agricultural field	Low	*		
4	8667897E 4499769N 52m + 1.6m**	909m	View looking SW from track at edge of village along unmade track to irrigation channel and associated spoil embankments, with site beyond, and views to distinctive distant ridgeline of hummocks.	Footpath/ Track	High	*		
*5	8667749E 4499713N 58m + 1.6m**	756m	View looking SW from track/minor road at edge of Yardili Village across irrigation channel and associated spoil embankments, with site beyond, and views to distinctive distant ridgeline of hummocks.	Footpath/ Track / Minor Road	High	*		
6	8667335E 4500040N 56m + 1.6m**	801m	View looking S from periphery of field adjacent irrigation channel at edge of village across the flat open expansive landscape of low lying agricultural fields	Agricultural field	Low	*		
7	8666093E 4501076N 80m + 1.6m**	2095m	View looking SSE from minor road/track on western embankment of Karabakh Canal across low lying land featuring an unmade road and a line of telegraph poles in foreground, settlement in middle distance and distant hills beyond.	Minor Road	High		*	*

View Point No.	Location Easting, Northing, Elevation	Distance From Centre Of Site	Direction Of View/ Description	Receptor Type	Receptor Sensitivity	Magnitude Of Impact		
						High	Med	Low
8	8666093E 4499268N 72m + 1.6m**	1049m	View looking E from minor road/track on western embankment of Karabakh Canal. Sparsely vegetated embankments and telegraph poles feature in the foreground, with low lying flat fields in the middle distance and Yardili and associated trees and vegetation in the background.	Minor Road	High	*	*	
*9	8666717E 4498163E 61m + 1.6m**	1178m	View looking NNE from minor road/track on western embankment of Karabakh Canal. Sparsely vegetated embankments and telegraph poles feature in the foreground, with low lying flat fields in to the middle ground and Yardili and associated trees and vegetation in the background.	Minor Road	High	*	*	
10	8666481E 4499809N 60m + 1.6m**	858m	View looking SE from minor road/residential properties at edge of village/refugee camp. The view is dominated and restricted by tall vegetation associated with an irrigation channel.	Residential/ Minor Road	High	*		
11	8666891E 4500132N 69m + 1.6m**	905m	View looking SSE from track adjacent irrigation channel and mounds at edge of village. The view is dominated and restricted by tall vegetation associated with an irrigation channel.	Footpath/ Track	High	*		
12	8667124E 4500182N 67m + 1.6m**	920m	View looking S from periphery of field adjacent village across flat, open expansive landscape of low-lying agricultural fields with few features.	Agricultural field	Low	*		
13	8672397E 4499202N 53m + 1.6m**	5255m	View looking W from track at edge of village flat, open expansive landscape of low-lying agricultural fields with few features.	Residential/ Minor Road	High			*
*14	8666407E 4501945N 68m + 1.6m**	2782m	View looking SSE from major Baku – Tiblisi road west of Karabakh Canal crossing. View is dominated by the Karabakh Canal in the foreground and the well vegetated settlement in the middle distance	Major Road	High			*

*** DENOTES PHOTOMONTAGE VIEWPOINT** **** + 1.6m INDICATES HEIGHT OF CAMERA ABOVE GROUND LEVEL**

1.9 Mitigation

The following mitigation measures are recommended to minimise the potential and predicted magnitude of landscape and visual impacts:

- Minimising the apparent height and mass of the complex through the careful choice of design, plant layout and colour scheme. The walls of buildings, associated pipe work and stacks will be finished with a colour that is similar to that of the stone used in local buildings. Roofs of the buildings will be treated to blend with the distinctive metallic roofing material used in local buildings.
- The perimeter wall will be finished with local materials, if possible, to provide consistency with other buildings in the area
- The pump station has been positioned so that when seen from a distance it is viewed against distant horizons to make use of existing local topography as a backdrop
- Planting will be undertaken on the banks around the pump station to minimise land take. The introduction of native species planting, in a mix reflecting those species found in the general area, will help to screen and soften the hard lines of the proposed buildings and facilities

The effect such mitigation measures can be seen in the following photomontage views (Figures 4, 5 and 6) that depict the proposed pump station immediately after construction and after 5 years post construction.

Figures 4,– Photomontage views

Figures 5 – Photomontage views

Figures 6 – Photomontage views

1.10 Monitoring

Following completion of landscape planting, a period of post planting monitoring (aftercare) will be implemented. During this period the landscape planting will be subject to regular inspections by representatives of BTC Co to ensure the plants establish successfully.

1.10.1 Inspections

Typically monitoring operations include:

- Regular inspections, at least once every four months
- The identification and replacement of trees and shrubs that have died within the previous growing season
- Maintaining the site in a neat and tidy condition and maintaining all planting and grassed areas in a healthy condition.

1.10.2 Maintenance Operations

The aim of the monitoring period is to provide for the proper establishment and growth of all landscape planting by:

Replacement planting as necessary

- Weed control
- Irrigation
- Pruning of trees and shrubs
- Prevention of insect attack and disease
- Checking of tree stakes, ties, and protection from grazing animals
- Checking of windbreak fencing if used
- Re-firming planted trees and shrubs
- Removal of waste materials

.

1.11 Conclusions

The impact on the landscape character and visual amenity of the proposed pump station development area and its immediate environs is caused by introducing a large scale industrial facility into an essentially rural agricultural landscape.

The change in land use from managed agricultural uses to that of an industrial complex and the introduction of large buildings in an area that has no major industrial activities and no significantly sized structures is a considerable change.

In the wider landscape, the built form and mature trees of the nearby settlement restrict views to the development site. Positioning the proposed development adjacent to the village, together with the adoption of careful architectural detailing, and the introduction of landscape planting to soften and screen the hard lines of the buildings and structures will visually integrate the development with the settlement.

It is assessed that the impacts of the proposed development will diminish over time, particularly as the landscape planting matures, and the development becomes an established feature in the landscape.

BTC Co is keen to adopt a sensitive and sustainable design approach to integrating installations into the landscape whilst retaining and respecting landscape character.

Appendix A

Photographic Viewpoints

Figure 7 Viewpoint 1 - View looking W from track at edge of village

Figure 8 Viewpoint 2 - View looking SSE from track adjacent irrigation channel and mounds at edge of village

Figure 9 Viewpoint 3 - View looking S from periphery of field adjacent village

Figure 10 Viewpoint 4 - View looking SW from track at edge of village

Figure 11 Viewpoint 6 - View looking S from periphery of field adjacent irrigation channel at edge of village

Figure 12 Viewpoint 7 - View looking SSE from minor road/track on western embankment of Karabakh Canal

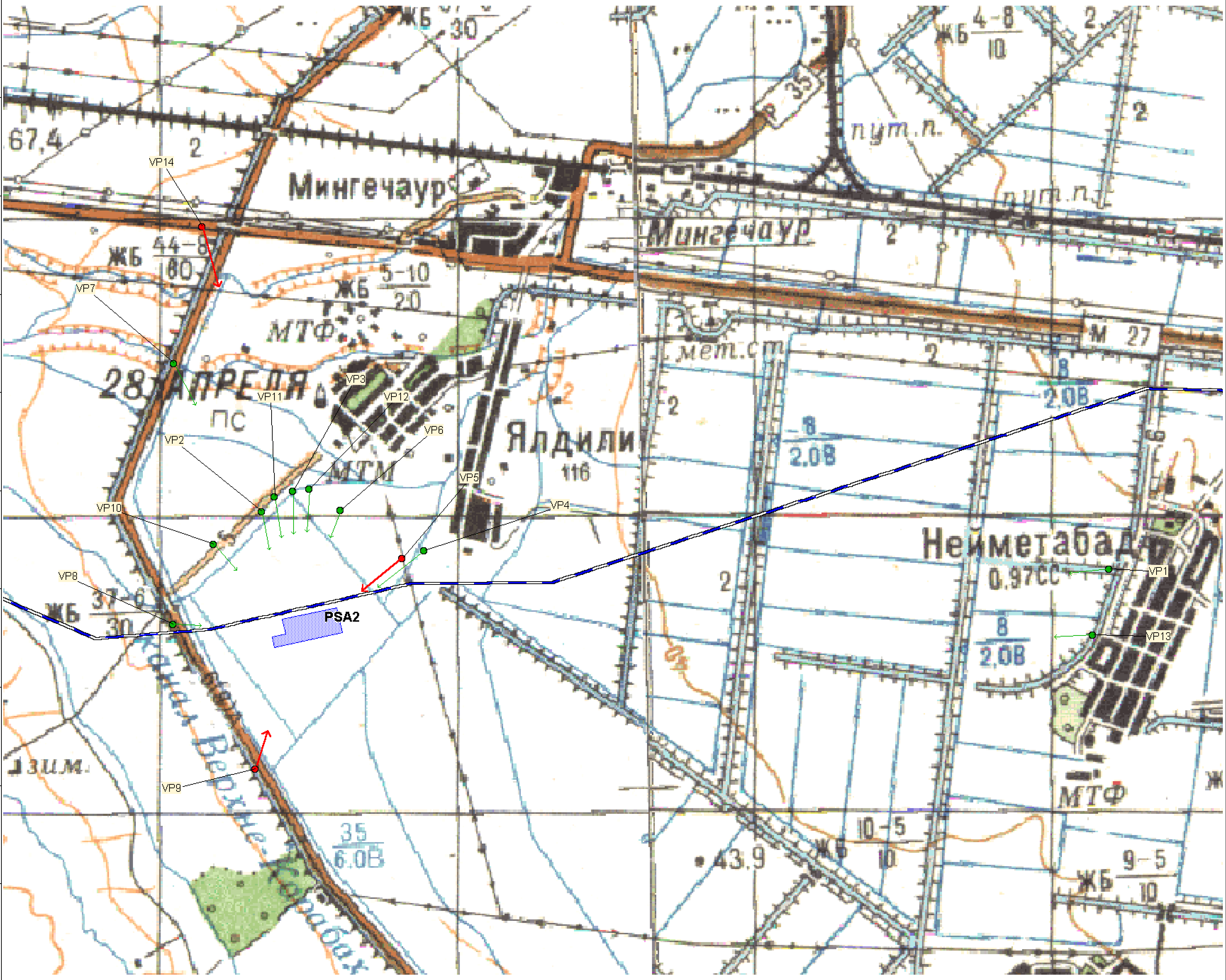
Figure 13 Viewpoint 8 - View looking E from minor road/track on western embankment of Karabakh Canal

Figure 14 Viewpoint 10 - View looking SE from minor road/residential properties at edge of village/refugee camp

Figure 15 Viewpoint 11 - View looking SSE from track adjacent irrigation channel and mounds at edge of village

Figure 16 Viewpoint 12 - View looking S from periphery of field adjacent village

Figure 17 Viewpoint 13 - View looking W from track at edge of village



- Proposed BTC Pipeline
- Pump Station Location
- Photographic Viewpoint Locations (with direction of view)
- Photomontage Viewpoint Location (with direction of view)

REV	DATE	DESCRIPTION	DRN	CHK	APP
02	13.03.02	Legend updated	MS	MS	WH
01	17.01.02	View point update	MS	MS	WH
00	12.12.01	FIRST DRAFT	DL	MS	NH

bp

BTC PIPELINE PROJECT

AETC
Azerbaijan Environment and Technology Centre

TITLE: **Figure 3: Photomontage and photographic viewpoint locations**

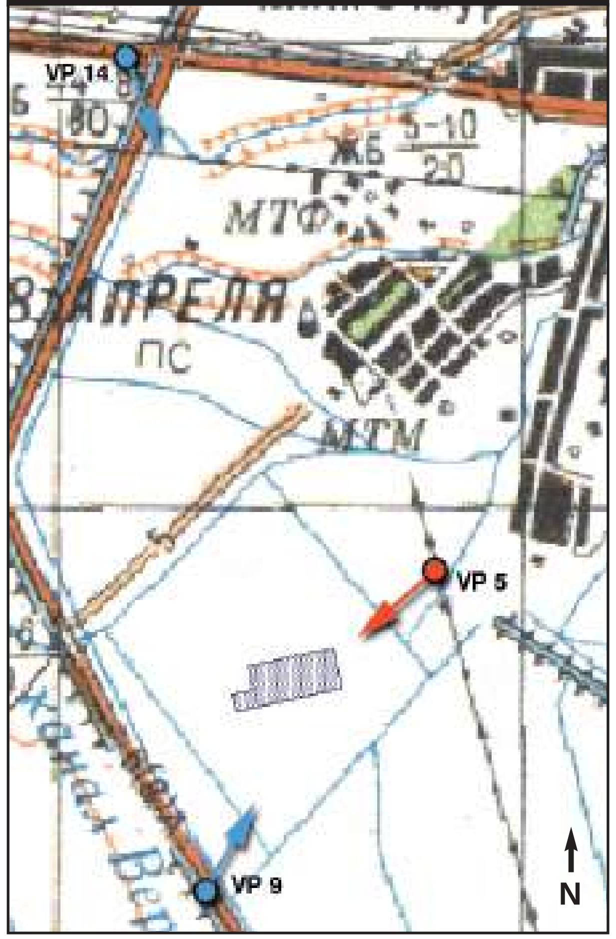
SCALE: 1:25,000 REV 02

FILE NAME:P8107viewpoints_rev01.WOR

BTC PIPELINE PROJECT, PUMP STATION PS-A2 VISUAL IMPACT ASSESSMENT

FIGURE 4: PROJECTED APPEARANCE AFTER COMPLETION

VIEWPOINT LOCATIONS



BTC PIPELINE PROJECT, PUMP STATION PS-A2 VISUAL IMPACT ASSESSMENT

FIGURE 4: PROJECTED APPEARANCE AFTER COMPLETION / 5 YEARS

VIEWPOINT DATA

TITLE: Viewpoint No.5

DESCRIPTION: View looking SW from track at edge of village

Date: 18/12/2001
Ground level of View Point: 58m AOD
Northing: 4499713
Easting: 8667749
Distance from Centre of Site: 756m
Date of Photograph: 2/11/01
Camera Height: 1.6m
Time of Photograph: 9.15am
Lens Type: 50mm

Rooves:
e.g Corus Colourcoat
HPS200 Hamlet SC

Buildings Stacks & Pipework:
e.g Corus Colourcoat
HPS200 Honesty SC

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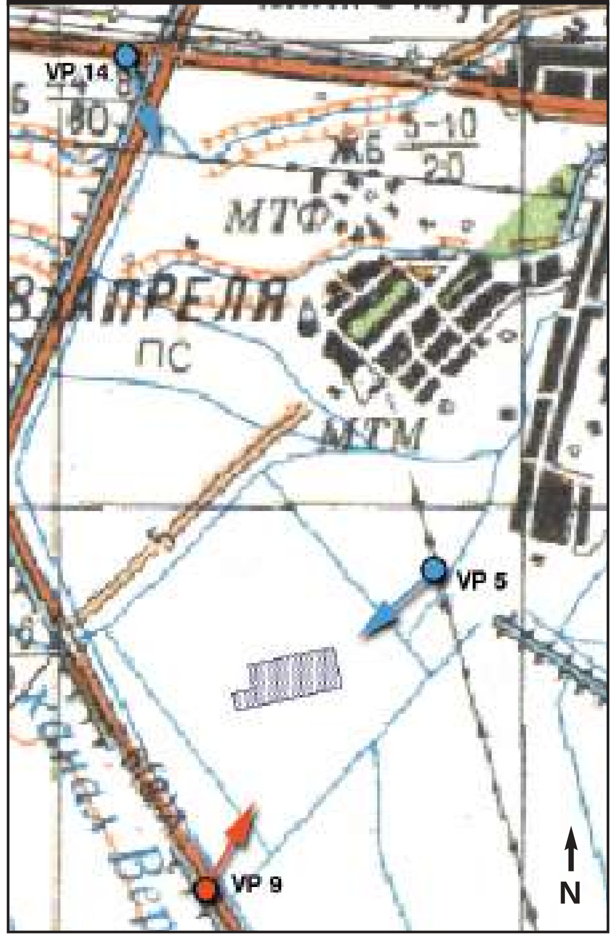
FIGURE 5: PROJECTED APPEARANCE AFTER COMPLETION

VIEWPOINT LOCATIONS



BTC PIPELINE PROJECT, PUMP STATION PS-A2 VISUAL IMPACT ASSESSMENT

FIGURE 5: PROJECTED APPEARANCE AFTER COMPLETION / 5 YEARS

VIEWPOINT DATA

TITLE: Viewpoint No.9

DESCRIPTION: View looking NNE from minor road to W of Karabakh Canal Crossing

Date: 18/12/2001	
Ground level of View Point: 61m AOD	
Northing: 4498163	
Easting: 8666717	
Distance from Centre of Site: 1178m	
Date of Photograph: 2/11/2001	
Camera Height: 1.6m	
Time of Photograph: 2.00pm	
Lens Type: 50mm	

Rooves:
e.g. Corus Colourcoat
HPS200 Hamlet SC

Buildings Stacks & Pipework:
e.g. Corus Colourcoat
HPS200 Honesty SC

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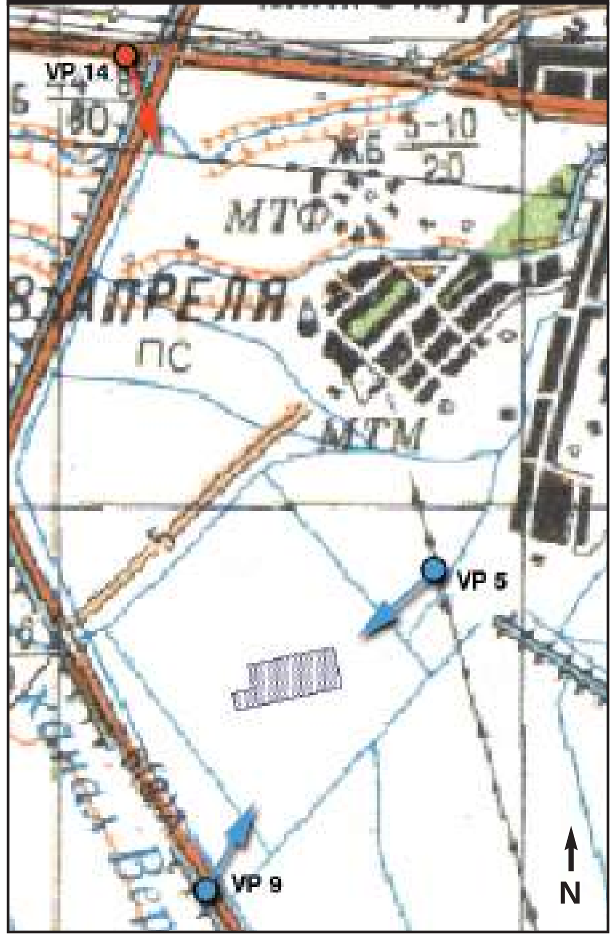
BTC PIPELINE PROJECT, PUMP STATION PS-A2 VISUAL IMPACT ASSESSMENT **FIGURE 6: PROJECTED APPEARANCE AFTER COMPLETION**

VIEWPOINT LOCATIONS



BTC PIPELINE PROJECT, PUMP STATION PS-A2 VISUAL IMPACT ASSESSMENT **FIGURE 6: PROJECTED APPEARANCE AFTER COMPLETION / 5 YEARS**

VIEWPOINT DATA

TITLE: Viewpoint No.14

DESCRIPTION: View looking SSE from major road W of Karabakh Canal Crossing

Date: 18/12/01
Ground level of View Point: 68m AOD
Northing: 8666407
Easting: 4501945
Distance from Centre of Site: 2782m
Date of Photograph: 2/11/01
Camera Height: 1.6m
Time of Photograph: 3.45pm
Lens Type: 50mm

Rooves: e.g. Corus Colourcoat HPS200 Hamlet SC	Buildings Stacks & Pipework: e.g. Corus Colourcoat HPS200 Honesty SC

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