Groundwater Assessment of the Southern Mongolia (SGR)

Preliminary Conclusions

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Current and future water demands
The reported (planned) water demand of the mining industry in the Southern Mongolia (SGR) is around 250,000 m^3/day of which 220,000 m^3/day for the four main mines: Oyu Tolgoi (60,000), Tavan Tolgoi (76,000), Tsagaan Suvarga (32,000) and Shivee-Ovoo (50,000). Future demand may increase to 300,000 m^3/day or more in 2020. These figures need to be cross-checked and specified in type of use and required quality. Other industrial water demand is still negligible but may increase under the economic development of the SGR

The current water demand for urban water supply to Dalangadzad, Mandalgobi and Saindhand is 12,500 m^3/day (total population 60,000) . Rural water supply is 3,000 m^3/day for domestic uses (population 90,000) and 32,000 m^3/day for livestock watering. Urban and rural drinking water supply is expected to increase under the SGR economic development and may reach 25,000-35,000 m^3/day in 2020.

Groundwater use for agriculture is limited and confined to subsistence farming in villages and hamlets. Irrigated agriculture is applied on a small scale with surface water from springs and stream flow during and after the rains. The present water demand for tourism and wildlife are also small compared to the mining, drinking and livestock water demand.

Groundwater use
Current groundwater use for rural water supply is mainly from appr. 7,000 traditional wells and shaft wells which are shallow (< 20m) and operated with manual pumps or buckets. There are also a considerable number of deepened shaft wells (depth 20-100 meter) and drilled production wells (depth 30-200 meter) but only a small portion of these wells (8-20%) is in operation (total 200-250). Urban water supply is from production wells. Based on typical abstraction rates of the different well types, a total abstraction of appr. 40,000 m^3/day is estimate, which a in the same order of magnitude as the total urban and rural water demand.

Groundwater potential
The hydrogeology of the SGR is characterized by limited recharge to the upper aquifers and the presence of deeper discontinues (local) aquifers of different depth, size, lithology and productivity, mainly containing fossil water with often a poor water quality.

The most recent estimate of the groundwater potential is prepared by Dr Jadambaa (ref #) and presented in a classification of the different aquifer productive types (table)

Table 1. Estimated groundwater reserves by Jadambaa (2007)

Aquifer classification	Productivity (lit/sec) per 1 km^2	Estimated groundwatersr resources (Mm^3/year)		
		Dundgovi	Umnogobi	Dornogobi
High productive	>1	25	31	19
Moderate to locally high productive	0.1-1.0	77	138	71
Low to moderate productive	0.03-0.1	2	89	19
Low productive	0.003-0.03	3	3	4
Essentially y no groundwater	<0.003	0	0.0	0.0
total		**107**	**261**	**113**

The figures in table 1 have been verified with an approach to classify the aquifers based on depth and recharge (table 2 and 3):

Shallow groundwater (< 50m): mainly granular aquifers in river beds and depressions and recharged from infiltration by rainfall. These aquifers are the main source of water for rural purposes. Recharge from rainfall is small, but studies in the Gobi Desert in China under comparable climate conditions (ref # and #) show a recharge of 1-2 mm/year. A study in the Mandalgobi area (ref #) also concludes the presence of recharge. These figures are consistent with research in other (semi)arid desert areas (Kalahari Desert, ref #). A recharge of 1 mm/year represents 950.000 m^3/day (175 Mm^3/year) over the total SGR area (350,000 km^2). Assuming that only 50% of this is reaching the groundwater table in the shallow aquifers, it represents 500,000 m^3/day

*Deep groundwater (50-170 meter***).** A large number (> 50) of groundwater studies in deeper aquifers were conducted in the 1970's and 1980's. These investigations covered the local aquifers till a depth of 170-200 meters (due to limitations in the capacity of drilling rigs). Most of the reports are available with the Geological Information Department. The studies give estimates of the groundwater potential based on the assumption of (i) a 25-27 years pumping period and (ii) 40-60% depletion of the groundwater reserve in the aquifer. The investigations include the aquifers for the water supply to the Tavan Tolgoi, Tsagaan Suvraga and Shivee Ovoo mine. There is still a degree of uncertainty in the validity of these estimates.

Deeper groundwater (> 200 meters)
The current study of the Gunii Hooloi groundwater area for the Ovon Tolgoi mine is the first deeper aquifer (> 170 meter) to be investigated. The study concluded that 60.000 m^3/day can be pumped from this aquifer during a 40 year period, assuming that the groundwater table will be lowered not further than the top of the aquifer. Another deep aquifer presently under investigation is in the area northwest of the Tavan Tolgoi mine (to be checked) . Future investigations may reveal the presence of other deeper aquifers in the SGR

Table 2. Estimates groundwater reserves

Aquifer type	parameter	dimension	Dundgovi	Umnogobi	Dornogobi
Surface aquifer	area	km	74,500	165,000	109,000
	recharge	mm/year	1	1	1
	losses	%	50	50	50
	effective recharge	m^3/dav	102,055	226,027	149,315
		Mm3/year	37	83	55
Aquifer < 200 m	no. sites		10	25	16
	est. reserve	m^3/dav	11,000	240,000	220,000
		Mm3/year	4	88	80
Aquifer > 200 m	Gunii Hooloi	m^3/day		60,000	
	other?	Mm3/year		22	
	Total:	m^3/dav	**113,055**	**526,027**	**369,315**
		Mm^3/vear	**41**	**192**	**135**
		Liter/sec	**1,309**	**6,088**	**4,274**

Groundwater potential
The estimate of the total (renewable and non-renewable) groundwater reserves in table 1 and 2 are in the same order of magnitude. The groundwater potential for exploration will be lower as not all groundwater can effectively be used. Assuming that 20% of the recharge can actually be pumped through shallow wells and spring flow and that 50% of the groundwater reserves in the deeper aquifers (< 170-200 meter) can be effectively be exploited, the total groundwater potential is as summarized in table 3.

Table 3: Estimated groundwater potential in the SGR

Aquifer type	parameter	dimension	Dundgovi	Umnogobi	Dornogobi
Surface aquifer	area	km	74,500	165,000	109,000
	recharge	mm/year	1	1	1
	usable fraction	%	20	20	20
	potential	m^3/day	40,822	90,411	59,726
		Mm3/year	15	33	22
Aquifer < 200 m	no. sites		10	25	16
	est.reserve	m^3/day	11,000	240,000	220,000
		Mm3/year	4	88	80
	usable fraction	%	50	50	50
	potential	m^3/day	5,500	120,000	110,000
Aquifer > 200 m	Gunii Hooloi	m^3/day		60,000	
	other?	Mm3/year		22	
	Total:	m^3/day	**46,322**	**270,411**	**169,726**
		Mm^3/year	**17**	**99**	**62**
		Liter/sec	**536**	**3,130**	**1,964**

The figures in table 3 indicate a total groundwater potential in the order of 500,000 m^3/day, which is more than the 2020 water demands for the mining and energy sector and for urban and rural water supply.

Despite the uncertainties in the estimated groundwater reserves and potential, the likely presence of substantial amounts of groundwater in the SGR at different depths makes it worthwhile to take further steps in investigating the larger scale exploitation of groundwater.

Water development options for the SGR

There are two options to supply the future water demands in the SGR region: development of local groundwater resources or long distance surface water conveyance. The two options are basically different. Surface water will be a centralized system with a concentrated flow of piped water (of a constant quality) while the groundwater option will be a decentralized approach with a large number of smaller supplies (well fields) providing water of different quality to nearby users. A combination scenario is therefore not an immediate option, although groundwater would still be needed in case of the surface water option, to supply the areas outside the reach of the pipeline(s) or as a backup supply for a surface water conveyance system.

Below an indicative comparison is presented of the two options, based on the water demand projections made by Mongolian National Water Programme Support Center.

Option 1. Long distance water conveyance

There are two existing plans to convey surface water to the SGR: the Herlen-Gobi Pipeline project (GHP) and the Orhon-Gobi Pipeline project (OGP). The HGP will convey 1500 l/sec from the Herlen river through a 540 km long pipe line to Shivee Ovoo, Sainshand and Zamin-Udd with a side branch to Tsagaan Suvraga. The OGP will pump 2500 l/sc from the Orhon river through a 740 km pipeline to Tavaan Tolgoi and Oyo Tolgoi with side branches to Mandalgobi and Dalanzadgad. The system includes a 20 MWt hydropower plant

Table 2. **Water Demand Projections for 2020**

№	Water User	Estimated Demand liter/sec	Source	
			Surface	Under-ground
	Energy and Mining Industry			
1	Shivee-Ovoo	616	467	149
2	Tsagaan Suvarga	604	300	304
3	Oyu Tolgoi	1060	360	700
4	Tavan Tolgoi	951	486	465
	Subtotal	***3231***	***1613***	***1618***
	Urban Water Supply			
5	Mandalgobi	50	50	0
6	Dalanzadgad	70	60	10
7	Choir	40	40	0
8	Sainshand	85	65	20
9	Zamiin-Uud	50	50	0
10	Soum Center and rural	104	52	52
	Subtotal	***399***	***317***	***82***
	Agriculture and Environment			
11	Livestock	200	100	100
12	Agriculture	1750	1750	0
13	Environment	300	100	200
	Subtotal	***2250***	***1950***	***300***
14	Other	120	120	0
	TOTAL	***6000***	***4000***	***2000***

The estimated water demand in the SGR in 2020 is 6000 l/sec of which 4000 l/sec will be supplied by the HGP and OGP and the remaining 2000 l/sec by groundwater (see table).

The table shows that 50% of the water is for the mining and energy sector and 30% for (irrigated) agriculture. Urban en rural water supply constitutes 7% of the demand. The environmental water demand is not further specified

The estimated total investment cost of the HGP were estimated US$ 400 million in 2005 . With the sharp price increases in energy and steel since 2005, the current cost of the probably will be substantially higher

Cost estimates of the OGP are not available, but will probably be higher than of the HGP because of the higher capacity and longer pipeline.

The rationale behind the two projects is to secure the long term water availability in the SGR in addition to available groundwater resources, most of which is the present (or presently planned) groundwater use. This option assumes that the groundwater potential in the SGR has no further scope as a long term source of water in view of the growing water demands under the expected economic development of the region.

Option 2: Groundwater Development

Resource potential
The estimated total groundwater potential is enough to support the economic development of the SGR for the years to come. There is however a need to verify these estimates and to make a more detailed assessment of the spatial and vertical distribution of the aquifers and groundwater (quantity and

quality) and groundwater potential. Based on this information, an SGR groundwater development plan can be established, which will show the possible gaps between groundwater availability and water demands and how to overcome these. This assessment can start using the wealth of available data and information, which is scattered amongst different agencies and institutions (GIC, IoE, MNE, private sector, individual experts) and needs to be brought together for an integrated assessment of the groundwater potential. More specifically the following aspects have to be addressed:

- assessment of the effective recharge to the shallow aquifers and the potential to increase this water through water conservation and groundwater storage systems (using experiences from other regions such as India, Yemen and East Africa)
- detailed analysis and verification of the studies done in 1970-1990. These studies contain a wealth of hard information (test drillings, geophysical surveys, aquifer tests, chemical analysis and detailed (hydro)geological maps) which represent a valuable asset.
- assessment of the potential of deeper aquifers (> 200m)
- formulation of additional surveys and investigations to complement the overall understanding of the groundwater system and to address areas where water demands cannot be met from known groundwater reserves
- matching water demands (quality and quantity) with available resources, especially with the mining and energy industry who represent the main users.

Development of groundwater

Providing groundwater means the installation of well fields, pumping systems, energy supply and piping to the point of use. At this stage of the study, not enough data and information are available to make a reliable estimate of the cost of groundwater development in comparison to the cost of long distance conveyance.

Information from IMMI for the OT mine shows an US$ 75 million investment for 40 production wells (1500 m^3/day/well, supplying 60,000 m^3/day) with a 75 km meter pipeline. This figure (from 2007) means an investment cost of 1,250 US$ per m^3 water/day installed capacity. Applying this figure to the total capacity of the Herlen Gobi Pipeline project 500 l/sec), the investment cost for a groundwater supply of the same size would be around160 million US$, excluding cost for treatment. This is in the same order of magnitude as the US$ 200 million mentioned by the Water Center in the Heren-Gobi project summary (2006). Additional cost for the groundwater option is the cost for the detailed groundwater assessment and for continuous management and monitoring (see next session).

O&M cost of a (decentralized) groundwater supply system will be 20-30 % higher (because of the decentralized nature of the system

Management

A groundwater management structure/entity for the SGR would be needed to accommodate all existing information, guide and integrate further investigations, check and approve investigations, oversee the allocation of groundwater to the different users, regulate and protect licensed abstraction and be responsible for monitoring.

Most of the groundwater in the deeper aquifers is fossil and hence not recharged. This requires a clear strategy for development of these non-renewable groundwater reserves including guidelines for the rate of depletion (% depletion during a certain time period). Use can be made of experiences in other region where fossil groundwater is exploited.

Groundwater is available, but not in unrestricted quantities and not always of the desired quality. Groundwater development planning should therefore be linked to demands management options (water re-use, water savings, green/blue/grey water) and monitoring / regulation will be a critical element for successful groundwater development

Comparison of options

Besides the technical and financial-economic feasibility there are a number of other issues that need to be compared in the decision making process. The table below gives first overview of the issues to be compared and discussed between the main stakeholders on the national, regional and local level.

Table 5. Comparison of the groundwater and surface water option

Issue	Groundwater development	Surface water conveyance
Description	Development of deep (>50 meter) groundwater potential of 350,000 m3/day (4000 l/sec) , through a number of well fields	Herlen-Gobi project (1500 l/sec) and Orkhon-Gobi Pipeline project (2500 l/sec).
Remarks	Shallow groundwater not included. No large quantities of water for irrigation	Includes water for agriculture
Construction Cost	About 50% of surface water investments.	
Phased implementation	Yes	no
O&M cost	Higher than surface water	
O&M practice	More complex because of decentralization	
Power supply	Decentralized	Central (booster stations)
Water quality	Variable, depending on location. Treatment needed for drinking water and possible for other purposes	Good and controlled. Treatment needed only for drinking water supply
Security of the source	Degree of uncertainty, back up to be included in design and operation (monitoring)	Flow changes in river (climate change) Stability of intake dam
Security of supply	Higher, because of decentralization	Risk of failures. Back up through storage?
Spatial coverage	In principle available throughout the SGR	Water available along the pipelines. Additional groundwater supply foreseen
Environmental impacts and concerns	impact on shallow groundwater and springs impact on vegetation partly mining of fossil water	impact on river and river water users pipe leakage impacts of pipe laying
Social impacts		
Political acceptance		
Land acquisition	For well fields and pipelines	Pipelines and pumping stations
Transboundary issues	No, except if transboundary aquifers	Yes (rivers cross boundary with h China)
Climate change	Impacts to be evaluated	Impacts to be evaluated

Preliminary Conclusions

- Groundwater is currently the sole source of water for the mining and energy industry and for rural and urban drinking water demands in the SGR.
- The estimated groundwater potential may be sufficient to cover the SGR water demands for the next 10-15 years but a more detailed assessment of the spatial and vertical of the groundwater quality and quality is needed along with the establishment of dedicated groundwater management institution/agency for the SGR .
- The alternative of a long distance pipeline should be evaluated against the groundwater potential once the detailed groundwater assessment is completed and future water demands are known in more detail
- From the demand side it is recommended to interact with the main mining and energy industries (representing 50% of the projected 2020 water demand) on their future water demands and the feasibility to cover these from groundwater. This should also include the drinking water demands for urban development around the mines and the possibility of groundwater irrigation for local food production.
- There is a need to evaluate the economic and social feasibility of agricultural water supply in the surface water option (20% of the capacity).
- Rural water supply demands (for human consumption, livestock and subsistence agriculture) are scattered and can most likely be supplied from local groundwater resources in the shallow aquifers, based on a more detailed mapping of the recharge and shallow aquifer, complemented with small scale recharge and storage systems
- The World Bank Groundwater Management Advisory Team (GWMATE) could possible give further guidance to the development of a groundwater management plan, including the technical, regulatory and institutional aspects and bring in useful experiences and good practices from other countries.