7. WATER RESOURCES

7.1 Water supply to farms

The agricultural year may conveniently be divided into two periods of six months, the growing season (April to September) and the dormant period. In both seasons, there are peaks of water supply that are practically invariable in occurrence year by year. For most farms in the region, the growing season peak is July-August, and in February–March there is the peak for pre-irrigation, very often with soil leaching. The water supply during the dormant period tends to be different in each republic. For example:

- in the rice growing farms of Kazakhstan canals are closed throughout, but in the cotton farms of S Kazakhstan they are closed for one month in March for repair and cleaning since winter wheat is irrigated in October - November and soil leaching takes place in January - February;
- canals of highland farms in Kyrgyzstan are practically closed but in the cotton growing farms, winter cereals are irrigated in October - November and for the rest of the period canals are closed.

The WUFMAS programme only measures water management within the sample fields so that the level of management for the whole farm cannot be evaluated directly. The extra information necessary for evaluation, such as total water supply to the farm, cropping pattern, and efficiency of on-farm irrigation system, are collected from official farm reports. The water supply to the main crops of the farm is calculated on the assumption that averages based on direct measurements on the sample fields may be extrapolated to the total irrigated area.

Data on planned water requirements and actual deliveries are summarised in Table 7.1 and given in more detail in Appendix 4, Table A4.1. Farms request their annual water supply early in the year from their RAIVODKHOZ, on the bases of the planned cropping pattern and the norms for water requirement. The Ministries of Agriculture and Water Resources and BVOs annually reconcile the collective demand for irrigation water with the hydrographs projected from winter snowfall, and a pre-season allocation of water is made. The overall average planning rate for the sample farms was 12 tcm/ha, which is close to the regional average, but there are marked differences between farms and therefore between the republics. Farms with rice in the crop rotation and farms with sloping stony soils, mainly in Kazakhstan and Tadjikistan respectively, requested much higher rates. Demand of the farms in Uzbekistan was mostly below the average but the reason for the considerable variation between farms there is not clear.

In this year, delivery of water during the vegetative season exceeded the requested volumes in the Kyzl Orda sample farms, and all but one of the sample farms in Uzbekistan, by an average of 36 percent. In the other republics, there was undersupply, as much as 37 percent to the farms in Tadjikistan at the end of the Big Ferghana canal, so that the overall average delivery to sample farms exceeded demand by only 15 percent.

The area being irrigated in each month varies according to climate and the irrigation schedule. Calculated by month as percent of the intended irrigable area, the value is somewhat variable and on different farms, reached a maximum in very different months. In some cases, the maximum occurred at the peak of irrigation demand, and in others in the winter and spring for land preparation, leaching and irrigation of winter wheat. With the exception of the Tadjikistan farms, the maximum value closely reflected the seasonal amount of water received as percent of the quantity for which the farm applied. Calculated per month as volume of water received per ha actually irrigated, values showed considerable variation between farms, with high values reflecting excessive tail escapes from farm canals. There were high deliveries to both farms in S Kazakhstan, one of two farms in Kanibadam, both farms in Karakalpakistan, and both farms in Syrdariya. The highest rate was recorded on farm Timur Malik in Syrdariya oblast, which received 1,374tcm in September most of which was in transit through the farm, but only irrigated 24ha, a rate equivalent to 57tcm/ha.

Table 7.1 Irrigation Water Supply and Use by Farms in 1997

Item	Units	Kazakhstan (4 farms)	Kyrgyzstan (4 farms)	Tadjikistan (2 farms)	Turkmenistan (2 farms)	Uzbekistan (10 farms)	Overall (22 farms)
Volume applied for	tcm	60,000	28,025	45,879	35,650	30,206	34,861
Planned irrigated area	ha	3,115	2,680	2,140	3,170	3,470	3,114
Planned water rate	tcm/ha	19	10	22	11	9	12
Water received in growing season	tcm	49,751	24,725	35,981	15,956	30,267	32,021
Drainage water used for irrigation: maximum monthly value	tcm	0	0	86	0	0	8
Water received: maximum monthly value	tcm	18,566	6,947	7,806	4,794	8,075	9,455
Water received per ha of planned irrigation: maximum monthly value	m^3/ha	5,611	2,525	3,588	1,507	2,386	3,027
Area irrigated in month: maximum monthly value	ha	4,096	2,509	5,005	2,064	3,530	3,448
Water received per ha of actual irrigation: maximum monthly value	m^3/ha	10,765	3,081	14,278	2,786	11,061	9,096
Area irrigated as percent of area planned: maximum monthly value	%	120	89	224	65	113	116
Water received as % of water applied for	%	137	90	87	63	136	115

7.2 Types of Field Supply Canals

Appendix 4 Table A4.2 details the types of supply canals bringing water to the sample fields and the data are summarised in Table 7.2.

Table 7.2 Canal Types Serving Sample Fields
(% of sample fields)

Type of canal	Kazakh-stan	Kyrgyz-stan	Tadjiki-stan	Turkmeni-stan	Uzbeki-stan	Overall
Unlined earth canal	8	73	90	0	70	55
Lined, concrete monolith	50	0	0	0	10	14
Concrete canalette	0	28	5	0	0	6
Temporary field canal	18	0	0	0	20	12
Temporary field furrow	25	0	0	100	0	14
Pipe, subsurface with hydrants	0	0	5	0	0	0

The large majority of supply canals (81 percent) are unlined, overall more than half are permanent but 26 percent are temporary field canals. Of the lined canals, proportionally more are in Kazakhstan but only a minority is of the pre-cast canalette type. In an area of steep slopes and coarse soil on a farm in Kanibadam, the supply is by gravity through a subsurface pipe with hydrant outlets. Flexible pipes for reducing water losses in the field are now out of use.

Temporary field canals, supplying water to groups of furrows or strips, increase conveyancing losses in the field but have the benefit of reducing the number of primary outlets from the supply canal. Specific length of such a temporary distribution network depends on the area of irrigated block and on average varies from 35m/ha (for a block of 20ha) to 80m/ha (for a block of 4ha).

7.3 Methods of In-field Irrigation

A feature of irrigation design in Central Asia is the prevalence of gravity irrigation systems with low hydraulic heads in the canal above the irrigated area, generally about 0.3-1.0m. In consequence, field irrigation is mostly by surface irrigation methods. The methods recorded in the sample fields are summarised in Table 7.3.

Table 7.3 In-field Irrigation Methods

Type of Irrigation	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan	Overall
Percent of fields actually irrigated:						
Normal furrow	37	79	100	45	59	61
Furrow with erosion control	0	0	0	0	3	1
Basin	50	0	0	0	11	14
Border strip	13	0	0	55	5	10
Border furrows	0	0	0	0	9	4
Wild Flooding	0	21	0	0	13	9
Non-irrigated (as % of total)	5	18	0	0	8	8

The method of surface irrigation is very dependent on the crop and the slope. Irrigation in furrows, spaced mostly at 0.6 and 0.9m down the slope, is the predominant method. It is commonly used for irrigating cotton, winter wheat, maize for grain, apricots, sugar beet, melons, onion, sunflower and tobacco. Sixty-two percent of irrigated fields had furrows, with only one percent protected against soil erosion at the off-take, usually with a small sheet of plastic. In flat terrain, particularly in the delta zone, basin irrigation is common for irrigating rice, lucerne, winter wheat and spring wheat, representing 14 percent overall of irrigated sample fields. Border strip irrigation is particularly common on the Turkmenistan sample farms and together with border furrows represents 14 percent of irrigated fields. Wild flooding is the least efficient method of irrigation and is common in Kyrgyzstan, where water is plentiful and slopes are steeper, and locally in the old lands of Bukhara oblast where the land is level. Nine percent of sample fields overall were irrigated by wild flooding.

Some eight percent of WUFMAS sample fields that were originally selected as irrigated fields were not irrigated in 1997. Reasons given were mostly shortage of irrigation water and that in places the groundwater is close to the surface so that irrigation is unnecessary.

7.4 Ground Water

A significant amount of water rises to the soil surface by capillarity from a water table closer than 2m from the surface in a silty soil, and its evaporation may cause serious secondary salinity unless controlled by leaching or rainfall. From an even deeper watertable, the daily contribution into the root zone may be considerable, reducing the crop irrigation demand. Variation of watertable depth depends on such factors as the position of the site in the catena, elevation above water bodies, rate of lateral drainage, season, irrigation schedules and presence and effectiveness of artificial drainage. Enumerators recorded the average depth of the groundwater in the WUFMAS sample fields twice monthly, the data are presented in Appendix 4 Table A4.3 and summarised in Table 7.4.

Overall, 41 percent of sample fields had an average watertable depth of 2m or less, with an associated risk of secondary salination. This is marginally more serious than recorded in 1996. The situation is worst in Kazakhstan and Uzbekistan, and least problematic in Kyrgyzstan. Overall, 74 percent of sample fields had average watertable depth closer than 3m to the surface and therefore contributing significantly to the net irrigation demand of crops. The effect of this contribution is to markedly lengthen the critical irrigation interval, and hence reduce the number of irrigations during the season in the ideal schedule.

Table 7.4 Average Groundwater Depth Below Surface
(as percent of sample fields by republic)

Depth (m)	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan	Overall
0-0.50	23	3	10	0	1	6
0.51-1.00	13	0	10	0	16	11
1.01-1.50	10	5	5	5	13	10
1.51-2.00	10	0	0	40	20	15
2.01-2.50	38	5	0	25	33	25
2.51-3.00	8	0	0	30	7	7
3.01-5.00	0	0	5	0	10	5
>5.00 (1)	0	88	70	0	0	22

(1) Note: Watertables deeper than 5m were not measured but recorded as a notional 10m deep

There is seasonal variation in depth of groundwater due to discharge of irrigation water and leakage from canals. This variation is significant where the watertable is close to the surface. Average monthly variation by republic in 1997 is shown in Table 7.5 and in detail in Appendix 4 Table A4.4.

Table 7.5 Seasonal Change in Watertable Depth
(average of sample fields in republic in m)

Month in 1997	Kazakhstan	Kyrgyzstan	Tadjikistan	Turkmenistan	Uzbekistan
April	2.0	(1)	5.8 (2)	2.3	2.0
May	1.6		2.1	1.9	1.9
June	1.3		5.7	2.0	2.0
July	1.6		1.9	2.1	2.0
August	1.7		6.1	2.2	2.1
September	2.4		6.0	2.4	2.3
October	2.7		3.9	2.6	2.7
November	3.2		1.0	2.6	2.6
December	3.3			3.0	2.8

(1) Note: Watertables deeper than 5m were not measured but recorded as a notional 10m deep
(2) Note: Variability in Tadjikistan caused by recording of temporary high watertables after irrigation

The Kyrgyzstan farms are representative of the upper reaches of the river, where the ground water depth is mostly 10m or more and there is no contribution to crop evapotranspiration. The Turkmenistan farms in Mary oblast and the Uzbekistan farms in Syrdariya oblast are representative of the rivers' middle reaches. The ground water table depths here are 1.3-2.5 m and depend on the effectiveness of the drainage system and irrigation water duties. There is a ground water contribution to crop evapotranspiration on such lands. Watertables in this region drop at the end of the summer and rise in the following spring due to overly heavy rates of soil leaching and pre-irrigation (250 - 400 mm in February-March).

The Kazakhstan farms in Kzyl-Orda oblast and the Uzbekistan farms in Karakalpakistan are representative of the rivers' lower reaches. Watertable variation totally depends on the rice irrigation schedules, and during the vegetation period they are close to the surface at 0.3-2.0m.

The Kyrgyzstan farms in the Chu Valley and the Uzbekistan farms in Surkhandariya oblast are representative of intermontane depressions. Groundwater depth depends on the location of the site in the catena. The upper slopes and terraces have deep watertables (5-10m and more) but inefficient irrigation and lateral drainage increase the groundwater levels in lower lands (typically 0.8-2.3m). This effect is observed during summer within the two farms in Leninabad oblast, Tadjikistan, where over-irrigation on the steep, coarse-textured soils of the upper slopes, and proximity of the lower lands to Kairakkum reservoir maintain high watertables at 0.5 to1.1m.

It is worthy of note that the drainage systems in the middle and lower river reaches of the Aral Sea Basin are designed to maintain the groundwater at 2.5-3.0m. However, only 10 percent of fields have a watertable in this range, which gives a measure of the unsatisfactory operation of the drainage systems.

7.5 Irrigation Water Use

Data on use of irrigation water in sample fields, collected during the 1996/97 season, have been reviewed and those from 97 fields of cotton and 48 fields of winter wheat are considered sufficiently accurate to be summarised. Averages by farm are given in Appendix 4, but are summarised by republic in Tables 7.6 and 7.7.

Table 7.6 Summary of Irrigation Water Use on Cotton

Characteristic	Units	Kazakh-stan	Kyrgyz-stan	Tadjiki-stan	Turkmeni-stan	Uzbeki-stan	Overall
Number of cotton sample fields	no.	13	13	10	9	52	97
Area of cotton sample fields	ha	10.1	5.2	8.8	8.3	6.9	7.4
Seasonal average watertable depth	m	2.4	10.0	6.5	1.9	2.0	3.6
Gross annual total field water application	tcm/ha	5.72	9.34	14.09	7.37	5.44	7.07
Water for leaching and pre-irrigation	tcm/ha	4.58	0.00	0.00	1.76	2.16	1.93
Number of applications	no.	1.0	0.0	0.0	1.0	1.5	1.0
Gross leaching per application	tcm/ha	4.58	0.00	0.00	1.76	1.66	1.67
Gross field irrigation application	tcm/ha	1.14	9.34	14.09	5.61	3.29	5.14
Irrigation as % of total water applied	%	20	100	100	76	60	73
No. of irrigations during growing season	no.	1.2	6.2	5.6	4.0	3.2	3.6
Gross irrigation per application	tcm/ha	0.97	1.51	2.60	1.38	1.11	1.32

Table 7.7 Summary of Irrigation Water Use on Winter Wheat

Characteristic	Units	Kazakh-stan	Kyrgyz-stan	Tadjiki-stan	Turkmeni-Stan	Uzbeki-stan	Overall
Number of winter wheat sample fields		2	8	6	8	24	48
Area of winter wheat sample fields	ha	14.3	10.3	8.7	7.7	9.7	9.5
Watertable depth during growing season	m	1.7	8.1	8.8	1.9	1.7	3.7
Gross annual field water application	tcm/ha	0.96	5.49	7.04	7.70	3.35	4.79
Number of irrigations		1.0	2.6	4.1	4.6	3.9	3.7
Gross irrigation per application	tcm/ha	0.96	2.15	1.74	1.74	0.91	1.36

Sample fields were markedly larger in Kazakhstan than the other republics, and the average depth of watertables were much greater in Kyrgyzstan and Tadjikistan

The reason for application of water to fallow fields during winter months is not always clear. The alternatives are leaching salts, moistening the soil for tillage and pre-irrigation before planting. For cotton therefore, irrigation is notionally water applied only between planting and harvesting the crop, and other water is regarded as applied for other purposes. The overall average of all water applied to cotton fields in the year was 7.07tcm/ha of which 73 percent was for irrigation and 27 percent during winter months. The corresponding average for winter wheat was 4.79tcm/ha.

There is marked variation between farms and between averages for republics. The average annual totals ranged from 14.09tcm/ha in Kyrgyzstan down to 5.44tcm/ha in Uzbekistan. In the sample fields in Kyrgyzstan and Tadjikistan, all the water applied to cotton was for irrigation compared with only 20 percent in Kazakhstan. The variation in water applied to irrigate cotton varied very considerably between republics: 14.09tcm/ha in Tadjikistan but only 1.14tcm/ha in Kazakhstan.

In the case of winter wheat planted in October or November, it is not possible to distinguish between water applied for irrigation, land preparation and leaching so all the water applied is regarded as irrigation of the crop. Winter wheat in Tadjikistan and Turkmenistan received more than 7tcm/ha compared with only 0.96tcm/ha in Kazakhstan.

Where water is applied during winter months in preparation for the following cotton crop, it is mostly applied in a single massive dose, as much as 4.58tcm/ha on average on the Kazakhstan farms. Some farms in Uzbekistan applied water for a second time prior to planting.

The number of irrigations during the vegetative period of both crops varied considerably. Overall, both crops were irrigated about 3.6/3.7 times. Cotton was irrigated from 6.2 times on average on Kyrgyzstan farms down to 1.2 times on Kazakhstan farms. Wheat was frequently irrigated in Turkmenistan, some 4.6 times, but in Kazakhstan only once.

The average rate of a single irrigation of the crops was much the same for cotton and wheat, slightly more than 1.3tcm/ha gross, but again there is considerable variation between farms and republic means. Both crops received less than 1tcm/ha in Kazakhstan, but cotton in Tadjikistan received as much as 2.6tcm/ha and wheat in Kyrgyzstan received 2.15tcm/ha on average at each application.

7.6 Water quality

Samples of water were collected at intervals from the canals supplying irrigation water to the sample fields, from collector drains removing water from the fields, and from five auger bores in each field, down to the groundwater where this was less than 5m deep. Electrical conductivity and pH were measured in the field using a portable instrument but saline samples (beyond the limit of the instrument) and representative samples were referred to the laboratory for more comprehensive analysis. Average values with maximum and minimum range are presented in Appendix Table A4.5 but averages are summarised in the tables below. There is close agreement between the sum of concentrations of cations and anions, no greater than 3 percent difference, indicating reliable data, but some questionable values have been eliminated from the database.

Table 7.8 FAO Interpretative Criteria for Irrigation Water

Laboratory measurements	Units	Degree of restriction in use		
		None	Slight/mod	Severe
Salinity:				
Ecw	dS/m	< 07	0.7 - 3.0	> 3.0
(or as TDS)	(g/l)	(< 0.45)	(0.45 – 2.0)	(> 2.0)
ECw in relation to SAR = 0 – 3	dS/m	> 0.7	0.7 - 0.2	< 0.2
3 – 6		> 1.2	1.2 - 0.3	< 0.3
6 – 12		> 1.9	1.9 - 0.5	< 0.5
12 – 20		> 2.9	2.9 - 1.3	< 1.3
20 – 40		> 5.0	5.0 - 2.9	< 2.9
Specific Ion Effects:				
Na^+ – surface irrigation	SAR	< 3	3 - 9	> 9
Sprinkler irrigation	me/l	< 3	> 3	
Cl^- – surface irrigation	me/l	< 4	4 - 10	> 10
Sprinkler irrigation	me/l	< 3	> 3	
B	me/l	< 0.7	0.7 - 3.0	> 3.0
Miscellaneous effects on specific crops:				
NO_3^- – N	me/l	< 5	5 - 30	> 30
HCO_3^-	me/l	< 1.5	1.5 - 8.5	> 8.5
pH (by nutrient imbalance)		Normal range 6.5 - 8.4		

Source: Booker Tropical Soil Manual, Ed Landon J R, Longman (1991)

To provide some indication of the distribution of values, they have been classified into three classes because the range is very wide. FAO criteria for evaluation of the quality of irrigation water, as shown in Table 7.8, have been used for analyses that are considered diagnostic of salinity. The classification of the other analyses is arbitrary. Limits for each class are shown at the top of the tables.

For discussion of the water analysis data, see Section 15.

7.6.1 Irrigation Water

Average values of the analyses of samples of irrigation water are shown in Table 7.9 and the percentage of samples in three classes in Table 7.10. More detail is given in Appendix 4.

Analyses of irrigation water show that on average the poorest quality was found on the Uzbekistan farms in 1996 but on the Kazakhstan farms in 1997. Fewer samples were analysed in 1997 and at different times so that these factors as well as the variation due to the amount of snowfall and amount of drainage returns may have been responsible. The best quality water was on the Kyrgyzstan farms.

The difference in water quality on Kazakhstan farms between 1996 and 1997 is reflected in the classification. Few samples were in class III in 1996 but more than a quarter in 1997 were seriously saline and in class III. In both years, the majority of farms in Kazakhstan, Uzbekistan and Turkmenistan had water of slight to moderate salinity hazard on the bases of TDS and ECw. With the exception of sodium in Tadjikistan, the majority of irrigation water samples were non-saline when assessed in terms of their sodium and chloride hazards.

7.6.2 Drainage Water

Calculated average values of the analyses of the drainage water are given in more detail in Appendix 4 but summarised in Table 7.11. Drainage water analyses are classified in Table 7.12.

The most saline drainage water on average was found in the fields of the Uzbekistan farms, except in 1996, when the most saline samples were from the Turkmenistan farms. On most farms, sodium sulphate is the main salt responsible for salinity in the drainage water, but magnesium sulphate also is an important salt. Drainage water in Kyrgyzstan, was markedly less saline.

The majority of drainage water samples have a high hazard rating for use as irrigation water, particularly on the bases of TDS and ECw, and although the pattern is more variable, in some cases on account of sodium and chloride.

7.6.3 Groundwater

Average content of dissolved solids (TDS), electrical conductivity and chemical composition of groundwater are summarised in Table 7.13, and more details are given in Appendix 4. Analyses are classified in Table 7.14.

The average salinity of the groundwater samples was somewhat more than that of the drainage water samples in 1996 but marginally less in 1997. There was substantially more sodium sulphate in the groundwater than in the drainage water in 1996.

The most saline groundwater on average was in Kazakhstan in 1996, caused mainly by sodium and magnesium sulphates, and in Uzbekistan in 1997. Chloride levels also were very high in Kazakhstan groundwater samples in 1996 and, excepting in Kyrgyzstan, in all republics in 1997.

These observations are reflected in the classification of samples in Table 7.14. The majority of groundwater samples would be unsuitable for irrigation of crops, particularly on the bases of TDS and ECw, but in some cases on account of chloride and sodium.

Table 7.9 Average Analysis of Irrigation Water

Characteristic	Units	Kazakhstan		Kyrgyzstan		Tadjik-istan	Turkm-enistan	Uzbekistan		Overall	
		1996	1997	1996	1997	1996	1996	1996	1997	1996	1997
pH		8.6	7.9	8.3	8.2	8.5	8.4	8.4	7.6	8.4	7.9
Ionic Concentration:											
$HCO3^-$	me/l	1.5		0.4		0.7	0.8	1.2		1.0	
Cl^-	me/l	2.9	8.2	0.7	0.6	2.7	2.6	3.3	3.5	2.7	3.2
$SO4^{--}$	me/l	7.4		2.3		7.3	5.5	7.0		6.1	
Ca^{++}	me/l	5.0		1.6		3.9	3.6	4.3		3.9	
Mg^{++}	me/l	4.6		0.9		2.3	2.1	3.5		2.9	
Na^+	me/l	2.2		0.6		4.6	3.1	3.5		3.0	
K^+	me/l	0.1		0.0		0.1	0.1	0.1		0.1	
Salinity:											
TDS	g/l	0.78	1.62	0.29	0.35	0.79	0.67	0.96	1.08	0.77	0.88
EC	dS/m	1.3	2.1	0.5	0.6	0.8	0.9	1.5	1.7	1.2	1.3
SAR		1.0		0.7		3.3	1.7	2.0		1.8	
Severity of hazard	EC	1.0	1.3	0.3	0.0	0.8	0.9	0.9	1.1	0.8	0.6
(0=nil, 3=severe)	Cl	0.0	0.4	0.0	0.0	0.3	0.1	0.4	0.3	0.3	0.2
	SAR	0.0		0.4		0.4	0.2	0.3		0.3	

Table 7.10 Classification of Irrigation Water Analyses

Class criteria	pH	TDS g/l	EC dS/m	Ionic Concentration in me/l HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Criteria of classes (in units shown):										
Class I = <	8.20	0.5	0.70	1.5	4.0	10.0	10.0	10.0	3.0	2.0
Class III = >	8.40	2.0	3.00	8.5	10.0	20.0	20.0	20.0	9.0	10.0
Kazakhstan 1996:	N = 34									
% in class I	12	18	0	32	97	88	97	97	91	100
% in class II	32	79	100	68	3	6	3	3	6	0
% in class III	56	3	0	0	0	6	0	0	3	0
Kazakhstan 1997:	N = 17									
% in class I	65	0	0		76					
% in class II	24	71	76		12					
% in class III	12	29	24		12					
Kyrgyzstan 1996:	N = 68									
% in class I	60	97	68	100	100	100	100	100	100	100
% in class II	25	3	32	0	0	0	0	0	0	0
% in class III	15	0	0	0	0	0	0	0	0	0
Kyrgyzstan 1997:	N = 32									
% in class I	63	69	100		100					
% in class II	34	31	0		0					
% in class III	3	0	0		0					
Tadjikistan 1996:	N = 36									
% in class I	6	58	25	94	72	58	97	97	64	100
% in class II	53	42	75	6	28	36	3	3	6	0
% in class III	42	0	0	0	0	6	0	0	31	0
Turkmenistan 1996:	N = 41									
% in class I	32	24	12	100	90	93	100	100	85	100
% in class II	15	68	88	0	10	0	0	0	7	0
% in class III	54	7	0	0	0	7	0	0	7	0
Uzbekistan 1996:	N = 250									
% in class I	26	31	13	66	64	78	96	97	61	100
% in class II	26	64	85	34	33	16	4	3	29	0
% in class III	49	5	2	0	3	6	0	0	10	0
Uzbekistan 1997:	N = 26									
% in class I	88	23	0		77					
% in class II	8	62	92		15					
% in class III	4	15	8		8					

Table 7.11 Average Analysis of Drainage Water

Characteristic	Units	Kazakhstan 1996	Kazakhstan 1997	Kyrgyz-stan 1996	Tadjiki-stan 1996	Turkm-enistan 1996	Uzbekistan 1996	Uzbekistan 1997	Overall 1996	Overall 1997
pH		8.5	7.6	8.3	8.4	8.5	8.3	7.8	8.4	7.8
Ionic Concentration:										
$HCO3^-$	me/l	2.6		0.6	1.7	2.1	2.1		2.0	
Cl^-	me/l	8.5	8.2	1.6	5.6	12.8	10.0	25.7	9.8	24.2
$SO4^{--}$	me/l	25.7		5.2	22.6	28.5	20.1		21.5	
Ca^{++}	me/l	9.2		1.4	9.3	7.6	7.6		7.7	
Mg^{++}	me/l	13.1		1.0	10.7	12.1	9.9		10.2	
Na^+	me/l	13.9		4.0	10.2	22.4	14.2		14.8	
K^+	me/l	0.4		0.1	0.3	0.7	0.4		0.5	
Salinity:										
TDS	g/l	2.4	3.3	0.6	2.0	3.5	3.4	6.4	3.1	6.1
EC	dS/m	2.5	3.8	0.5	1.8	3.3	4.8	6.9	4.2	6.7
SAR		3.6		6.6	3.5	6.9	5.7		5.5	
Severity of hazard	EC	1.2	1.8	0.2	1.2	1.3	1.7	1.8	1.6	1.8
(0=nil, 3=severe)	Cl	0.5	1.0	0.0	0.5	1.1	0.8	1.7	0.8	1.6
	SAR	0.0		0.5	0.2	0.2	0.1		0.1	

Table 7.12 Classification of Drainage Water Analyses

Class criteria	pH	TDS g/l	EC DS/m	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
				Ionic Concentration in me/l						
Criteria of classes (in units shown):										
Class I = <	8.20	0.5	0.70	1.5	4.0	10.0	10.0	10.0	3.0	2.0
Class III = >	8.40	2.0	3.00	8.5	10.0	20.0	20.0	20.0	9.0	10.0
Kazakhstan 1996:		N = 16								
% in class I	25	0	0	25	69	0	75	81	6	94
% in class II	19	75	81	75	13	63	19	6	44	6
% in class III	56	25	19	0	19	38	6	13	50	0
Kazakhstan 1997:		N = 9								
% in class I	67	0	0		11					
% in class II	33	11	22		67					
% in class III	0	89	78		22					
Kyrgyzstan 1996:		N = 5								
% in class I	40	60	80	80	100	80	100	100	60	100
% in class II	40	40	20	20	0	20	0	0	20	0
% in class III	20	0	0	0	0	0	0	0	20	0
Tadjikistan 1996:		N = 28								
% in class I	0	11	0	50	54	29	61	75	21	100
% in class II	61	64	79	50	43	39	36	4	29	0
% in class III	39	25	21	0	4	32	4	21	50	0
Turkmenistan 1996:		N = 47								
% in class I	11	17	2	17	17	36	94	70	19	91
% in class II	26	47	68	83	53	28	2	9	23	9
% in class III	64	36	30	0	30	36	4	21	57	0
Uzbekistan 1996:		N = 253								
% in class I	34	38	1	46	53	47	66	61	43	95
% in class II	32	19	26	51	11	10	27	25	12	5
% in class III	34	43	72	3	36	43	8	14	45	0
Uzbekistan 1997:		N = 85								
% in class I	78	1	0		9					
% in class II	8	11	15		13					
% in class III	14	88	85		78					

Table 7.13 Average Analysis of Groundwater

Characteristic	Units	Kazakhstan 1996	Kazakhstan 1997	Kyrgyzstan 1996	Kyrgyzstan 1997	Tadjik-istan 1996	Turkm-enistan 1996	Uzbekistan 1996	Uzbekistan 1997	Overall 1996	Overall 1997
pH		8.0	8.0	8.4	7.5	8.3	8.5	8.2	7.6	8.2	7.7
Ionic Concentration:											
$HCO3^-$	me/l	2.9		1.6		2.0	3.0	2.0		2.2	
Cl^-	me/l	34.3	23.3	0.6	1.0	11.7	26.9	14.1	22.6	16.2	22.2
$SO4^{--}$	me/l	66.7		10.8		24.6	56.8	33.3		36.7	
Ca^{++}	me/l	13.1		4.0		13.8	13.8	9.9		10.5	
Mg^{++}	me/l	42.4		5.9		10.9	24.0	17.1		18.8	
Na^+	me/l	45.8		2.9		14.9	46.5	21.6		24.8	
K^+	me/l	1.4		0.1		0.5	1.4	0.7		0.8	
Salinity:											
TDS	g/l	6.9	3.3	0.9	0.4	2.5	5.7	5.9	6.6	5.6	5.8
EC	dS/m	4.1	3.4	0.4	0.7	2.8	4.4	5.8	7.2	5.3	6.2
SAR		6.1		1.3		4.4	8.0	6.7		6.5	
Severity of hazard	EC	1.4	1.4	0.0	0.5	1.4	1.4	1.8	1.8	1.7	1.7
(0=nil, 3=severe)	Cl	1.1	1.0	0.0	0.0	1.4	1.6	0.8	1.6	0.9	1.4
	SAR	0.0		1.0		0.1	0.1	0.0		0.1	

Table 7.14 Classification of Groundwater Analyses

Class	pH	TDS g/l	EC DS/m	Ionic Concentration in me/l HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Criteria of classes (in units shown):										
Class I = <	8.20	0.5	0.70	1.5	4.0	10.0	10.0	10.0	3.0	2.0
Class III = >	8.40	2.0	3.00	8.5	10.0	20.0	20.0	20.0	9.0	10.0
Kazakhstan 1996:		N = 24								
% in class I	42	4	0	13	21	4	33	29	13	92
% in class II	42	21	58	88	50	17	50	38	29	0
% in class III	17	75	42	0	29	79	17	33	58	8
Kazakhstan 1997:		N = 35								
% in class I	57	0	0	100	23	100	100	100	100	100
% in class II	11	40	60	0	60	0	0	0	0	0
% in class III	31	60	40	0	17	0	0	0	0	0
Kyrgyzstan 1996:		N = 10								
% in class I	0	0	100	0	100	0	100	100	100	100
% in class II	100	100	0	100	0	100	0	0	0	0
% in class III	0	0	0	0	0	0	0	0	0	0
Kyrgyzstan 1997:		N = 4								
% in class I	100	75	50	100	100	100	100	100	100	100
% in class II	0	25	50	0	0	0	0	0	0	0
% in class III	0	0	0	0	0	0	0	0	0	0
Tadjikistan 1996:		N = 14								
% in class I	21	0	0	50	7	7	36	50	0	100
% in class II	64	29	64	50	43	21	50	36	21	0
% in class III	14	71	36	0	50	71	14	14	79	0
Turkmenistan 1996:		N = 34								
% in class I	6	0	0	0	6	12	44	59	9	88
% in class II	38	29	56	100	32	26	38	6	6	9
% in class III	56	71	44	0	62	62	18	35	85	3
Uzbekistan 1996:		N = 273								
% in class I	39	45	0	50	52	49	62	53	50	93
% in class II	34	11	20	48	15	9	12	16	8	6
% in class III	27	44	80	1	33	42	25	31	42	1
Uzbekistan 1997:		N = 117								
% in class I	94	0	2	100	5	100	100	100	100	100
% in class II	3	10	16	0	28	0	0	0	0	0
% in class III	3	90	82	0	67	0	0	0	0	0