At present, the Ishim River is evaluated as "Moderately Polluted" according to the classification in (1) above.

Quality of Water Resources at Present

Resources	Location	Category	Contamination
Ishim River	U/S of Vyacheslavsky reservoir	Class II	potable
	D/S of Astana City	Class III	moderate

Source : KAZGIPROVODHOZ Report, 1997

Major part of the pollution load to the Ishim River is wastewater generated in Astana. Suitable treatment of wastewater is the single most important measure for water pollution control.

6.3.2 Air Pollution

(1) Standards

The air quality standard in RK on the other hand sets the permissible level of pollution (PLP) on 14 air quality items. On the international sphere, the standards prepared by the World Health Organization (WHO) stipulate the level of air quality on 6 items, including sulfur dioxide, nitrogen dioxide, carbon dioxide, total suspended participate (TSP) and particulate matter less than 10 micrometer in diameter (PM10) in view of the protection of human health. In comparison, the Kazakhstan standards are in most items much more stringent than the WHO standards, except for TSP. A comparison of the two standards is summarized in the table below.

Comparison of Kazakhstan Standard and WHO Guidelines on Air Quality Criteria

Pollutant	Averaging time	WHO Guideline (1)	Kazakhstan Standard
Sulfur dioxide	Maximum Occasional 1 hour 24 hours 1 year	-- 0.35 mg/ m^3 0.125 mg/ m^3 0.05 mg/ m^3	0.5 mg/ m^3 0.05 mg/ m^3 --
Nitrogen dioxide	Maximum Occasional 1 hour 24 hours	-- 0.3 mg/ m^3 0.1 mg/ m^3	0.085 mg/ m^3 -- 0.04 mg/ m^3
Carbon monoxide	Maximum Occasional 1 hour 8 hours	-- 30 mg/ m^3 10 mg/ m^3	5 mg/ m^3 -- 3 mg/ m^3
Total Suspended Particulate (TSP)	Maximum Occasional 24 hours 1 year	-- 0.15 mg/ m^3 0.09 mg/ m^3	0.5 mg/ m^3 0.15 mg/ m^3 --
PM10	24 hours 1 year	0.1 mg/ m^3 0.06 mg/ m^3	-- --
Lead	Maximum Occasional 3 months	-- 0.001 mg/ m^3	0.003 mg/ m^3 --

Data Source: Recommended Air Quality Guidelines for the Western Pacific Region, WHO, December 1995.

(2) Present Issues

The city of Astana is located on a vastly open and predominantly flat terrain. Winds are strong throughout the year, which help bring in fresh air and dissipate even polluted atmosphere to a large extent. Compared with Almaty, which is located in a basin like topography surrounded by high mountains, Astana has a considerable advantage with regard to the atmospheric pollution.

According to the results of air quality monitoring carried out by Hydro-meteorological Center on NOx, SOx, CO, HF and TSP, the air quality in Astana are found to be within the permissible level of pollution (PLP) established in the Kazakhstan standards, with the only exception being TSP. Staple of TSP, the total suspended particle, is dust. The semi-dry climate with average annual precipitation of little more than 300 mm is presumably part of the reasons that TSP exceeds PLP.

6.3.3 Noise

According the Kazakhstan standard, PLP for noise is set at 45 dB in newly developed residential area and 55 dB in existing residential area.

Noise surveys along main streets in Astana City were carried out between 1991 and 1996. Accordingly, the noise levels along the eight (8) main streets were found to exceed 70 dB. Along the railway track, records show that the noise levels 7.5 m away from the track are estimated between 68 and 102 dB;100 m away from the track 46 and 80 dB. SNiP defines the permissible noise level in residential area at 55 dB. The above shows that some part of the residential area along the main streets and railway track do not conform to this PLP level, even at present.

The international airport of Astana City is another main source of noise. According to simulation analysis by Kazaeroproject, permissible levels of noise would be exceeded in some area along the Nura-Ishim canal. In other area noise would be controllable by noise-suppressing structures.

Particular attention needs to be paid to the noise level in residential areas at night, as this closely relates to the well-being of residents.

6.4 Mitigation Measures Adopted in this Master Plan

Development and expansion of a city generally would cause, among others, increase in generation of wastewater and solid waste and emission of air pollution. This would normally lead to increase in the pollution loads on the environment. Such increase in pollution loads will normally materialize in the form of worsening air quality, water quality, noise levels, etc. In order for preparing Master Plan for city development that will establish the basis on which to create and maintain pleasant and sustainable living environment, an appropriate environmental framework needs to be established. For this purpose, basic principles for countermeasures to mitigate the expected negative impacts caused by the development are essential.

The present Master Plan has adopted a number of measures to safeguard the quality of the natural and urban environment. The following Sub-sections will discuss the already embedded specific measures for mitigating possible effects in this Master Plan.

6.4.1 Aquatic Environment

Preservation of the aquatic environment could be achieved by combination of three essential measures; securing sufficient flow in the river; control of pollutant load; and better treatment of effluent. The following describes the specific measures adopted in this Master Plan in each category

(1) Securing of sufficient flow in the river

Sanitary flow discharged from Vyacheslavsky Reservoir replenishes and helps maintain the aquatic environment in Astana. The proposed water balance includes increased amount of water not only for Astana but also for the areas downstream of Astana. In addition, supplementary considerations were made on the landscaping and miscellaneous use of water, which includes the water for the replenishment of the water impounded in Astana City. He details of water requirement estimation is presented in Sub-section 4.2.2,

(2) Taldy Kol Reservoir

It is planned to reduce treated wastewater discharge to Taldy Kol Reservoir, in order to decrease size of and the water level therein. The plan of sewerage system development plan related to Taldy Kol Reservoir is described in sub-section 4.4.3.

(3) Control of pollutant load

The most effective and lasting measure for avoiding the deterioration of aquatic environment is to control the pollutant. In this Master Plan, the following measures to control the pollutant load is embedded.

1) Expansion of Sewerage Service Area

According to the sewerage development planning described in Section 4.4 of this Report, the service population of sewerage service will increase from the current 73% to 86% in 2010, 93% in 2020 and 95% in 2030 (Refer to Sub-section 4.4.2). This will considerably control the emission of untreated municipal effluent to be discharged to the natural water body. To achieve this, the rehabilitation and installation of sewage pipes were adopted in this Master Plan.

2) Improvement of Solid Waste Collection

Municipal solid waste (MSW), if not properly collected, shall become secondary source of water contamination. According to the solid waste management plan in this Master Plan, the collection rate of MSW is planned to be raised from the current 80% to 100% in 2020. Better collection of MSW will allow urban resident to easily dispose the waste at the generating end, and contribute to the reduction of pollutant load.

3) Better management of landfill

There is certain level of apprehension about the water-tightness of the city's landfill where most of the solid waste is dumped. If not water tight, the landfill site may create contamination of water, particularly groundwater. The solid waste management plan discussed in Section 4.8 stipulates early closure of the existing landfill site with the covering of the surface by reclamation soil. New landfill proposed in this Master Plan shall be equipped with leachate control and environmental monitoring devices (Refer to Sub-section 4.8.5).

(4) Better treatment of effluent

One of the most crucial measures proposed in this Master Plan pertinent to the preservation and enhancement of aquatic environment is the rehabilitation and future expansion of the sewerage treatment plant (STP), as discussed in full in Section 4.4. The existing STP shall be rehabilitated and maintained for use in the next 20 years, while new capacity at the same site will be added. After about 20 years of extended operation, the existing and rehabilitated STP equipment will be reconstructed.

In the new development areas mostly on the left bank of the Ishim, generated sewage shall be collected and transmitted to the same STP, which will harness the effective removal of pollutant load that would otherwise be discharged directly to the water bodies.

In the future, advance treatment facilities are proposed to be in operation. With the advance treatment, the quality of treated water shall further be improved considerably, which will further lessen the negative impact on the environment.

6.4.2 Atmospheric Environment

Preservation of atmospheric environment could be achieved in essence by reducing the pollutant load emitted to the atmosphere. Effects of atmospheric pollution depend on the diffusion due mainly to winds, and thus the appropriate siting of pollution source will be of concern, too.

(1) Reducing the pollutant load at TETs

One of the major sources of pollution load in Astana is the city's thermal power plants, *TETs*-1 and 2. In general, the boilers have been in operation for extended period of time and the pollution control devices adopted are also old. Along with the capacity expansion of power generating units, facilitation of air pollution management is proposed in this Master Plan, which will include;

- Adoption of boiler with combustion control technologies to minimize NOx emission
- Installation of an electrostatic precipitator to collect dust particles in the flue gas

- Installation of a flue gas desulfurization plant to remove sulfur oxide in the flue gas

(2) Consideration of alternative energy source at TETs

As discussed in Sub-section 4.1.4, this Master Plan presumes that natural gas will be available as an alternative energy option for Astana after the year 2010. The real availability will depend the economic viability yet to be tested in the on-going feasibility conducted following the bilateral agreement between the RK and Russian Federation. When and if natural gas is made available economically for Astana, the energy mix for the power and heat supply of Astana will be changed drastically.

Natural gas is a highly environmentally favorable energy option for Astana, as the combustion of natural gas produces little or no pollution load. In the Master Plan, natural gas-fired thermal power plants and regional heat centers are considered for the future (Refer to Sections 4.5.3 and 4.5.4).

(3) Better control of automobile exhaust

Automobiles in general are another staple source of air pollution. As depicted in Sub-section 3.9.3(1), the number of automobile trips is bound to increase with the progress of economic growth in Astana. Increased occurrence of congestion shall add to the atmospheric pollution load.

The basic concept for the transportation planning in this Master Plan is avoidance of traffic concentration anywhere in the city, by providing ring roads for circular and bi-pass traffic for fluent traffic movement in the urban area. This will facilitate not only reduce exhaust gas but also keep it away from the center of the city.

Enhancement of public transport means is another way of achieving efficient transportation system (Refer to Sub-section 3.9.3(1)). Exhaust-free public transport means such as trolley buses will be maintained to service the business areas. In future, introduction of LRT system will also be facilitated which will lessen the dependency on the individual automobile transport.

6.4.3 Noise

High level of noise imposes nuisance to urban dwellers. Aside from the temporary activities related to construction works and transportation necessitated thereby, there are two major sources of harmful noise; automobile traffic and airplanes taking off (and landing at) the airport. Locational factor is also imperative, as the noise level is known to reduce quickly with the distance from the source.

(1) Reducing the noise effects from automobile traffic

Better control of traffic flow discussed in Sub-section 6.4.2(3) above also applies to the reduction of noise generated by automobiles. Diverting a substantial part of traffic flow to the proposed outer ring roads is the most effective measures in terms of noise reduction. Wide road with robust hierarchy structure as discussed in Sub-section 3.9.3(2) will help mitigate the effects of noise to urban dwellers.

Some of the townscaping measures such as providing tree lining along major streets and wide sidewalks, proposed in Sub-sections 3.8.3 3.8.4 and 3.8.5, will have effects of mitigating the impacts of noise to neighboring residents along major streets.

(2) Mitigation of noise impacts of airport

The International Airport of Astana, which is now being refurbished into a full-fledged international standard airport, may cause some apprehension as a possible source of noise. In general airplanes generate larger noise at the time of lift-off than touch down. The runway of the airport could be used in two directions NE and SW. Critical noise may thence occur at the time of lift-off to NE, in which case the airplane shall fly over the SE fringe of the proposed residential areas. The possible noise could also depend on the type of aircraft; a B727 will impose the "footprint" of high noise contour on the ground area, which is about 6km long and 1 km wide.

Spatial alignment of residential areas were carefully contemplated in this Master Plan to avoid serious impacts that could be inflicted in residential areas from the noise of airplanes. Between April and July, 2000, when the Master Plan drawings were modified, residential areas immediately below or within 1 km from the flight line were removed. The phasing of residential development were contemplated duly so that the areas close to the flight line would be done only after 2020, by which time more elaborate information will be available for any necessary changes of residential allocation.

6.4.4 Preservation of Fauna and Flora

In order not to disturb the existing fauna and flora with conservation value, the following mitigations were adopted in this Master Plan. If deemed necessary, more detailed study and assessment of environmental impact shall be conducted at the time of project implementation.

(1) Preservation of eco system along Ishim

As discussed in depth in Section 3.10, this Master Plan considers the greenery along the Ishim River as a major greenery axis to prevent disorderly expansion of urban areas. In the land use plan of the Master Plan, as depicted in Section 3.6, preservation of green buffer is clearly maintained not only along the Ishim, but also along two major tributary streams joining the Ishim River. The riverine areas are in general a crucial element of wild life habitat. Preservation of this riverine area constitutes an imperative factor for the preservation of fauna and flora. Water quality improvement measures already discussed in Sub-section 6.5.1 above will further effectuate this preservation.

(2) Careful alignment of new development

In Sub-section 6.2.2 (2), it was pointed out;

From geo-technical and financial viewpoints, the low flood plain is unsuitable for construction due to water-logged phenomena and the high flood plain is also basically unsuitable for construction. The river terrace is most suitable for construction on the left bank of the Ishim River.

Accordingly, most of the medium term new development of the city is carefully designed to take place on the relatively elevated river terrace part of the left bank of the Ishim. Some types of human activities, such as agriculture and pasture, have taken place in these river terrace areas in the past, and thereby the possibility of impairing fauna and flora is minimal.

6.5 Preliminary Assessment of Environmental Impact

6.5.1 General

The objectives of this section are as below.

- To clarify the sources of environmental impact and pollution in Astana City in the future.
- To clarify expected major impacts caused by the development of Astana City.

A further study will prepare recommendations measures for mitigation of the expected serious environmental impacts.

6.5.2 Source of Environmental Impact and Pollution

As mentioned in chapter 3, the city of Astana will be developed to full scale by 2030. Due to the development, negative environmental impacts may happen, mainly caused by following aspects.

- Increase of population (due mainly to the expansion of human activities)
- Development of industrial activity
- Development of transportation system
- Expansion of city area on previously unused areas

Expected source of environmental impact and pollution are descried briefly as below.

(1) Increase of Population

The population in Astana City will increase from 322,000 in 2000 to 800,000 in 2030. Due to such an increase in the population, the following sources of environmental impacts and pollution are expected to occur.

1) Increase of Intake Water from the Ishim River

Due to the increase of population, raw water demand in Astana City will increase from 160,320 m^3/day in 1999 to 175,100 m^3/day in 2010, 243,700 m^3/day in 2020 and 295,300 m^3/day in 2030. At present, the Ishim River is the only water resource for Astana City. To meet the water demand in Astana City, a large part of the Ishim River should be sent to water supply system in Astana City.

For the purpose of increasing the water supply capacity to Astana City, construction of the IKC project is going on. After completion of the IKC project, large amount of water will be transferred from the Irtysh

Karaganda Canal to the Ishim River. This may cause other impacts to the Ishim River.

Water resources development plan and water supply development plan are described in Sub-section 4.2 and 4.3

2) Increase of Wastewater Generation

Due to the increase in population, amount of wastewater generation will also increase from 104,133 m^3/day in 1999 to 112,224 m^3/day in 2010, 171,273 m^3/day in 2020, and 216,842 m^3/day in 2030. As the basic concept of the Master Plan, all of the wastewater should be treated properly and discharged to Taldy Kol Reservoir. Taldy Kol Reservoir is expected to facilitate additional treatment and storage of treated sewage. Some parts of treated sewage are to be used for irrigation water. Surplus water of the reservoir is to be discharged to wetland west side of the reservoir. The wetland is also expected to exert natural treatment process. No serious impact of wastewater generation is expected, as long as the proposed system works properly. Sewerage development plan is described in Sub-section 4.4.

3) Increase of Solid Waste Generation

Some environmental experts in Kazakhstan believe that the solid waste disposal site, which is the only disposal site in Astana, is a major pollution source of groundwater in Astana, though there is not enough data for evaluation of groundwater condition. The disposal site is a landfill type and it is believed that leachate water in the disposal site infiltrates and deteriorates groundwater since no penetration protection layer is provided. Amount of solid waste generation in Astana is expected to increase from 463,287 m^3/year in 1999, to 102,022 m^3/year in 2010, 155,703 m^3/year in 2020, 1,526,339 m^3/year in 2030. Management of solid waste disposal site will be crucial in this regard. Solid waste management plan is described in Sub-section 4.8.

4) Increase of Emission

The electric power and heat energy demand will also increase. The demand for electric power is expected to increase from 226 MW in 2000 to 362 MW in 2010, 485 MW in 2020, 570 MW in 2030. The heat energy demand is expected to increase from 2.72 million Gcal in 2000 to 4.81 million Gcal in 2010, 5.97 million Gcal in 2020 and 7.28 million

Gcal in 2030. At present, coal is fired to generate the electric power and heat. To meet the increasing demand, several negative impacts on air quality pollution and ash waste generation are expected. Introduction of an emission quality improvement system and fuel changing from coal to natural gas is considered as an effective measure to reduce the air pollution load.

(2) Industrial Activities

GRDP in industrial field will increase from Tenge 18 billion/year in 1999 to Tenge 134 billion/year in 2030. Industrial activities in Astana is expected to grow rapidly, though the composition of the industries may be shifted to research oriented high-tech types. In the statistical category, GRDP in industrial field also includes not only production of industrial factories but water, electric power and gas supply, etc, which continue to be important basis of the city's development.

According to the concept of industrial development in Astana City described in Sub-section 3.4.4, the industrial factories targeting markets outside Astana or environmentally harmful ones shall be closed, transformed or relocated elsewhere. Heavy industries with sizable environmental pollution sources are not expected to locate here in future. Due to development of industrial activities, wastewater and air emission may increase, but the environmental impacts are not expected to be any worse, due to this change in orientation.

For realization of the concept of industrial development in Astana City, the environmental protection law shall be reinforced. The law to be reinforced shall include regulation on wastewater and air emission, and procedure of permission to construct industrial factories.

(3) Transportation

Due to development of Astana City, traffic volume of automobile, railway and airplane are expected to increase. The transportation plan is described in sub-section 3.9.

1) Emission of pollution

Usually, exhaust gas from motor vehicles is a dominant source of air pollution emission, especially, carbon monoxide, nitrogen oxides, lead, sulfur dioxide and dust. Exhaust emission from vehicles is calculated based on the following data.

- Total trip length of vehicles
- Quality of fuel
- Exhaust system of vehicle

Quality of fuel and type of exhaust system are expected to be improved because of going environmental effort of the Kazakhstan government. The ring road planned in the Master Plan will contribute to reduction of the total trip length of vehicles in the central area of Astana. Due to rapid development of the city, however, total trip length of vehicles shall be increased accordingly, and the air emission may be increased.

2) Noise

Even at present, airplanes, trains, vehicles in Astana cause offensive impacts of noise. Traffic volumes of airplanes, trains, vehicles in Astana are expected to increase duly.

An airplane generates clamorous noise especially when it takes off. Astana International Airport is located close to the city border to the south, and outgoing airplane needs to take off to the southwest or northeast depending on wind directions. If the take-off route is kept in the direction away from the city, out of the Ring Road 2, noise in Astana caused by airplane is not expected to be serious.

Noise of automobile and railway may become somewhat serious along major roads and railway tracks. The traffic volume during night-time may have to be controlled under law, if the noise level would become serious. Noise protection device such as walls may have to be installed in residential area along major roads and railway track.

(4) Expansion of City

In accordance with the development of Astana City, urban areas of the city will expand. The area of residential area will increase from 3,355 ha in 2000 to 6,767 ha in 2030. The expansion of the area will cause relocation of existing rural residences and *dachas*, and may have impacts on fauna and flora in new development area. For those who live in the residences and use dacha to be relocated, compensation for relocation will be rendered.

Special species of fauna and flora to be conserved are not found out in the proposed development area in Astana. The impacts on fauna and flora thus are not serious, as long as the effects of construction are controlled properly.

6.6 Environmental Check List

According to JICA Environmental Consideration Guideline, the environmental items as shown in the table below shall be checked as Initial Environmental Examination. In conclusion, the table shows the list of expected impacts caused by each activity, to which the Study Team has concern.

Preliminary Environmental Check List

Item	Increase of Population	Industrial Activities	Transport System Development	Expansion of City
1. Resettlement	D-2	D-2	D-2	B
2. Economic Activities	D-2	D-2	D-2	D-2
3. Transport	B	B	D-2	D-2
4. Separation of Community	D-2	D-2	D-2	D-2
5. Cultural Assets and Archaeology	D-2	D-2	D-2	D-2
6. Water and Common Rights	B	D-2	D-2	D-2
7. Sanitation	D-2	D-2	D-2	D-2
8. Waste	B	D-2	D-2	D-2
9. Dangers	D-2	D-2	D-2	D-2
10. Topography and Geology	D-2	D-2	D-2	D-2
11. Soil Erosion	D-2	D-2	D-2	D-1
12. Groundwater	C	D-2	D-2	D-2
13. Lake, Marsh and River	C	D-2	D-2	D-2
14. Flora and Fauna	D-2	D-2	D-2	B
15. Weather	D-2	D-2	D-2	D-2
16. View	D-2	D-2	D-2	B
17. Air Pollution	B	A	B	D-2
18. Water Pollution	B	B	D-2	D-2
19. Soil Contamination	C	D-2	D-2	D-2
20. Noise and Vibration	D-2	D-2	A	D-2
21. Ground Subsidence	D-2	D-2	D-2	D-2
22. Noxious odors	D-2	D-2	D-2	B

A: Serious Negative Impact expected, if proper countermeasure is not taken
B: Minor Negative Impact expected
C: Uncertain (may become clear on investigation)
D-1: Almost no Negative Impact expected, if proper construction is carried out
D-2: Almost no Negative Impact, or Positive Impact only

Nine (9) environmental items are evaluated as "D: Almost no Negative Impact". Remaining thirteen (13) environmental items are evaluated as negative, even as it is minor. The countermeasures, which are mentioned in the master plan, are summarized in the table below.

Evaluation and Countermeasures of Environmental Imapact

Items	
1. Resettlement	As mentioned in 6.5.2 (4), compensation for relocation will be rendered.
3. Transport	For establishment of suitable transportation system to meet the future demand in Astana, Transportation Planning is described in Section 3.9. Environmental mitigation measures related to Transport are described in Sub-section 6.5.2 and 6.4.3.
6. Water and Common Rights	Taking into account water right in Ishim River, Water resources development plan is established as shown in Section 4.2 and Supporting Report (E).
8. Waste	For establishment of proper Solid Waste Management System to meet future demand in Astana, a plan for Solid Waste Management System is prepared as described in Section 4.8 and Supporting Report (L).
11. Soil Erosion	Soil erosion will not be serious in Astana, as long as the effects of construction are controlled properly.
12. Groundwater	As described in sub-section 6.4.1 (3), major pollution sources of groundwater will be improved.
13. Lake, Marsh and River	Taking into account Ishim River and Taldy Kol Reservoir, environmental mitigation measures are proposed as described in sub-section 6.4.1.
14. Flora and Fauna	As mentioned in 6.5.2 (4), special species of fauna and flora to be conserved are not found.
16. View (Townscape)	For creating and maintaining the favorable and harmonious townscape in Astata, Townscape Guidelines are prepared in M/P, as shown in Section 3.8.
17. Air Pollution	Environmental mitigation measures on Air Pollution are decribed in sub-section 6.3.2. The future prediction is described in further section.
18. Water Pollution	Taking into account reduction of water pollution load generated in Astana, a development plan of sewerage in Astana is planned as described in section 4.4 and Supporting Report (G).
19. Soil Contamination	Soil Contamination will not be serious, if Solid Waste Management System will work properly as described in Section 4.8 and Supporting Report (L).
20. Noise and Vibration	Environmental mitigation measures on Noise are described in sub-section 6.3.3. The future prediction is described in further section.
22. Noxious Odor	Major source of Noxious Odor is STP. Taking into account Noxious Odor, Improvement of STP is described in F/S and Supporting Report (G).

6.7 Evaluation of Future Condition

"Air Pollution" and "Noise" are closely related to the living environment in Astana. For confirmation of effectiveness of the environmental mitigation measures to the both items, the future predictions are carried out.

(1) Air Pollution

For the projection of future condition of air quality in Astana, "Industrial factories", "Electric power and heat supply plants" and "Auto transport" are considered as the air pollution source in Astana City. Development plan of Industrial factories, Electric power and heat supply plants and Auto transport are described in Sections 3.4, 4.5 and 3.9, respectively. The results of the conclusions are summarized as below.

- At present, Electric power and heat supply plants (Thermal Plants) burns coal. The coal firing is a source of heavy air pollution. As they will gradually be switched to gas firing, the impact from Thermal Plants is expected to decrease.
- Some existing major industrial factories located in the residential area (southern part of Astana) are planned to relocate to the industrial area (northern part of Astana). Accordingly, the air pollution caused by emissions of the industrial factories will be lessened in the center of the city.
- Due to intensive auto transport development in future, emission volume will increase. As a countermeasure, the construction of ring road eases traffic congestion is proposed, and the maximum air pollution level in Astana will decrease. Influence area caused by emission of auto transport will expend, but pollution level will not be serious.
- Atmospheric pollution index (API) is an integrated index of the atmosphere pollution over four contaminants (NO_X, CO, SO_2 and TSP). The API index is projected as follows:

  2001 – 3-4, "moderately contaminated"

  2010 – 1-2 "allowable level of pollution"

  2030 – < 1. "No pollution"

  In the residential area API will decrease from 2-3 (low pollution level) to < 1 by 2030.
- Even at present air pollution levels in Astana are within the standard, except for TSP, which is caused primarily by dust. The future condition of

air quality is not expected to have any serious problem, if the mitigation measures as discussed earlier are carried out properly.

(2) Noise

For evaluation of future condition of noise in Astana, "Airport", "Railway transport" and "Auto transport" are considered as the sources of noise in Astana City. The evaluation is carried out on each source. The results of the calculations are summarized as below.

1) Airport

According to "Environment Impact Assessment", project – Reconstruction and expansion of IAA, "Kazaeroproject" – 2001, noise from the airport after its reconstruction may reach inadmissible values on Residential Area 9, 10, 17, 18, 19 and Station No40. If the course of the aircraft follow the present practices, a zone of unfavorable noise impacts has a prolonged shape which extends from north to south with width of 1750 m. An axial line of the zone extends a little leftward from the district of station No40. More than half of the noise zone is characterized as inadmissible for construction of residential buildings. The remaining part of the zone can be used (developed) under the condition of application of constructive decisions aimed at noise reduction inside of apartments.

Considering the above results it is proposed to move the noise zone from the IAA out of the Ring Road 2. Changing of the route of aircraft take-off and landing, imposing of night flight limitation, prohibition of flights over settlements shall have to be implemented in the due course of the expansion of Astana City to contemplate with the requirements stipulated in SNiP.

2) Railway transport

The noise level will be increased with the growth of intensity of train operation. The noise caused by cargo and passenger trains in 2030 between Akmola railway station and station No40 will be 87 dB. In 2030 the value of the noise level caused by trains will exceed the allowable noise level by 9 dB – at a distance of 50 m from the source of noise, and by 5 dB – at a distance 100 m. The noise from Akmola station, freight yards, railway and cargo centers will exceed the allowable noise level by 26 dB at a distance from a source of noise 40-60 m and by 22 dB – at a distance

80-100 m. The route of cargo railway is proposed to relocate to north to pass through the industrial area and to separate the source of noise far from the residential area.

3) Road network

As the results of the calculation, the noise level in 2030 is expected as below.

Area along third Ring Road:	82 – 84 dB
Area along Second Ring Road:	80 – 82 dB
Area along First Ring Road:	75 – 78 dB
Area along major Road in City Center	74 – 76 dB

Noise impact from the road network on residential areas depends on the width of the street in building lines (BL). If the width of the street in BL is 25-30 m the noise created by the road network will exceed the allowable noise level by 10-12 dB. If the width of the street in BL is 40-50 m the allowable noise level will be exceeded only by 6-8 dB. The following countermeasures are required in case by case.

- Planting of deciduous tree species for noise reduction on the main streets
- Possible extension of the area between the major roads for the relocation of the development area from the roads
- Construction of noise protecting reinforced concrete structures that will allow to reduce the noise level.

In addition, the allowable noise impact caused by the traffic flow will be achieved if its speed is below 40 km/h

6.8 Conclusion and Recommendation

Basically, no serious environmental impacts are expected to take place if Astana City is to be developed following the Master Plan. The state ecological expertise of the Republic of Kazakshtan approved the Master Plan on 14th May 2001.

As the development of Astana isa going ahead, the environmental mitigation measures shall be modified to meet actual development of Astana.

TABLE

Table 6.2.1 Geo-technical Characteristics and Counter Measures for Construction

Geomorphology	Groundwater level below ground surface	Lithological characteristics		Counter measures for construction
		Type	Lithology	
River terrace	Less than 2 m	a_1^1	Clay up to depthes of 3.6-5.2 m Sand & rarely clayey sand from the deeper	- Surface drainage - Flood protection - Subsurface drainage
		a_1^2	Loam up to depthes of 2.5-4.7 m Sand of various sizes from the deeper	
		a_1^3	Clayey sand up to a depth of 2.5 m Sand from the deeper	
		a_1^4	Clayey sand up to depthes of 1.7-1.8 m Fine sand from the deeper	
		$a1^5$	Clay, loam, clayey sand & sand up to depthes of 6.1-6.6 m Clay from the deeper	
		a_1^6	Clay, loam & clayey sand up to depthes of 4.0-7.0 m Sand of various sizes from the deeper	
		a_1^7	Sand up to depthes of 1.5-3.0 m Clayey soil from the deeper	
		a_1^8	Loam up to depthes of 1.5-3.0 m Clay from the deeper	
	From 2 to 5 m	b_1^1	Clay, loam, clayey sand & sand up to depthes of 2.6-10.0 m Clay from the deeper	
Peneplain	Less than 2 m	a_2^1	Loam & clayey sand up to depthes of 0.5-2.0 m Clay from the deeper	- Surface drainage - Flood protection - Subsurface drainage
		a_2^2	Loam, clayey sand & sand up to depthes of 3.6-8.0 m Clay from the deeper	
		a_2^3	Loam up to depthes of 2.8-3.7 m Clay from the deeper	
		a_2^4	Clayey sand up to depthes of 2.2-2.4 m Clay from the deeper	
	From 2 to 5 m	b_2^1	Clayey sand up to depthes of 0.4-1.4 m Detritus from the deeper	
		b_2^2	Loam & clayey sand up to depthes of 1.5-8.0 m Clay from the deeper	
Low hill	Less than 2 m	a_3^1	Loam, clayey sand & sand up to depthes of 0.5-3.0 m Detritus from the deeper	- Subsurface drainage
		a_3^2	Loam & clayey sand up to depthes of 0.7-4.0 m Clay(elluvial) from the deeper	
	From 2 to 5 m	b_3^1	Loam, clayey sand & sand up to depthes of 0.5-3.0 m Detritus from the deeper	
		b_3^2	Loam, clayey sand & sand up to depthes of 0.7-4.0 m Clay(elluvial) from the deeper	
High flood plain	Less than 2 m	a_4^1	Loam, clayey sand & sand up to a depth of 8.0 m	- Flood control - Surface drainage - Subsurface drainage
		a_4^2	Sand up to depthes of 2.8-6.0 m Clay from the deeper	
		a_4^3	Clay, loam, & sand up to depthes of 3.0-4.0 m Detritus from the deeper	
	From 2 to 5 m	b_4^1	Clay, loam, clayey sand & sand up to depthes of 2.4-4.0 m Clay from the deeper	
Low flood plain	Water-logged		Quaternary sand & muddy clay	- Flood control - Surface drainage - Subsurface drainage

Table 6.2.2 Water Balance between Groundwater Resources and Consumption

Aquifer	Sub-aquifer		Rock	Groundwater resources by degree of exploration (1000 m³/day) Exploited A	Confirmed B	Potential C1	Potential C2	Total	Groundwater consumption (1000 m³/day) Public water supply	Industry	Agri-culture	Watering of pasture	Irriga-tion	Fishery	Total	Water balance (1000 m³/day)
A : Akmolinsky	A-1	Zholymbet	Limestone	0.0	0.0	1.8	9.0	10.8								
	A-2	Sofievsky	Limestone	0.0	1.7	14.4	0.0	16.1								
	A-3	Koyandinsky	Limestone	0.0	15.0	0.0	0.0	15.0								
	A-4	North-eastern	Limestone	4.1	2.5	1.6	0.0	8.2								
	Sub-total			4.1	19.2	17.8	9.0	50.1	0.05	0.04	0.02	0.00	0.00	0.00	0.11	49.99
B : Tselinogradsky	B-1	Left bank (Ishim River)	AQ*	3.0	0.0	0.0	0.0	3.0								
	B-2	Right bank1 (Ishim River)	AQ*	0.0	0.0	2.1	0.0	2.1								
	B-3	Right bank2 (Ishim River)	AQ*	0.0	0.0	1.7	0.0	1.7								
	Sub-total			3.0	0.0	3.8	0.0	6.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.80
C : Rozhdestvensky	C-1	Western	Limestone	0.0	0.0	4.7	0.0	4.7								
	C-2	Eastern	Limestone	0.0	0.0	0.0	3.2	3.2								
	C-3	Upper	AQ**	0.0	14.2	0.0	0.0	14.2								
	C-4	Lower	AQ**	0.0	22.0	0.0	0.0	22.0								
	Sub-total			0.0	36.2	4.7	3.2	44.1	0.00	0.00	0.33	0.00	0.00	0.00	0.33	43.77
D : Nurinsky			AQ**	16.0	11.3	0.0	0.0	27.3	0.79	3.18	2.70	0.00	0.00	0.00	6.67	20.63
Total				23.1	66.7	26.3	12.2	128.3	0.84	3.22	3.05	0.00	0.00	0.00	7.11	121.19

Alluvial sediments along the Rivers of Ishim (*) and Nura (**)

Table 6.2.3 Monthly Air Temperature in the Period 1960-1984 (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1960	-13.3	-15.1	-16.8	0.6	8.5	18.2	16.0	15.8	11.3	0.3	-12.3	-11.6	0.1
1961	-14.4	-16.3	-5.4	6.9	14.9	18.4	19.1	17.9	11.6	-0.6	-6.7	-12.1	2.8
1962	-14.7	-14.4	-3.7	6.4	16.1	19.8	23.2	17.8	11.5	3.3	-8.6	-12.7	3.7
1963	-11.8	-9.6	-6.1	2.7	12.7	21.0	21.4	15.4	9.5	5.1	-2.0	-11.0	3.9
1964	-11.9	-19.8	-12.1	-0.7	12.2	17.3	19.5	17.3	11.1	0.8	-2.0	-9.8	1.8
1965	-14.1	-16.3	-4.8	4.4	15.0	19.7	24.4	16.6	12.4	2.7	-5.8	-12.0	3.5
1966	-16.7	-14.3	-6.9	3.8	10.1	18.2	22.5	19.5	14.7	0.7	-8.5	-23.4	1.6
1967	-17.9	-17.7	-6.8	7.3	15.1	20.3	21.0	16.8	8.5	5.2	-4.0	-10.1	3.1
1968	-14.7	-14.1	-4.4	4.5	16.0	18.0	19.8	18.7	9.1	0.9	-9.1	-18.8	2.2
1969	-30.1	-24.1	-14.1	4.3	10.0	18.9	21.6	15.1	11.4	1.7	-3.8	-10.5	0.0
1970	-17.1	-14.6	-10.8	6.3	12.1	17.8	18.9	17.4	13.4	3.3	-7.0	-16.8	1.9
1971	-13.5	-17.9	-9.1	3.9	11.2	18.1	21.2	15.2	14.3	4.2	-1.9	-8.2	3.1
1972	-25.0	-18.3	-12.2	5.0	12.1	17.3	16.9	15.0	8.5	2.5	-5.0	-10.3	0.5
1973	-19.3	-15.5	-8.5	6.8	12.6	18.5	19.8	17.4	9.8	1.6	-2.3	-8.7	2.7
1974	-19.9	-21.2	-7.7	6.2	15.6	18.3	23.5	17.3	12.9	4.9	-8.5	-17.7	2.0
1975	-11.2	-13.5	-6.2	8.3	11.2	18.7	21.8	17.7	12.7	1.8	-8.4	-11.2	3.5
1976	-8.7	-20.8	-12.6	4.9	14.7	19.8	18.7	20.3	10.7	-5.0	-12.9	-17.8	0.9
1977	-23.3	-18.1	-7.0	9.2	16.1	22.7	20.7	16.2	11.7	2.3	-1.1	-13.7	3.0
1978	-14.7	-15.3	-7.4	6.2	11.3	20.2	21.1	16.1	14.6	3.2	-4.4	-12.2	3.2
1979	-20.2	-12.3	-9.5	-0.8	12.4	17.3	20.4	17.2	12.8	4.9	-6.0	-8.3	2.3
1980	-17.8	-17.0	-11.7	5.2	15.4	18.6	20.5	16.3	13.3	4.2	-4.0	-12.0	2.6
1981	-15.9	-13.0	-5.2	5.4	12.8	20.1	21.6	21.6	13.2	4.6	-4.9	-12.5	4.0
1982	-14.4	-15.4	-12.1	8.3	14.7	20.8	20.7	18.3	13.9	4.1	-5.0	-8.9	3.7
1983	-9.0	-8.7	-6.0	6.5	9.8	20.0	22.8	19.2	10.1	4.8	-2.9	-8.9	4.8
1984	-13.4	-20.3	-6.6	1.0	13.4	18.8	21.5	19.1	11.2	4.2	-9.4	-23.5	1.3
Average	-16.1	-16.1	-8.5	4.9	13.0	19.1	20.7	17.4	11.8	2.6	-5.9	-12.9	2.5
Maximum	-8.7	-8.7	-3.7	9.2	16.1	22.7	24.4	21.6	14.7	5.2	-1.1	-8.2	
Minimum	-30.1	-24.1	-16.8	-0.8	8.5	17.3	16.0	15.0	8.5	-5.0	-12.9	-23.5	
S. D.	4.9	3.5	3.4	2.7	2.2	1.3	1.9	1.7	1.8	2.3	3.2	4.4	

Table 6.2.4 Monthly Precipitation in the Period 1960-1984 (mm/month)

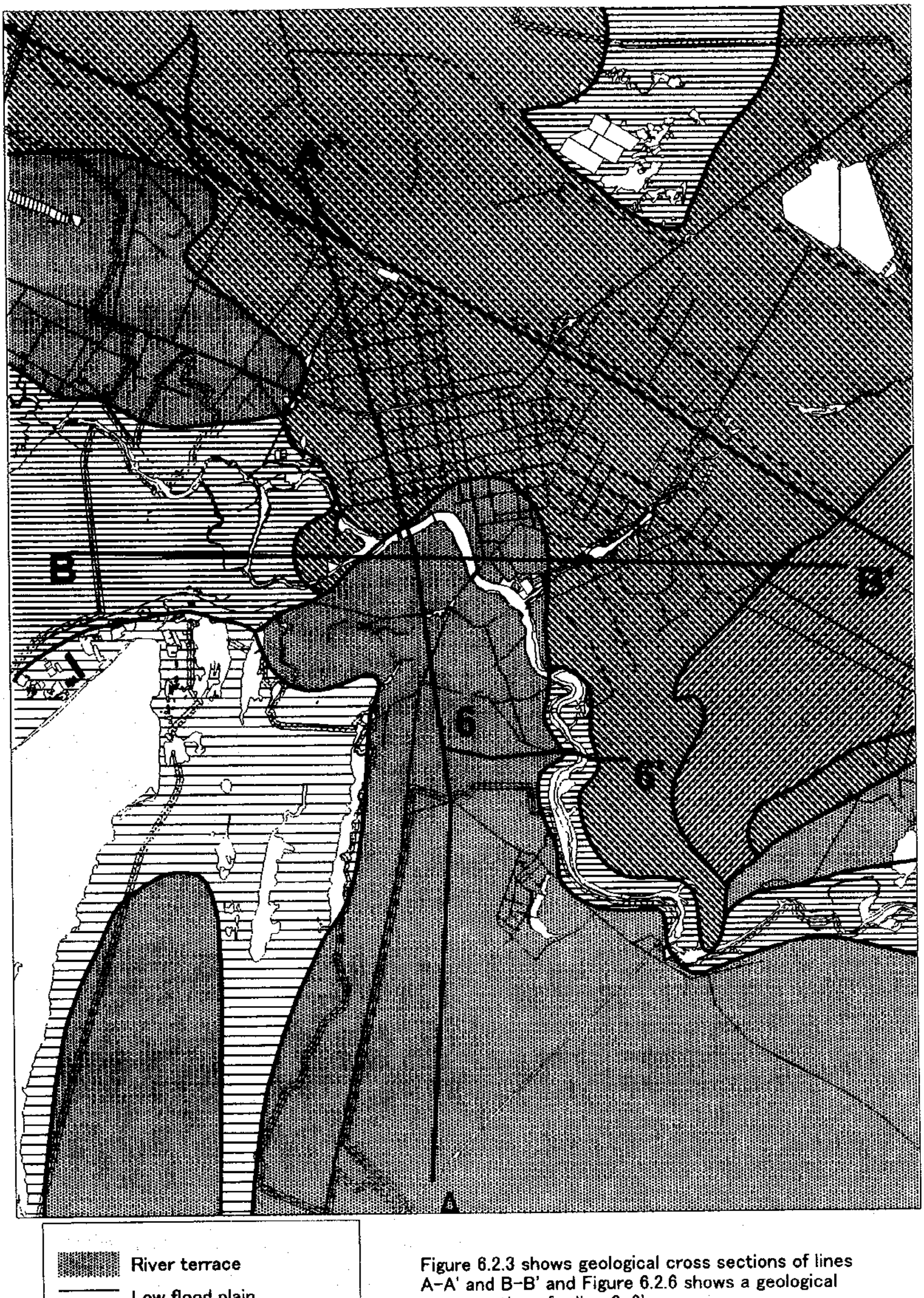
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1960	17.4	7.4	13.7	10.9	52.5	70.0	85.8	62.1	9.7	12.2	11.2	17.7	370.6
1961	7.4	11.3	14.6	12.5	13.9	80.9	104.2	14.6	5.1	34.7	18.6	24.7	342.5
1962	16.5	1.8	6.4	8.5	56.5	51.1	12.7	164.9	11.1	29.1	6.1	8.9	373.6
1963	15.7	17.7	11.1	0.0	13.4	9.5	51.6	61.2	59.4	21.2	30.4	16.2	307.4
1964	42.3	5.9	11.4	25.0	31.1	46.4	36.5	68.0	26.5	8.9	10.1	9.9	322.0
1965	6.8	7.1	14.4	20.6	4.9	30.6	6.4	54.1	38.8	20.5	25.7	5.7	235.6
1966	21.3	41.8	14.2	32.8	24.1	18.9	28.8	31.9	8.0	20.4	26.1	8.5	276.8
1967	2.9	13.4	19.3	6.2	31.0	23.4	64.9	98.8	43.8	18.6	2.7	7.9	332.9
1968	12.5	8.5	31.1	21.4	52.5	28.3	35.5	31.0	23.0	36.9	12.2	18.3	311.2
1969	4.3	7.9	14.6	5.0	42.3	7.1	157.1	74.5	19.1	61.0	10.9	14.5	418.3
1970	35.5	36.7	9.6	11.5	31.0	13.0	16.9	18.4	53.6	26.2	20.8	14.4	287.6
1971	49.1	11.8	3.7	16.9	60.4	14.6	27.0	69.4	1.4	15.0	14.4	35.0	318.7
1972	27.0	20.0	29.1	53.3	31.4	24.9	139.0	27.8	24.0	19.1	17.9	18.7	432.2
1973	28.6	20.2	11.9	22.8	48.0	64.1	14.9	25.7	20.7	35.2	17.5	9.7	319.3
1974	13.2	7.3	11.8	19.8	22.3	53.9	75.3	23.1	44.2	9.7	14.4	1.8	296.8
1975	14.6	11.6	20.3	20.4	30.6	21.6	30.2	1.1	15.9	28.4	14.8	20.4	229.9
1976	18.5	12.3	8.5	32.0	10.7	44.7	29.3	5.6	11.8	60.2	8.6	9.6	251.8
1977	11.2	18.3	12.9	2.6	22.7	5.9	40.5	58.9	26.1	15.5	12.8	20.5	247.9
1978	7.6	9.2	4.0	62.6	49.0	45.3	20.3	9.9	14.3	22.2	36.7	21.9	303.0
1979	12.1	12.5	9.0	20.9	43.6	33.0	85.6	28.7	15.8	33.8	7.4	17.5	319.9
1980	15.8	7.6	4.1	19.8	37.1	37.9	62.6	78.4	12.4	10.3	28.6	11.4	326.0
1981	8.1	10.4	21.2	44.0	43.0	70.1	11.5	9.2	23.3	9.9	18.5	6.9	276.1
1982	15.2	11.2	8.3	17.3	22.7	14.9	42.9	28.4	21.4	56.5	23.5	15.3	277.6
1983	30.0	22.7	15.0	11.3	62.8	36.1	12.7	2.5	30.7	24.0	38.1	22.4	308.3
1984	6.3	11.7	14.5	20.2	28.9	28.9	9.5	15.5	38.9	70.4	57.3	12.8	314.9
Average	17.6	13.9	13.4	20.7	34.7	35.0	48.1	42.5	24.0	28.0	19.4	14.8	312.0
Maximum	49.1	41.8	31.1	62.6	62.8	80.9	157.1	164.9	59.4	70.4	57.3	35.0	
Munimum	2.9	1.8	3.7	0.0	4.9	5.9	6.4	1.1	1.4	8.9	2.7	1.8	
S. D.	11.9	9.1	6.9	15.0	16.0	21.1	40.4	37.3	15.1	17.4	12.1	7.2	

Table 6.2.5 Monthly Average Discharge at Romanobka of Nura River (m^3/sec)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1979	3.98	4.17	4.72	172.00	88.40	18.80	13.20	11.40	13.80	19.80	14.70	9.84	31.23
1980	7.00	5.69	6.01	47.50	19.30	9.42	3.41	3.31	7.65	14.70	13.20	6.87	12.01
1981	8.95	9.28	9.88	84.30	17.10	8.24	3.46	2.29	6.53	8.06	7.34	7.15	14.38
1982	7.21	6.78	6.81	61.60	30.00	9.75	1.65	4.17	5.37	6.55	11.30	8.21	13.28
1983	5.51	5.72	9.24	173.00	28.80	14.50	9.23	5.30	7.65	10.30	12.00	13.00	24.52
1984	10.90	8.46	10.50	142.00	25.30	12.60	11.60	8.58	9.98	12.40	12.70	9.40	22.87
1985	7.74	7.47	6.86	127.00	40.70	20.50	19.20	14.70	16.90	19.10	17.20	12.90	25.86
1986	11.90	11.30	12.00	139.00	49.80	21.80	14.90	15.80	16.70	16.30	17.00	10.10	28.05
1987	9.89	9.70	10.70	88.30	46.50	22.50	15.20	16.00	20.00	20.00	22.30	12.90	24.50
1988	11.90	10.40	10.10	234.00	88.70	29.50	15.80	17.10	20.10	21.70	22.80	15.70	41.48
1989	13.20	10.50	11.90	95.30	40.20	26.80	13.30	9.89	12.60	14.80	13.50	11.00	22.75
1990	8.91	8.47	8.29	463.00	116.00	24.80	23.50	19.60	18.90	19.70	18.50	19.00	62.39
1991	17.90	17.20	15.70	217.00	156.00	30.70	18.60	14.20	16.60	17.20	16.30	17.30	46.23
1992	10.90	10.20	17.60	45.70	17.60	12.90	9.98	10.70	12.00	9.50	8.72	8.26	14.51
1993	8.32	5.96	4.23	370.00	230.00	46.40	24.20	15.50	16.00	15.80	13.60	12.90	63.58
1994	13.10	13.20	14.20	33.40	23.60	11.90	15.70	11.10	8.31	9.07	8.45	6.93	14.08
1995	6.93	7.61	38.40	165.00	34.20	16.60	10.30	9.41	9.45	9.46	9.14	6.90	26.95
1996	6.81	6.79	7.09	57.80	26.00	15.30	10.60	9.17	9.39	9.57	7.26	5.60	14.28
1997	5.99	5.94	6.83	143.00	32.30	21.50	14.80	10.70	9.83	10.50	8.10	5.96	22.95
1998	5.20	4.60	1.76	18.70	22.00	15.00	12.20	6.41	6.87	7.34	5.66	4.30	9.17
1999	3.61	3.69	2.92	20.80	11.60	5.70	4.03	5.09	5.36	5.37	5.44	4.24	6.49
Mean	8.85	8.24	10.27	138.02	54.48	18.82	12.61	10.50	11.90	13.20	12.63	9.93	25.79

Source: Hydrometeorological Monitoring Center of Astana City

FIGURE



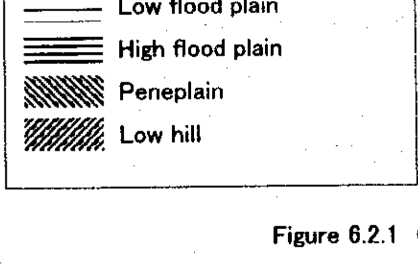


Figure 6.2.3 shows geological cross sections of lines A-A' and B-B' and Figure 6.2.6 shows a geological cross section of a line 6-6'.

Figure 6.2.1 Geomorphological Map of Astana Area

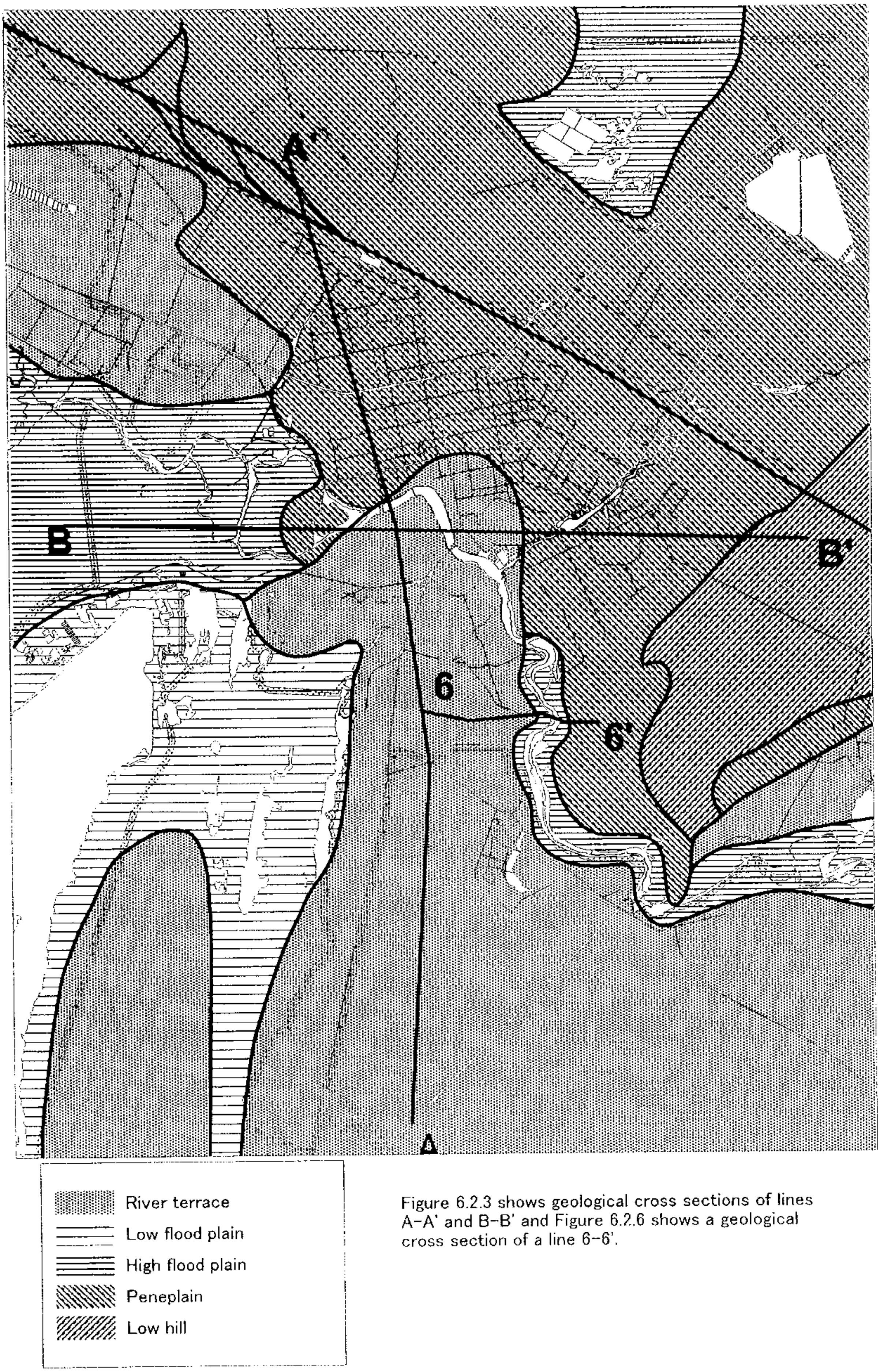
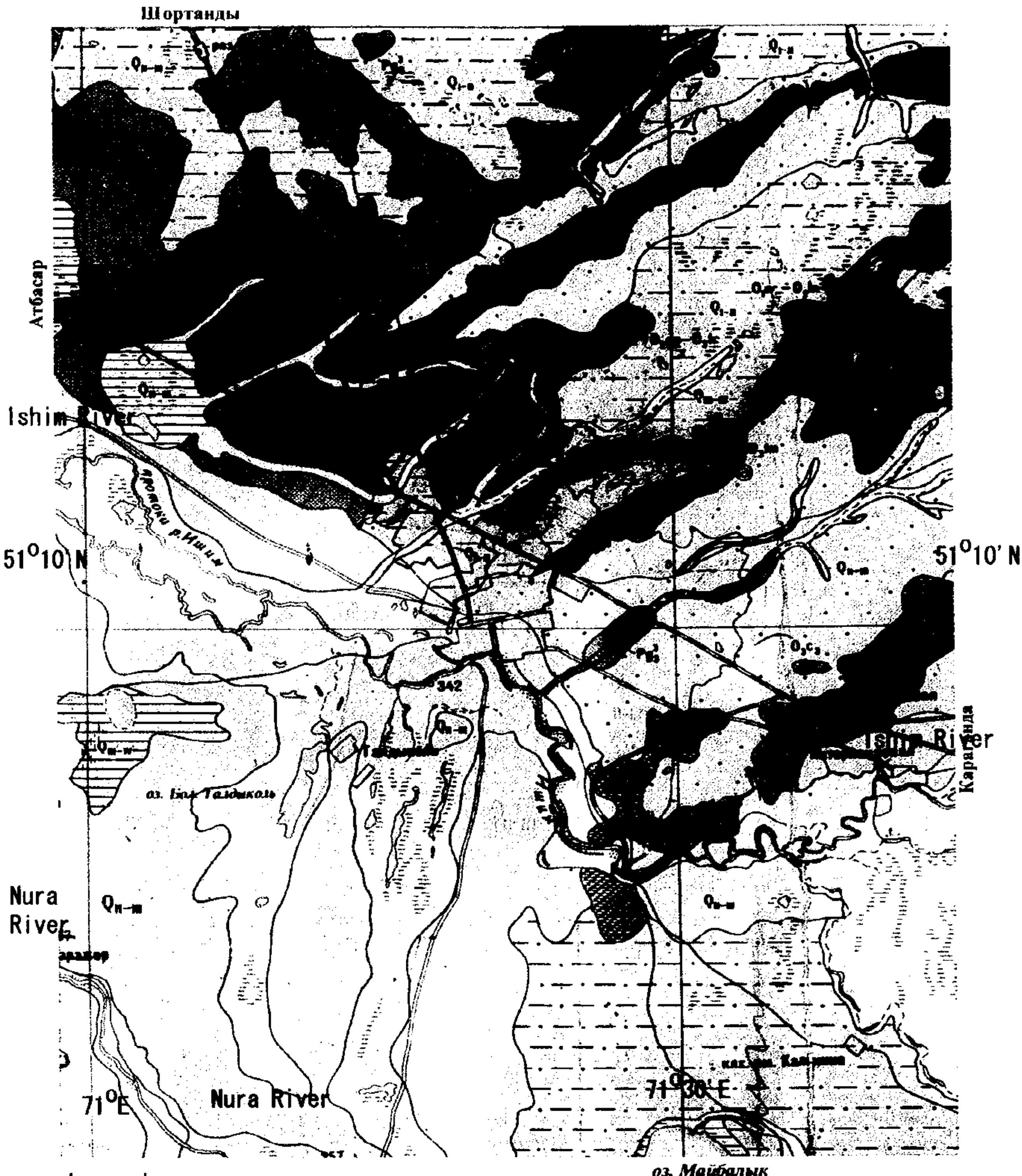


Figure 6.2.3 shows geological cross sections of lines A-A' and B-B' and Figure 6.2.6 shows a geological cross section of a line 6-6'.

Figure 6.2.1 Geomorphological Map of Astana Area



Legend

Q_{III-IV} : Upper-recent Quaternary sediments (sand, gravel, loam and clay)

Q_{II-III} : Middle-Upper Quaternary sediments (sand and clay)

Q_{I-II} : Lower-middle Quaternary sediments (sand, gravel, loam and clay)

Pg_3 : Upper Paleogene clay and sand

C_{1v} : Carboniferous (Visean series) siltstone, argillite and sandstone

C_{1t} : Carboniferous (Tournaisian series) limestone and siltstone

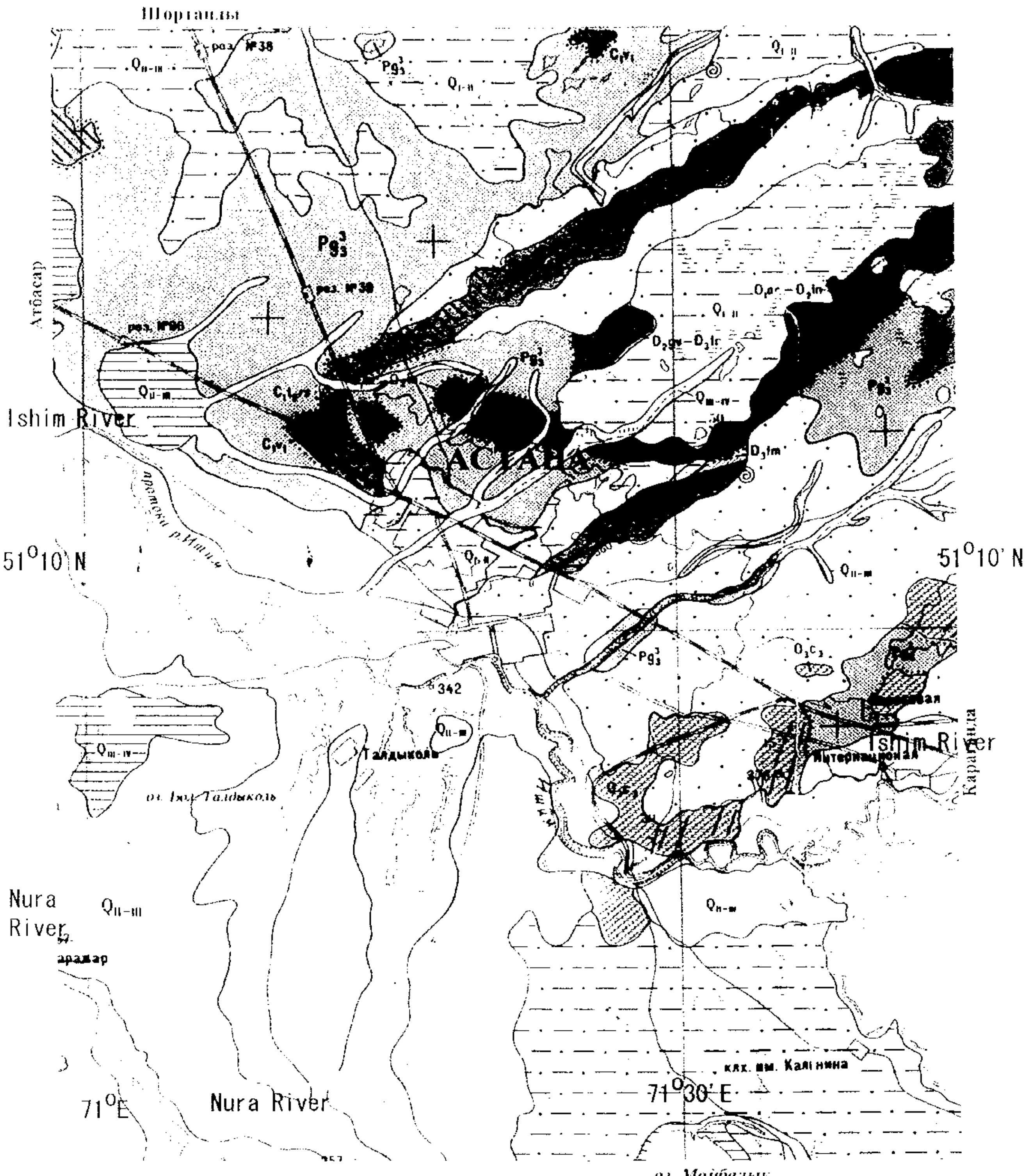
D_{3fm} : Devonian (Famennian series) limestone

D_{2gv}–D_{3fr} : Devonian (Givetian–Frasnian series) sandstone, conglomerate and siltstone

O_{3c3} : Ordovician (Caradocian series) conglomerate and sandstone

O_{1ar}–O_{2ln} : Ordovician (Arenigian–Llandeilian series) aleurolite and sandstone

Figure 6.2.2 Geological Map of Astana Area

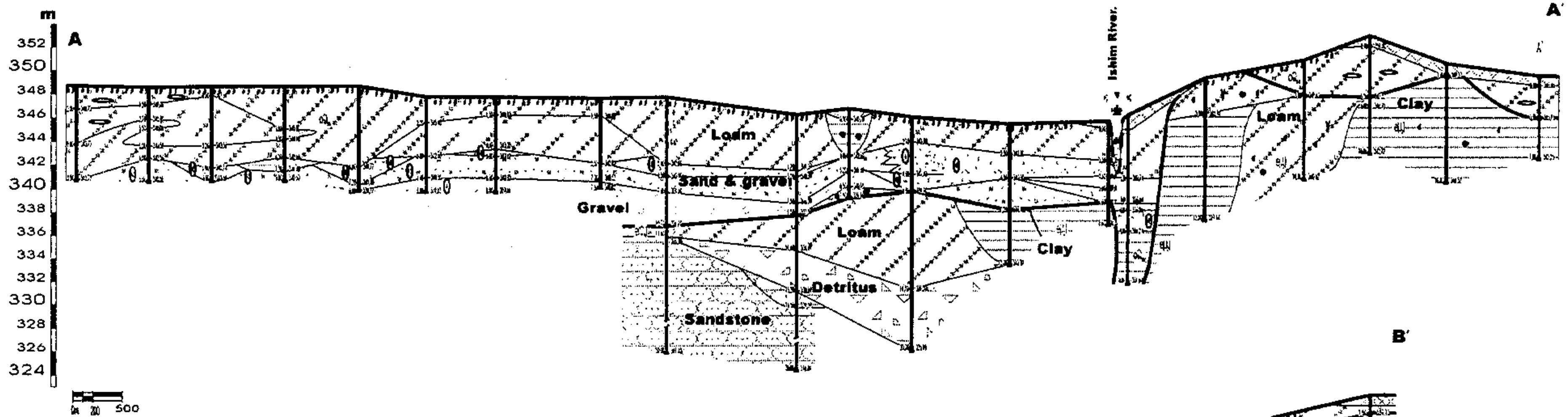


Legend

- Q_{III-IV} : Upper-recent Quaternary sediments (sand, gravel, loam and clay)
- Q_{II-III} : Middle-Upper Quaternary sediments (sand and clay)
- Q_{I-II} : Lower-middle Quaternary sediments (sand, gravel, loam and clay)
- Pg_3 : Upper Paleogene clay and sand
- C_{1v} : Carboniferous (Visean series) siltstone, argillite and sandstone
- C_{1t} : Carboniferous (Tournaisian series) limestone and siltstone
- D_{3fm} : Devonian (Famennian series) limestone
- D_{2gv}-D_{3fr} : Devonian (Givetian-Frasnian series) sandstone, conglomerate and siltstone
- O_{3c3} : Ordovician (Caradocian series) conglomerate and sandstone
- O_{1ar}-O_{2ln} : Ordovician (Arenigian-Llandeilian series) aleurolite and sandstone

Figure 6.2.2 Geological Map of Astana Area

Cross section A-A′



Cross section B-B′

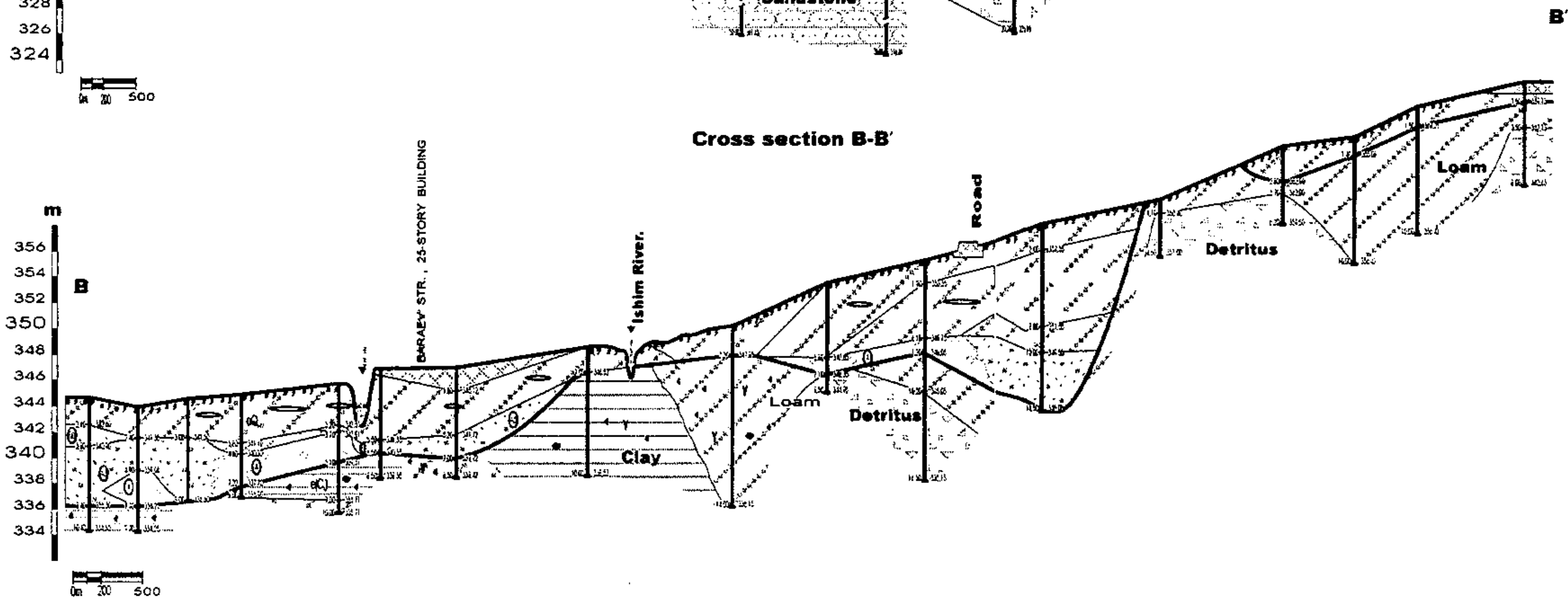


Figure 6.2.3 Geological Cross Sections of Astana Area

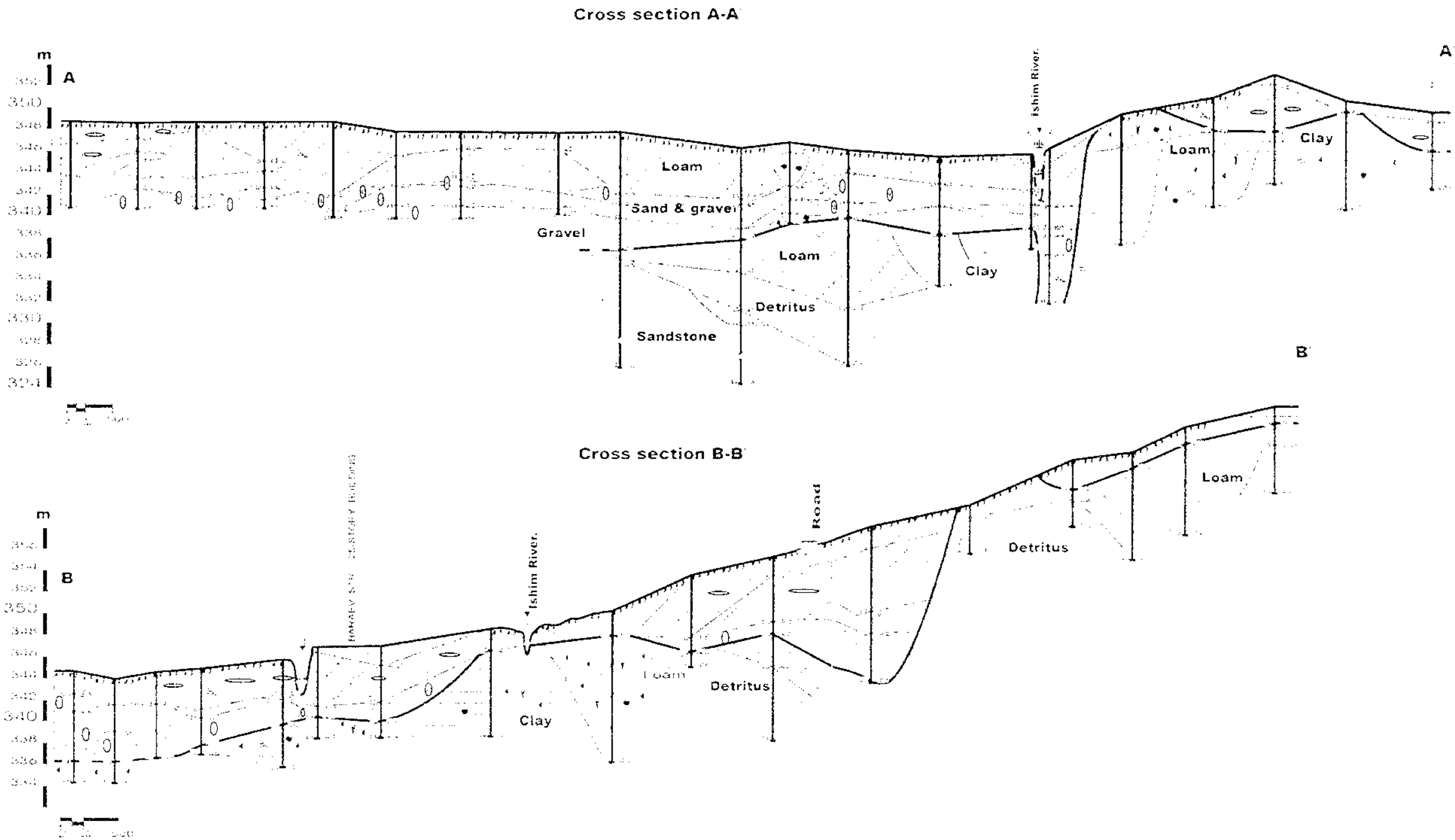


Figure 6.2.3 Geological Cross Sections of Astana Area

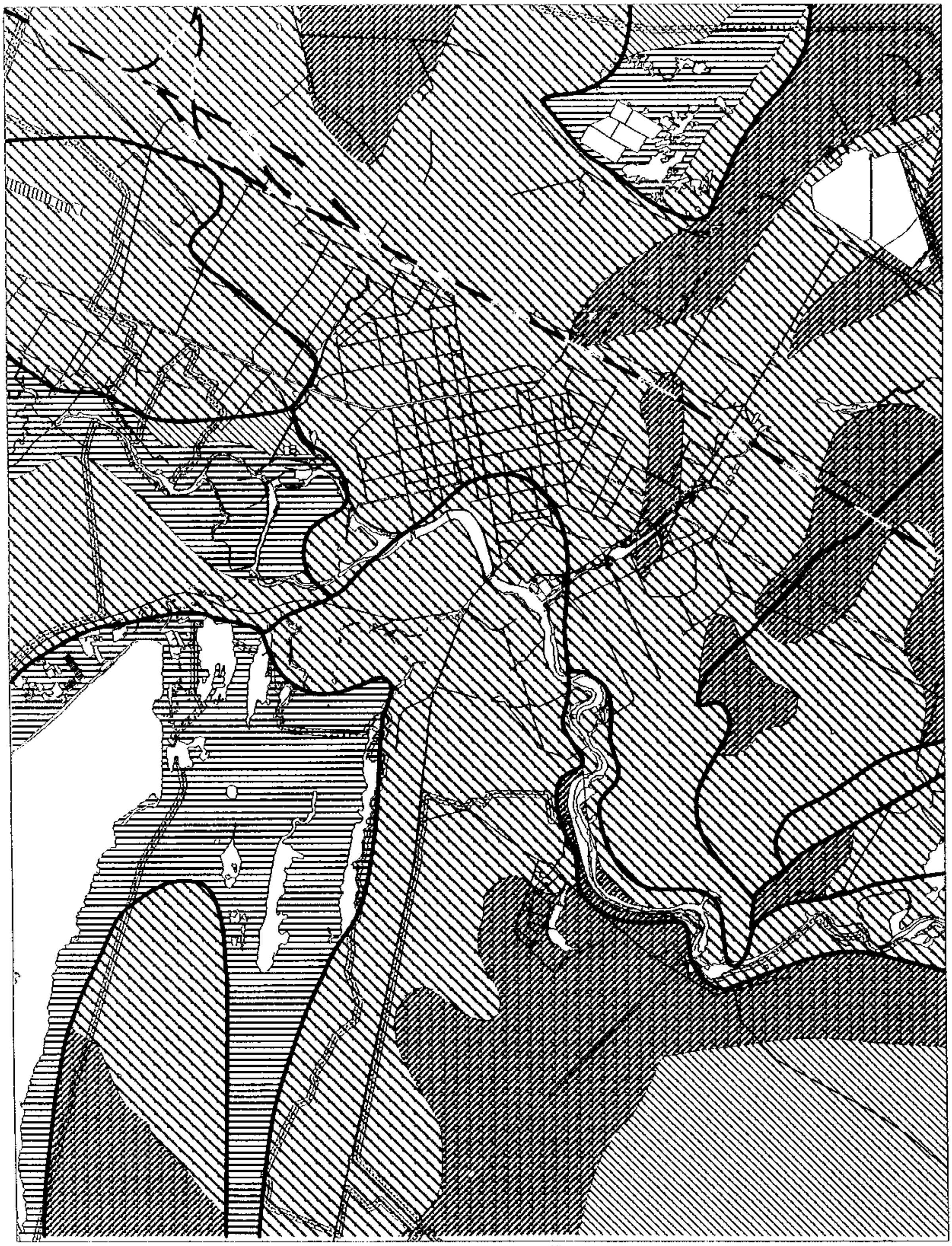
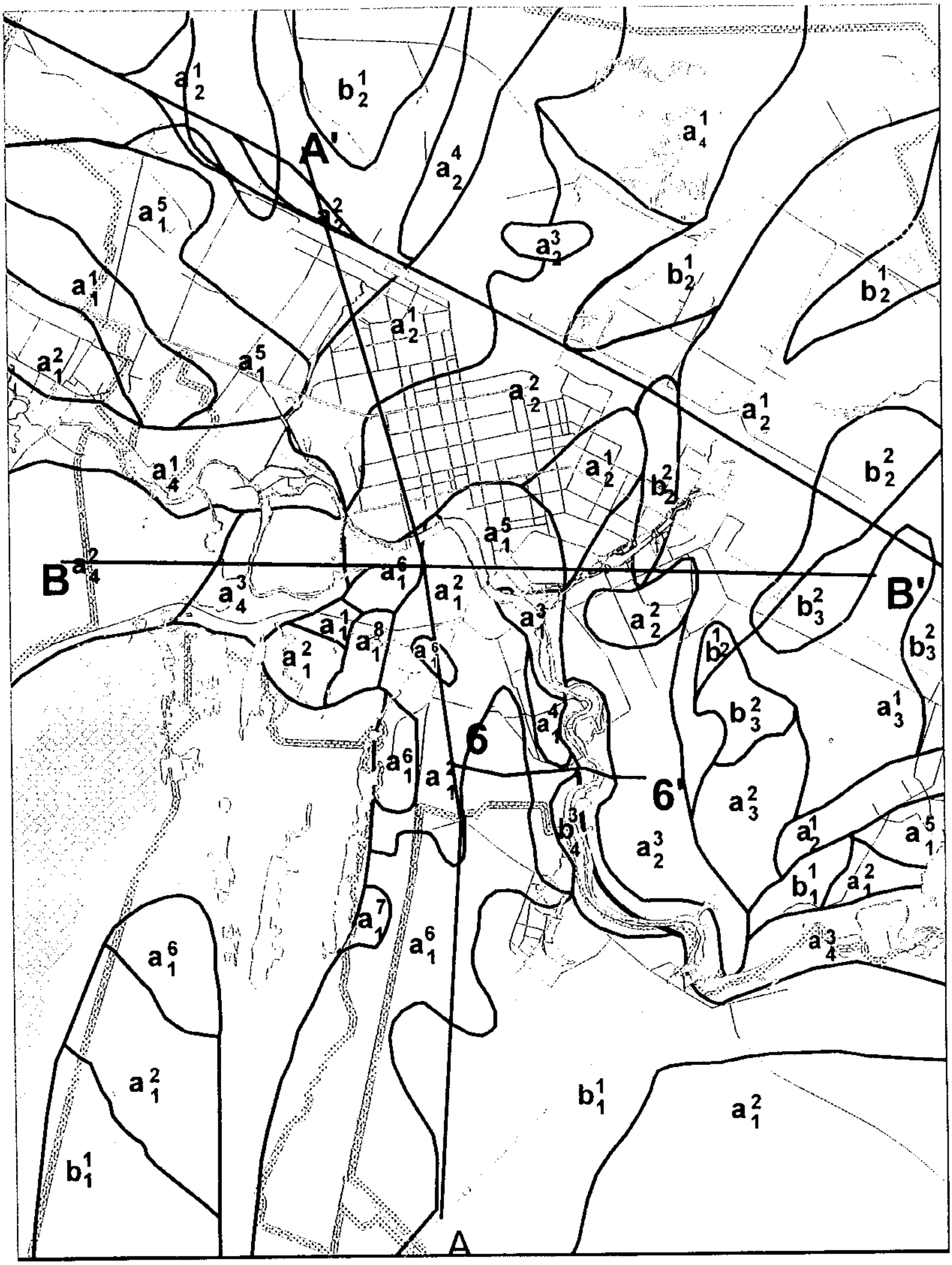
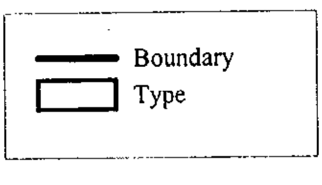


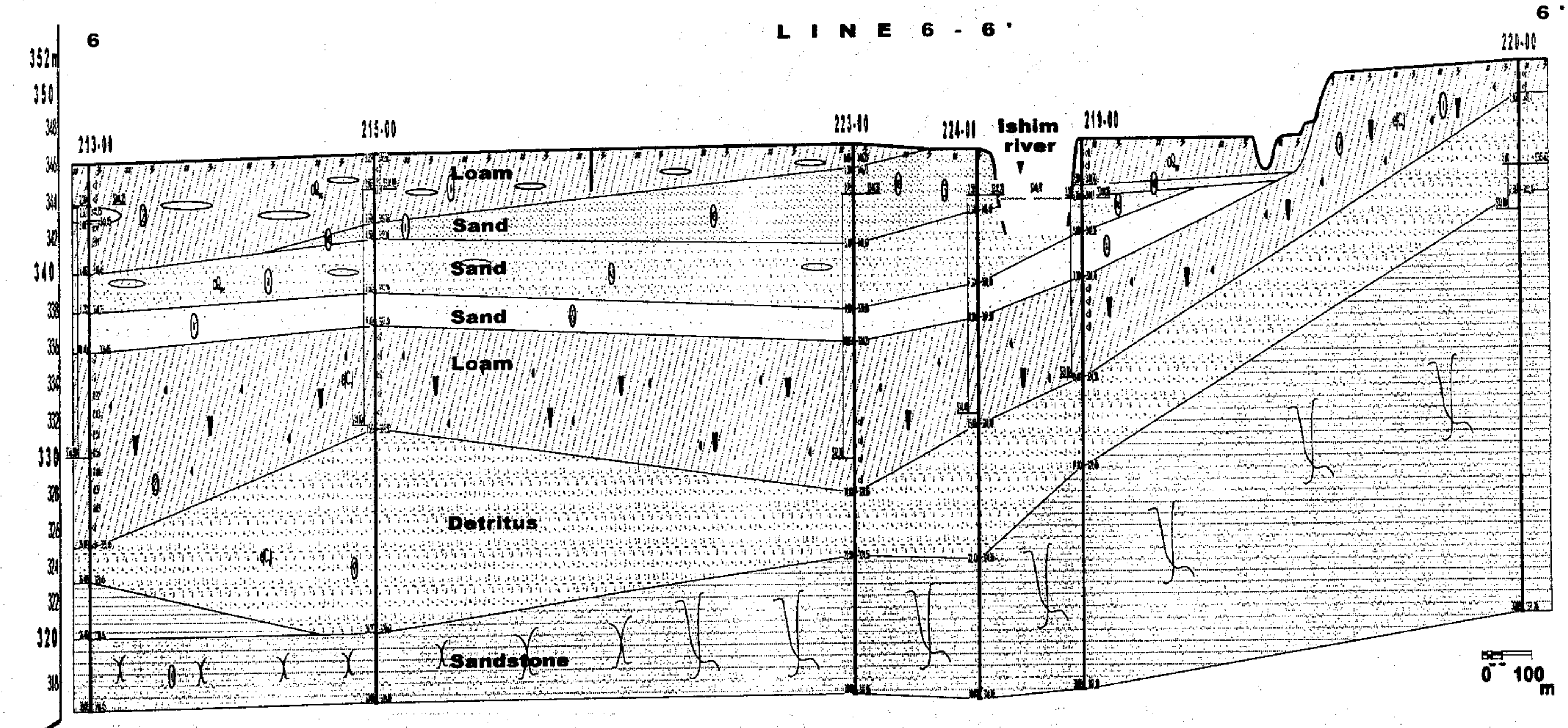
Figure 6.2.4 Groundwater Level Map of Astana Area





Detailed explanation of geo-technical types is shown in Table 6.2.1.

Figure 6.2.5 Geo-technical Map of Astana Area



Serial number	213-00	215-00	223-00	224-00	219-00	220-00
Altitude (m)	346.45	346.80	347.03	[illegible]	347.20	351.20
Dist. between points	600.00	1006.00	260.00	220.00	910.00	

Figure 6.2.6 Geological Cross Section of Line 6 - 6'

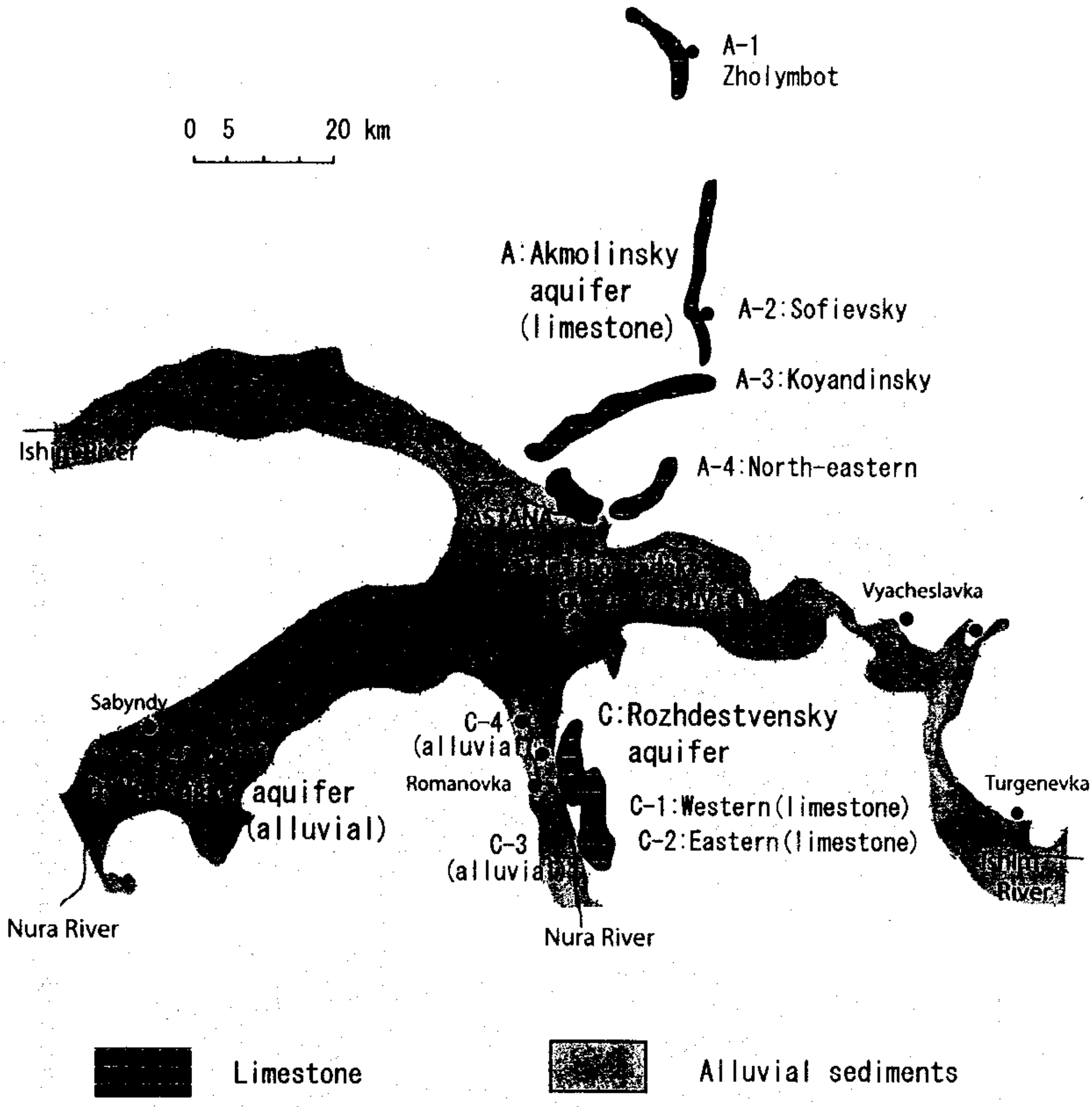


Figure 6.2.7 Groundwater Aquifers of Astana Area