3.6 Issues Relating to Water Resources Management and Water Users Association (AUEA) / Farm Household Survey

3.6.1 Problems and Constraints of Water Sector of the State

The World Bank issued the Country Assistance Strategy (CAS) for Morocco in 2005. For the formulation of strategy of water sector assistance to the government, they analyzed the present constraints for the long-term development program for the water sector on 1) Ensure better governance of the water sector, 2) Ensure that the population and economic sector's water demands are met in a sustainable manner. They are summarized in Table 3.6.1. Based on the CAS, presently Water Sector Reform Project (DPL) is under operation

3.6.2 Problems and Constraints on Water Resources in the Study Area

(1) Present water supply and demands

The water source of the Study Area relies on rainfall and snow in the Tensift River Basin and they are used as river water, dam water and recharged groundwater. The water transferred from the Oum Er Rbia River Basin, which is located neighboring to the Tensift River Basin, as to cover the deficit as well. The amounts of water use by source types are: 336 Mm^3/year (36%) by surface water including river water and dam water, 505 Mm^3/year (54%) by groundwater, and 101 Mm^3/year (11%) by transferred water in the average of 1993/94-2003/04. The amount of available water is limited in whole sources, so that the water demand is not fully satisfied at present. This water deficit causes limitation of economic activity especially in the agricultural sector in the Area. Furthermore, the dependence of water source upon groundwater has been increased and the aquifer has been close to over abstraction than its potential, as a result of limited water supply and increasing water demand.

(2) Problems and constraints on water resources in the Study Area

As stated above, water balance in the Study Area is facing serious conditions. Causes and problems brought to the present deficient water balance are categorized into 1) new water, 2) surface water not utilized, 3) over abstraction of groundwater, 4) water use, 5) organization / institution of water resources management, and 6) involvement of stakeholders. Their correlations are summarized in problem tree are shown in Fig. 3.6.1.

3.6.3 Water Users Association (AUEA) / Farm Household Survey

(1) Objectives of survey

The survey aims to collect socio-economical data and information concerning agricultural water use and management by the Agricultural Water Users Associations (AUEA) also by the farmers as the principal water users. It aims to figure out the intentions of association and farmers towards the cultivation or the water use by studying the situation of their activities, to collect their opinions on water use and management in order to examine countermeasures relating to the water resource management (underground, surface, irrigation) that will be proposed by the Study on the Integrated Water Resources Management Plan in the Haouz Plain.

(2) Area and methods of survey

The survey was carried out in whole of the Study Area, the Provinces of Marrakech, Al Haouz, El Kelaâ Sraghna and Chichaoua. This survey was carried out in close collaboration with the ABHT, the ORMVAH, DPA/Marrakech and DPA/Chichaoua.

The process of this survey is as follows:

Stage 1 : Discussion and determination on the principles of the survey and establishment of TOR

- Discussion with the counterparts on the principles of the survey and definition of the survey frameworks.
- Establishment of the questionnaires (questionnaires for AUEA and farmers).
- Establishment of TOR and the survey guide.

Stage 2 : Formality and coordination for obtaining of the survey execution authorization (ORMVAH, DPA, Local authorities)

- Contact of the organizations concerned of the survey (ORMVAH, DPA, Local authorities) and discussion on the survey implementation (objectives, contents and survey methods).
- Selection of the AUEA and farmers surveyed. The AUEA and the farmers were selected according to definite criteria (geographical distribution, association size, surface, type of the activities, methods of agricultural water use, etc).
- Establishment of the survey program
- Discussion on the survey methods
- Licensing procedure to the local authorities for the survey execution.

Stage 3 : Training to the investigators and the personnel of the concerned organizations
- Training was given to the investigators during two (2) days.
- Survey Preparations (preparation of the questionnaire, appointment arrangement etc).

Stage 4 : Survey execution
- Three (3) teams consisted by two (2) investigators carried out the field survey.
- The field survey was carried out during twelve (12) days:
  1) 8 days in the zone of the ORMVAH (19 AUEA and 39 farmers)
  2) 2 days in the zone of the DPA/Marrakech (6 AUEA and 12 farmers)
  3) 3 days in the zone of the DPA/Marrakech (3 AUEA and 10 farmers)

Stage 5 : Tabularizing and analyze of the survey results

(3) Survey implementation

The questionnaire survey proceeded from October 26 to November 10, 2006 (12 days in total). The survey was carried out with the questionnaires elaborated and the interview. 86 investigations were carried out of which 28 to the AUEA and 58 to the farmers. The number of the AUEA and the farmers surveyed is shown in the Table 3.6.2.

As the subject of the survey is focused on water, the majority of the farmers were told to exercise normal behavior at the time of the survey. Thus, before the beginning of the survey, the investigators amply explained to the farmers the objective of this survey (to collect information on the rural reality and to collect the opinions on the water use and management to examine countermeasures relating to the water resources management) in order to alleviate their limitations.

Survey Items to Agricultural Water Users Associations (AUEA)

I. Generalities/Status of AUEA	Year of creation, Objective of association, Members of AUEA, Conditions of being adhering, Composition of administrative council and Internal regulator, Method of council member selection, General Assembly of AUEA (frequency, principal subject of discussion, minutes or official reports), Perimeter of the AUEA, Land ownership of AUEA members
II. Productive activities of the AUEA	Area and Production, Cultivation method and irrigation technique, Infrastructures available for agriculture, Asset, Problems and Constraint for the activities
III. Financial standing of the AUEA	Financial assessment (Contribution by adhering, expenditure, loan etc), financial report with General Assembly
IV. Legislative knowledge	Legislative knowledge on the water management and use in particular law 10-95. Opinions to the legislations related to the water management
V. Relation with administration	Relation type, frequency, expectation to administrative services
VI. Access to the financial resources	External support : Amount and contents of support. Agricultural credit : Amount and loan method
VII. Water resources management	Hydraulic infrastructure types (channels, séguia, deep well and well, pumps, irrigation systems), Water quantity to be taken and used, Agricultural water management systems, Method and situation of the royalty, Problems/constraints on the water management
VIII Opinion on management and use of the water resources	Passed and current state of water resources (perception of the situation), Degrees of the conscious on the water resources management which the financial and physical participation, Intent of participation for the water resources management, Method for the applied water economy

Survey Items to Farmers

I. General information on the household	Family composition (sex, old, profession and education level), Land status, Land acquisition methods, Concern on the daily life, Definition of the rules of decision-making in the household
II. Income and expenditure	Annual income and expenditure, Expenditure for water intake and pumping up
III. Productive activities	Area and Production, Cultivation method and irrigation technique, Infrastructures available for agriculture, Asset, Problems and Constraint for the activities
IV. Legislative knowledge	Legislative knowledge on the water management and use in particular law 10-95, Opinions to the legislations related to the water management
V. Relation with administration	Relation type, frequency, expectation to administrative services
VI. Access to the financial resources	External support : Amount and contents of support, Agricultural credit : Amount and loan method
VII. Water resources management	Hydraulic infrastructure types (channels, séguia, deep well and well, pumps, irrigation systems), Water quantity to be taken and used, Agricultural water management systems, Methods and situation of the royalty, Problems/constraints on the water management
VIII Opinion on management and use of the water resources	Passed and current state of water resources (perception of the situation), Degrees of the conscious on the water resources management which the financial and physical participation, Intent of participation for the water resources management, Method for the applied water economy

(4) Survey Results

1) Issues in agricultural practices

Out of the issues identified in the AUEA and Farm Household Survey, those related to agricultural practices are summarized below. The environment surrounding agriculture contains various problems including low productivity of agricultural products, deficiency of agricultural infrastructure/machinery, increased price of agricultural input as well as decrease in marketing price, thus causing a difficult situation for the farm households.

Major Issues Relating to Agricultural Practices

Issues regarding AUEA			Issues regarding Farm Households		
Rank	Issues	%	Rank	Issues	%
1	Decrease in price of commodities	89.3	1	Low income	91.4
2	Lack of irrigation water	85.7	2	Increased price of seeds/seedlings	82.8
3	Low income	82.1	3	Lack of agricultural machinery	82.8
4	Lack of rainfall	82.1	4	Decrease in price of commodities	81.0
5	Increased price of seeds/seedlings	78.6	5	Lack of irrigation water	79.3
6	Lack of storage facilities	78.6	6	Decrease in agricultural productivity	77.6
7	Lack of means of transportation	78.6	7	Lack of storage facilities	75.9
8	Lack of agricultural machinery	75.0	8	Lack of opportunities for selling products	74.1
9	Decrease in agricultural productivity	75.0	9	Lack of means of transportation	70.7
10	Lack of opportunities for training	75.0	10	High cost for irrigation	69.0
11	Lack of opportunities for selling products	71.4	11	Lack of agricultural infrastructure	65.5
12	Lack of agricultural infrastructure	67.9	12	Lack of financial resources (loans/subsidies)	65.5
13	Lack of financial resources (loans/subsidies)	64.3	13	Lack of rainfall	63.8
14	Lack of agricultural technology	57.1	14	Lack of opportunities for training	63.8
15	Lack of guidance by govt. organizations	50.0	15	Lack of agricultural technology	56.9
16	High cost for irrigation	46.4	16	Lack of guidance by govt. organizations	51.7

As for the results of the Survey, AUEAs tended to raise issues related to irrigation such as slack of water or rainfall and those related to their cooperative activities such as sales of agricultural commodities. On the other hand, individual farm households were keen on issues related to activities for crop cultivation such as the price of seeds/seedlings or lack of agricultural mochniery.

In comtrast to 46% of the AUEAs (12 associations) answering that irrigation cost is not of a financial burden, 70% of the individual farm households regarded this as a major issue. This indicates the difference of ideas between the AUEAs which are specialized in operation and maintenance of channels and seguias, and farmers who are obligated to the actual payment of the water fee.

2) Activeness of AUEAs

Almost all of the surveyed AUEAs had a set of official regulations for their activities and claimed that they have held general meetings. However, half of the surveyed AUEAs have not held their general meetings after the year 2005.

Out of the surveyed AUEAs, 12 (40%) associations were not collecting / saving membership dues. On the other hand, 5 out of the 16 associations which are collecting membership dues raised the issue of non-/ delayed payment of the dues.

Issues raised in the Survey indicates somewhat of stagnation / inactiveness of some of the AUEAs. These are: deficient sharing of information (2 AUEAs), inactive participation of members to AUEA activities (5 AUEAs), conflict between members (2 AUEAs). These issues indicated

3) Understandings / opinions of users on the current situation of water resources

Only 16% of the Surveyed AUEAs / households indicated that they have some knowledge on the Water Law (Loi 10-95).

The most significant issue raised commonly by the AUEAs and farm households was the lack of irrigation water (84.9%), followed by the difficulty in maintenance of water use facilities (77.9%), insufficient channel/seguia network (irrigation network does not reach the end user, 66.3%), difficult to purchase fuel for groundwater exploitation (65.1%), decrease of groundwater table (57.0%) and difficulty in paying water fee (53.5%).

Individual farm households tended to see issues related to their own property such as drop of groundwater table and insufficient drip irrigation facilities, as issues of more importance. In contrast, AUEAs emphasized the issues of lack of maintenance and insufficient water supply to the seguias and channels of which they manage as their utmost issue, followed by difficulty of maintenance of the facilities.

Farm households having more land tended to have more issues of water deficiency, fuel cost of pumps and drop of groundwater table. This is because larger farms, needing more water for irrigation are more dependent on groundwater resources to satisfy these needs. As a result, excessive pumping of groundwater further induces the drop of groundwater table.

On the other hand, issues of irrigation facilities including drip irrigation systems tended to increase as the farm size reduced, indicating the difficulty of small and marginal farmers to invest in such infrastructure and facilities.

In regard of the needs for the above issues, 81% of the individual farm households, as well as 96% of the AUEAs replied that measures for the management of water resources are required. On the other hand, there was somewhat of a gap in the sense of crisis between the farm households and AUEAs, which was assumed to be caused by the difference in the accessibility to information: while the AUEAs have frequent contact with government agencies and obtaining information on the state of water resources, the information does not necessarily reach the majority of individual farm households.

Many of the reasons of why the surveyees think that measures for water resources management was required, were mainly based on ideas to decrease production cost and to raise agricultural productivity. These were to be realized through saving the amount of water use, using water efficiently and reducing the cost of irrigation. In contrast, only 15% of the surveyees aware of the needs to conserve water resources.

Many of the measures that were proposed by the surveyees were related to installation / expansion of infrastructure, further exploitation of groundwater resources or those directly benefiting the surveyees (subsidy for fuel, lowering water fees). Proposals with the viewpoint of conserving water resources, such as the users efforts to save water and stop excessive usage were seldom. This indicated the presence of awareness for issues such as shortage of irrigation water and drop of groundwater table, but also the lack of awareness on the decreasing / exhaustion of water resources.

4) Understandings on water fees

a. Willingness to pay fees for channel / seguia use

While 47 % of the AUEAs think that the current water fees were too high, some 21% of them think that it is affordable. For individual farm households, 54% answered that the fee for channel use is high. The current system obligates individual farm households to directly pay the water fees to ORMVAH, thus individual farmers tend to think of this fee as a burden.

In regard of the willingness to pay water fees, 60 to 90% of the farm households under the irrigation scheme of ORMVAH expressed the necessity of payment. In contrary, 25 to 55% of the farm households under DPA schemes, where seguias and wells are used as water sources are not paying their fees.

The reasons of why water fees should be paid includes: to ensure access to irrigation water (40%), promote water saving (27%) and because it is obligated by law (27%).

The reasons of why water fees need not to be paid includes: irrigation water should be supplied by the government in order to promote agriculture (37%), users have the rights to use water for iirigation (30%), users already invest in facilities and need not to pay additional water fee (19%).

b. Willingness to pay fees for groundwater use

Out of all surveyees, 75% expressed negative comments in regard of the willingness to pay groundwater fee, which is currently not being charged.

Negative expressions increased in proportion with the size of the farmland owned by the farmers. All farm households with land of more than 10ha opposed groundwater fees. On the other hand, 45% of farm households with land of less than 5ha expressed their consent with groundwater fee.

The reasons of why groundwater fees should be paid includes: to ensure access to enough water for irrigation (31%), promote water saving (additional cost will work as a control on water use, 28%), dictated in the Water Law (19%) and to conserve groundwater resources (13%).

The reasons of why groundwater fees need not to be paid includes: water should be free (38%), people do not have the capacity to pay (26%), users already invest in facilities and need not to pay additional water fee (21%) and additional payment for groundwater will countervail the benefit form agricultural products (14%).

c. Willingness to participate / contribute in water resources management

Willingness of participation/contribution was examined through interviewing the surveyees based on expected actions involving farm households and AUEAs participation / contribution to water resources management.

Almost all of the surveyees (94%) expressed their consent in regard of educational activities to raise awareness on water saving. Items such as strengthening subsidies for drip irrigation, minimizing irrigation water through the introduction of xerophilous / value added crops were also generally welcomed (88%). However, in many cases, introduction of new crops were only welcomed if they were to bring higher productivity / benefit. The “water police” defined under the Water Law, was also positively responded (82%) in regard that it may prevent excessive / unauthorized pumping of groundwater to realize sustainable management of groundwater and improve fairness in water use.

On the other hand, 67.4% of the surveyees opposed towards raisin the price of water fee. Further more, 66.3% opposed to charging water fees for groundwater use, while 57% opposed to installation of water meters on wells. In general, there were large oppositions towards actions involving increased of burden for the farmers.

Opinions on Possible Actions for Water Resources Management

Possible Actions for Water Resources Management	Reasons for supporting the Action	Reasons for opposition
Limit amount of intake from channels / seguias	There should be a system to manage and save irrigation water	There is already not enough water Necessary amount of water will be inaccessible
Introduce xerophilous / value added crops	Needed for water saving. However, introduction must lead to increased production It is expected to increase productivity	Knowledge / training for new cultivation is insufficient
Increase current water fee	Supported in premise that production will increase, and that there is enough water for production	The burden of water fee is already large
Limit construction of / pumping from wells	Necessary to stop excessive pumping of groundwater	Farmers have the rights to use groundwater
Install water meters to wells	Necessary to make clarify the amount of groundwater pumping and to prevent excessive exploitation	Wells are private assets and built on investments by individuals
Charge water fee to groundwater	It is dictated in the Water Law (Loi 10-95)	Wells are private assets Construciton and running cost is already burdened Additional payment will countervail the benefit from agricultural production
Strengthen control among pumping / water use (water police)	Necessary to improve fairness of water use Necessary to prevent excsessive pumping and to realize fair water management	-
Enlarge subsidy for drip irrigation	It will enable water saving and improve agricultural production	-
Educational activities for awareness raising	Knowledge on water resources management and water saving technologies will be learned Currently, there are no information on water resources. Awareness raising is useful for water resources management	-

3.7 Re-use of Treated Sewage and Drainage Water of Marrakech

3.7.1 Present Conditions of Sewage and Drainage of Marrakech Town

Sewage and Drainage System in Marrakech Town

Sewer system in Marrakech is the so-called combined sewer system to collect both storm water and wastewater from the houses and buildings by reinforced concrete pipes. Collected sewage is discharged at 3 outfalls (Azib Ayadi, El Azzouzia and Issil) on the shore of the Tensift river and it causes water pollution. The total length of the combined sewer system reaches approximately 1,400 km and is connected at about 106,000 points to cover 82 % of the city area.

No sewage treatment facilities are operated in Marrakech at present except for the sewage treatment plant managed by the community in the private housing development housing area of ERAC[26] (*Etaolissement Regionale o Arrenagement et de Construction*) located about 25km away from the city center to the West.

The project for sewerage system development started in 1998 with the objective to construct a sewage treatment plant, and installation and rehabilitation of existing sewers and intercept sewer system to collect and convey sewage to the sewage treatment plant. The project is financed by EU Bank for Reconstruction and Development and the construction work started in August 2006. The outline of the sewerage system development is discussed in the following section.

Total Volume of Sewage and Drainage Water

No flow survey data was available. Assuming 80 % of the quantity of water consumption is discharged as sewage and the coverage area of sewers is 82%, the sewage quantity discharged to the Tensift River

[26] Etaolissement Regionale o Arrenagement et de Construction

is estimated as 62,000 m^3/day.

Daily Average Water Consumption in 2005	:	94,800 m^3/day
Sewage Generation Amount	:	76,000 m^3/day
Sewage Collected and Discharged to the Tensift	:	62,000 m^3/day

Construction Plan of Sewage System in Marrakech Town

Development project of sewerage system is being implemented by RADEEMA to construct sewage treatment plant at Azib Ayadi in the Tensift River side including the rehabilitation of existing sewers and the intercept facilities and sewers. The project was awarded to the joint venture of DEGEAMONTE, France and SOGEA, Morocco in 2004. Construction work started in August 2006. The construction project is outlined in the following.

Outline of Construction Project of Sewerage System in Marrakech

Planned Capacity of Sewerage System	
Daily Average Treatment Flow (Dry Weather Flow)	90,720 m^3/day
Treatment Flow in Summer (Max. Daily Treatment Flow)	117,936 m^3/day
Peak Treatment Flow	184,896 m^3/day
Wet Weather Flow	9,828 m^3/hr or 2.73 m^3/s
Sewage Treatment Sequence	
Phase 1 (2007）	Grit Removal－Primary Sedimentation -Disinfection - Discharge
Phase 2 (2012)	Grit Removal－Primary Sedimentation – Biological Treatment (Aeration) – Final Sedimentation - Disinfection - Discharge
Construction Cost (Phase 1)	
Construction Work (18 months)	190 Million Dhs
O & M Work (5 years)	20 Million Dhs
Funding Agency :	EU Bank for Reconstruction and Development RADEEMA (50%) and BEI (50%)

In addition to this Sewage Treatment Plant, RADEEMA is now planning for another plant (capacity: 37,000m^3/day) in the southern areas of Marrakech. However the details of the plan is not fixed at the point of the Study.

Construction Plan of Sewage System in Communes in the Study Area

ONEP is implementing the development project of sewerage system in communes, 10 of which are communes within the Study Area. Currently, ONEP sublet the study and engineering design to the private consulting firms, and the implementation plan of the project will be started when the sharing of 30% of the construction cost is agreed by the commune. The following are the names of the 10 communes under preparation of the sewerage system development plan.

(1) Ait Ouir (Al Haouz), (2) Amiz Miz (Al Haouz), (3) Ghmate (Al Haouz), (4) Tahanaoute (Al Haouz), (5) Tamesloht (Al Haouz), (6) Chichaoua-center (Chichaoua), (7) Imintanout (Chichaoua), (8) Tammelalt (El Kelaa Des), (9) Sidi Zouine (Marrakech), (10) Tnine Laudaya (Marrakech)

3.7.2 Possibility of Re-use of Treated Sewage Water

(1) Water Quality of Treated Waste Water and Possibility of Re-use

The sewage treatment plant of Marrakech will be completed in two phases. Phase 1 treatment process is constructed with the primary settling process mainly aiming at reducing suspended solids by 66% or less than 200 mg/ℓ in concentration. Biological treatment process and final settling tank is added in Phase 2 construction work to decompose organic matter in sewage and reduce BOD5 less than 25 mg/ℓ in concentration.

The concentration level of SS and BOD5 of the treated sewage of Phase 1 treatment process is rather high and water is still aggressive in nature to consider about wastewater reclamation. Treated sewage from the Phase 2 treatment process will reach the allowable level and is expected to be re-used for irrigation and similar level water use.

Mixture of industrial wastewater to the public sewers may cause contamination by hazardous material and water will be become unfavorable condition for re-use. Pre-treatment measures shall be regulated by the responsible agency(ies) to force the discharger to remove the hazardous material up to the acceptable level before connecting to the public sewer.

(2) Economic Feasibility of Purified Waste Water Re-use

The method for conveying reclaimed sewage water to the sites for re-use will be a key factor to consider the costs and economics to materialize the wastewater reclamation. This subject is dealt with in the course of the study.

3.8 Analysis of the Water Balance

3.8.1 Previous Studies on Groundwater Balance

The first groundwater balance analysis was conducted early in the 70's, for Central and Oriental Haouz[27]. For this part of the aquifer, it gives a total annual entry of 280 Mm^3, equivalent to the output. At this date, the groundwater abstraction there was estimated as some 160 Mm^3/year, the complementary output occurring by the aquifer drainage in the rivers (120 Mm^3/year). This work was recently[28] extended to the Mejate plain and limited to the Tensift basin sector. For an average year in the early 70's, the total annual entry in the system was then evaluated as 410 Mm^3, the abstraction remained about 160 Mm^3/year, and the aquifer drainage in the river reached 250 Mm^3/year.

The latest groundwater modeling (i.e. 2001 model) work was conducted in 2004[28] over the aquifer extension in the Tensift basin. Some basic figures of the 2001 model is indicated in Figure 3.8.1. It gives detailed results for the 2000/01 season. The total annual entry to the aquifer was then estimated as 425 Mm^3, while for an output of 704 Mm^3, mainly constituted in abstraction (509 Mm^3 which becomes 346 Mm^3 if considering the net abstraction only) and some remaining drainage (186 Mm^3). This water balance estimate gives some 279 Mm^3 of deficit for the 2000/01 season, extracted from the aquifer reserve.

The ABHT conducted a water balance estimate in 2004 as an average year. The main difference with the 2001 model consists of infiltration along the rivers for about 65 Mm^3 modified to 94 Mm^3 in 2006[29] (2 Mm^3 only for the 2001 model) and a very limited lateral inflow (17 Mm^3).

All these estimates, conducted with different hypotheses, give equivalent order of magnitude: namely, a net abstraction roughly two to three times larger in 2002 (from about 300 to 450 Mm^3) than in 1972 (160 Mm^3) and a roughly constant inflow of about 360 to 425 Mm^3/year. However, some major uncertainties remain:

- The level of net abstraction, especially for irrigation in agriculture, is still not known precisely (±80 Mm^3).
- Particularly, the part of the rainfall covering the crop water demand needs to be approximate: estimates based on international evaluation methods gives some 72 - 92%, (an average annual volume of about 270 to 340 Mm^3), far from the null value previously considered.
- The direct infiltration of rainfall was never defined. Up to now, there is no clear reason to consider it only for the Mejate plain as was done for the 2001 modeling.
- The levels of drainage and the level of lateral entry may probably be optimized.

3.8.2 Methodology of Groundwater Modeling and Simulations

The groundwater flow simulations, using a mathematical model, will produce an evaluation of the

[27] Bernert G., Prost J-P (1975), Le Haouz de Marrakech et le bassin du Mejjate *in* Ressource en Eau du Maroc Tome 2, Plaines et bassins du Maroc Atlantique. DRE, Rabat

[28] Etude de synthèse hydrogéologique pour l'évaluation des ressources en eau souterraine du bassin hydraulique du Tensift. (2004) ANTEA-ANZAR for ABHT

[29] *Alimentation en Eau Potable et Industrielle de la Ville de Marrakech*, April 2006, ABHT Internal document

future groundwater levels and impacts for the development options. This will be used as material for discussion in Stakeholder Meetings and for the preparation of the Master / Action Plan.

The last groundwater flow model (2003), constructed using MODFLOW under the GMS software, still shows some imperfections. The two main problems faced here are: i) the inflow into the aquifer from High Atlas mountains, which are expected to be 200 - 250 Mm^3 (see previous section) is underestimated with the figure of only 17Mm^3, and ii) the aquifer bottom elevation is artificially lowered by 50 m to prevent mesh drying. In regard of such issues, the Study prepared a new model for groundwater simulation. The features of the new model is summarized as follows.

(1) Model limit and form of the aquifer

The updated model limit is set to the extension of the mio-plio-quaternary plain, excluding the oriental Haouz (outside the Tensift Basin limit) which appears to be separated from the rest of the plain by a piezometric crest, i.e. a no flow limit (Figure 3.8.2).

The updated model includes the part of the plain located south of the Jebel Timrar (Guemassa sector), as it appears on the hydrogeological map drawn in 1972 (Bernet, Boudon and Prost). The model is extended to the Tensift river in the north-western sector of the plain, including some Jurassic limestone outcrops, as the piezometric heads are unknown in the sedimentary plain but clearly fixed at the riverbed elevation in the Jurassic limestone.

The aquifer bottom map (Figure 3.8.4) was drawn based on the substratum point's database (source ABHT). In the updated model, a constant value of bottom elevation is set by sector, at the minimum bottom elevation found in the sector from this map. The sectors are those where constant K and S values are set ((3) Calibration of Permeability). Setting the bottom elevation node by node is only possible if the K value is calibrated element by element, which is not possible here, due to the poor number of piezometric measurement points.

(2) Boundary Conditions

The current updated model is based on the Inflow/Outflow values as described in section 3.3.3. The boundary conditions are outlined as follow:

- 4% of the rainfall falling on the surface of the aquifer areas will directly infiltrate and contribute in recharging the aquifer (excluding the area of Marrakech City)
- The exploitation of groundwater for irrigation is as described in section 3.4.2.
- The Marrakech water supply well field is regarded as a major individual well
- The outflow of groundwater into the rivers is estimated based on elevation (read from 1/50,000 maps)
- Infiltration from river beds and major seguias is estimated to be 25% of the flow (infiltration from seguias is calculated together with the infiltration from river beds)
- Fixed hydrological heads:
  - ✧ Lalla Takerkoust dam (mean water level of reservoir)
  - ✧ Major springs in Chichaoua
  - ✧ Jbeliat and inflow points from the High Atlas mountains

(3) Calibration of Permeability

The calibration of the permeability (K) was conducted in steady state mode. According to the piezometric history indicated in section 3.3.2, a pseudo steady state situation can be found for the 1997-1998 period, and the piezometric campaign conducted in September-October 1998 can be considered as a reference situation. In addition to the measurements in the observation network of ABHT, the campaign includes measurements in 2 points near the boundaries of the aquifer, which are found useful. The total number of reference points is 96. The topographic elevation of these points is taken from the 50.000 scale topographic maps, based on the point position. The precision in this topographic elevation, and then the precision in the corresponding piezometric heads is then not greater than 15 m.

Using this 96 reference points, a K calibration of the model was conducted by sectors. Some 81 different sectors were defined (Figure 3.8.5), each of them controlled by one or more reference point.

The precision of the calibration is indicated in Figure 3.8.5.

The simulation results of piezometry at this point is indicated in Figure 3.8.6. It is noteworthy that at this Figure indicates the results of the simulation before the calibration of the storativity (S) in transient mode is examined.

3.8.3 Present Conditions in Groundwater Balance

Assessment of the groundwater balance can be done for the last ten years, based on a first estimate of each of the inflow and outflow topics (see sections 3.2 and 3.4). For this first estimate, it is assumed that any excess water can be drained to the rivers within one year, which may be wrong in such a large porous aquifer, and that no drainage occurs when the reserve is realized, which does not take into account the spatial distribution of the deficits and the potentially local excess (the 2001 simulation shows that some drainage could still occurs in 2000/01, despite the 279 Mm^3 deficit estimated by the model).

The figures indicated in Table 3.8.1 are consistent with the piezometric drawdown observed from 2001 (see section 3.4.2). They are also consistent with the decrease of the wet aquifer volume observed between 1998 and 2002, if a porosity coefficient of 1.5% is applied (consistent with the 1 to 8% range indicated by Bernert and Prost[27]).

3.8.4 Current water demand

The surface water resources of the Study Area and the Tensift Basin are summarized in Table 3.8.2. A part of the upstream of the conjunction of the Chichaoua River can be considered as a potential water resource for the Study Area, which is estimated 668 Mm^3 without water transfer and 968 Mm^3 with transfer based on the data of 1970-2002. This estimation is 93~95% of the estimate in the Master Plan in 2001, which was based on the data of 1935-1997.

Actual surface water use in the study area is estimated as 400 Mm^3 including water transfer, which is considered as an available surface water source at present (Table 3.8.3). Contrary to the planned amount of water transfer of 300 Mm^3, the actual amount is around 100 Mm^3 on average.

As for the groundwater resources, it is difficult to discuss the amount of AVAILABLE abstraction at this stage. The present level of groundwater abstraction in the Study Area is estimated as 334 Mm^3 as an average of 1993/94-20003/04 as described in the section 3.4.2. In total, the present amount of water use is tentatively estimated to be around 735 Mm^3/year.

(1) Water Demand for Irrigation

As discussed in §3.5.1 (3), water demand for irrigation is summarized as in the following table. The future water demand is estimated based on the continuation of the present water demand and does not include measures such as water saving irrigation.

Preliminary Evaluation of Water Demand for Irrigation

Unit: Mm^3

	Present	Future (2020)
Irrigation Water Demand	1,061	1,459
Irrigation Water Demand (maximum demand)	1,260	1,720

(2) Water Demand for Water Supply

Table 3.8.4 shows the result of prediction of present and future demand of water supply systems in Marrakech, the 11 communes by ONEP and other 41 communes locate within the groundwater simulation area. Total water demand in terms of required water intake quantity from surface water and groundwater sources. The required water intake quantity will be broken down into surface water and ground water sources in the course of the Study. However, the total required water intake quantity for water supply systems will increase from 69.2 Mm^3/year in 2005, and to 89.4 Mm^3/day in 2020.

(3) Water Demand by Golf Courses

There are currently three golf courses in the Study Area (Marrakech Royal Golf Club, Amelkis Golf

Club and Palmeraie Golf Club) using water with the volume of 2.5 Mm^3/year. Three more golf courses have already obtained permission from ORMVA/ABHT to withdraw water from Rocade Canal and groundwater from dug wells. The name of those golf courses and the permitted water quantity is summarized in Table 3.9.5. Furthermore, there are 5 golf course projects currently applying for approval. They have requested to withdraw water from the Rocade Canal and from groundwater as listed in Table 3.9.6. The total water intake quantity requested by the new projects total 7.85 Mm^3/year. Accordingly, the total water intake quantity in the future will become 14.27 Mm^3/year once the requests of new projects will be permitted. For the upcoming development plans, an assumption of 5.2 Mm^3/year is made for 4 new golf courses.

Estimated Water Demand of Golf Cources

	Present	Completed by 2008	Completed by 2010	Completed by 2015
No. of cources	3	3	5	4
Water Demand	2.5Mm^3/Year	3.92Mm^3/Year	7.85Mm^3/Year	4.2Mm^3/Year
Total	2.5Mm^3/Year	5.5Mm^3/Year	14.3Mm^3/Year	19.5Mm^3/Year

(4) Total Water Balance

The estimates of water demand discussed above are summarized as follows.

Summary of Estimates for Water Demand

(Unit: Mm^3)

Item	Current Water Consumption	Current Potential Water Demand	Estimated Water Demand in 2020/21	Estimated Water Demand in 2020/21 (maximum demand)
Water Demand	**1,147**	**1,544**	**1,389**	**1,588**
1. Irrigation	**1,061**	**1,459**	**1,260**	**1,459**
(1) ORMVAH	835.6	1,158.0	960.8	1,158.0
1) GH	242.2	370.9	242.2	370.9
2) PMH	593.4	787.1	718.6	787.1
(2) DPA Marrakech	51.8	69.2	69.4	69.2
(3) DPChichaoua	173.7	231.5	229.3	231.5
2. Water Supply	**76.5**	**76.5**	**100.3**	**100.3**
1) Marrakech : RADEEMA	58.9	58.9	77.3	77.3
2) 11 Communes under ONEP	3.5	3.5	4.7	4.7
3) Rural areas: Communes other than those under ONEP	14.1	14.1	18.4	18.4
3. Others (Urban Areas)	**9.2**	**9.2**	**28.8**	**28.8**
1) Golf Cources	2.5	2.5	19.4	19.4
2) Others (Gardens, Hotels)	6.7	6.7	6.7	6.7

3.8.5 Available Amount of Water Resources

The plan for integrated water resources management plan for the Tensift basin (2001) examines 12 new dam sites, and proposes 7 dams (with the total capacity of 200 million m^3) to be constructed by 2011. As described in section 2.2.4, Wirgane dam is already under construction. The construction of Taskourt dam is also planned to start next year. However, at this point, there are no provisions for the other remaining dams to be implemented. The situation of the 12 dams examined are indicated in table 3.8.8.

Currently, there is a discussion on the implementation of a large-scale water diversion plan from the northern parts of Morocco to Marrakech, via Rabat and Casablanca. However, this is still in its conceptual stage. DAH is preparing a study on the inter-basin water diversion from the basins of Lokous, Law and Sabou to the southern basins. The actual study is expected to be commenced soon.

Desalinization of marine waters may also be considered as an additional water source. However, it may not be practical in short to mid terms.

(1) Evaluation of Current Water Consumption

The results of the examination of water balance for the period of 1993/94 to 2003/04, based on the water demand of various sectors and the amount of available water resources including the estimated amount of groundwater extraction, are summarized in Table 3.8.7. The average of the whole period is indicated below in order to understand the total picture of the water balance. The total annual water use is estimated at 942 Mm^3 of which 93% is used for irrigation and 7% for other sectors. 54% of the water is obtained from groundwater, while 36% and 11% are taken from surface water and through inter-basin water diversion from the basin of Oum Er Rbia.

Estimation of Water Balance in the Study Area (average of 1993/94-2003/04)

(Unit: Mm3)

Supplied Amount			Used Amount		
Water from Dam: Lalla Takerkoust Dam (including a part of water from Mouay Yossef Dam	135	14.3%	Irrigation	880	93.3%
River Water	201	21.4%	Water Supply	55	5.8%
Inter Basin Transfer (Water from Oum Er Rbia Basin transferred through Rocade Canal)	101	10.7%	Others (Urban)	8	0.9%
Groundwater Abstraction	505	53.6%			
Total Suplied	942		Total Used	942	

(2) Precipitation

The basin average precipitations of the Haouz plain area and the Tensift basin were assessed as shown below. The average of 1970/71~2005/06 was adapted to the design precipitation for evaluating water balance, which was set as 281 mm for the Haouz plain area.

Basin Average Precipitation and Probable Precipitation

	Haouz Aquifer		Tensift Basin	
Data period	1970/71-2005/06	1991/95-2005/06	1970/71-2005/06	1991/95-2005/06
Area (km2)	6,124		19,800	
Average Basin Precipitation (mm)	281	272	288	281
Probable Precipitation (mm)				
1%	83	75	98	85
2%	106	98	120	108
5%	141	133	154	142
10%	172	164	183	173
20%	209	201	219	210
50%	281	272	288	281

(3) Dam Water

1) Lalla Takerkoust Dam and Wirgane Dam

A 82 Mm^3 is set as projected amount of water distribution by the Lalla Takerkoust Dam, which is design amount of the Dam. The distribution plan of dam water is set based on the proportion of average distribution from 2001/02 to 2005/06. After starting the operation of the Wirgane Dam, which is scheduled in 2008, a 17 Mm^3/year of the additional water resources regulated by the Dam is expected to be supplied, which is planned to supply to the Marrakech water supply.

2) Taskourt Dam

The Taskourt Dam has been started its construction from 2007 and it is scheduled to be competed in 2010. The design regulation water amount is 24Mm^3/year and it is planned to be used for irrigation. In the Study, the water distribution by the Taskourt Dam will be considered to be utilized from the year 2010/2011.

Even the beneficiary area of the Taskout Dam was set as 4,500 ha according to the Feasibility Study on Water Resources Development in Rural Area conducted by JICA, the detail of the irrigation development plan of the beneficiary area has not yet decided and the DPA Chichaoua is conducting the study at present. In the irrigation development plan has a basis that the project is improvement of existing seguia irrigation area by changing the water resources and development of new irrigation area dose not planned in the project.

3) Moulay Youssef Dam

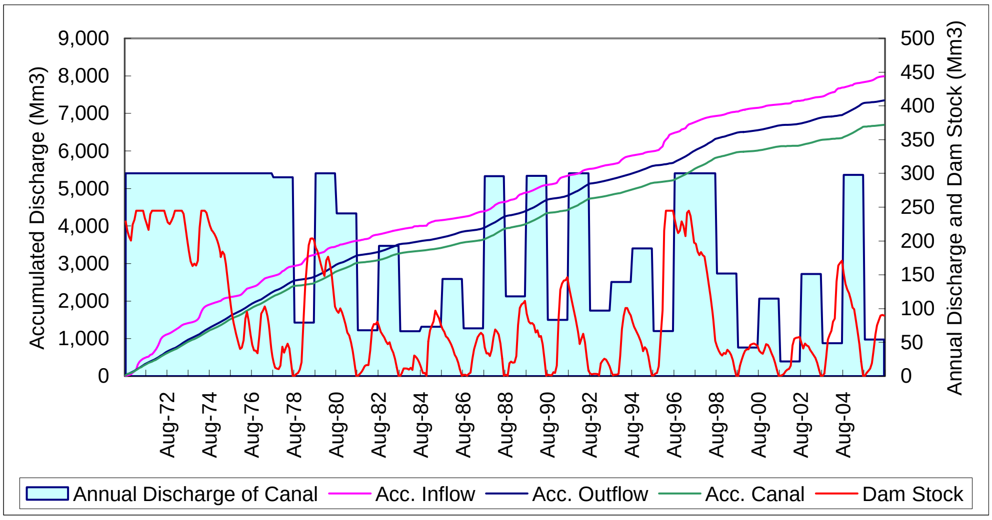
The Moulay Youseff Dam is located in the Oum Er Rbia basin, which supplies water to Upper Tessouat Irrigation Sector. A part of the Upper Tessouat Sector located within the Haouz Plain (Skhirat and Bouidda Sector) is also supplied water by the Dam. In the Study, it is assumed that the Moulay Youseff Dam supplies 46.2 Mm^3/year to the area within the Haouz Plain, which is 30% of the total amount supplied to the whole Upper Teesout Sector of 154 Mm^3/year (average in 1990/91 to 2004/05) corresponding to the ratio of the area.

(4) River Water

Even the amount of the water taken by seguias are reported based on the observation, it should be considered that whole sguias are not always observed and there is a gap between the observation and actual amount of water taken by seguias. In the Study, the average amount of water taken by seguias from 1985 to 2001 in each river is considered as an available water resources for sguias, based on "Etude hydrologique des prélèvements au fil de l'eau dans le basin du Tensift, ABHT, 2003". As for the Chichoua river and Assif El mal river which do not have actual record, the available water for seguias are estimated based on the ratio of withdrawing in other rivers. After completion and starting operation of the Taskourt Dam, the seguias in the Assif El Mal river are considered that they receive water from the Taskourt Dam directly.

(5) Water Transferred from Oum Er Rbia Basin

The possible amount of water supplied to the Haouz Plain by the Rocade Canal was examined. Because the Hassan 1 Dam has constructed in 1988/89 and actual record exists after the operation started, the possible amount of water supplied was estimated by the trial calculation that is simplified dam water balance analysis for long period based on the inflow of dam site observed. As a result of the analysis, possible water amount of the Rocade Canal was estimated as 186Mm^3/year in average 1970/71 to 2005/06, 146 Mm^3/year in average 1981/82 to 2005/06 and 152 Mm^3/year in average 1991/92 to 2005/06. The inflow of the dam site shows significant decrease after the rich period of 1970's, especially in the second half of 1970's. It is considered that there is a risk that the possible outflow might be overestimated based on the record including 1970's and before. Thus, the possible outflow to the Rocade Canal was set as 146 Mm^3/year in the Study, which is based on the average of the actual outflow from 1991/92 to 2005/06. The design distribution to the Rocade Canal, which excludes amount supplied to the Lower Tessout IrrigationSector and El Kelaa des Sraghna Water Supply, was set as 120 Mm^3/year.



Simplified Dam Water Balance Analysis of Hassan 1st Dam

(6) Groundwater

The actual groundwater abstraction in the Haouz Plain varies 274 Mm^3/year to 750 Mm^3/year between 1993/94 and 2003/04, of which average was 505 Mm^3/year. The quantity of available groundwater is set at 564Mm^3/Year, which is the quantity estimated to enable sustainable use of groundwater, based on the result of groundwater simulation examined in Chapter 5 (The maximum groundwater extraction in 2020 based on the Major Actions Scenario).

(7) Available Water Resources

According to the examination, the available water resources are summarized as shown bellow:

(Unit: Mm^3)

Water Source	Period	
	2008-2009	2010-2020
1. Surface Water	518	522
(1) Dam	145	169
1) Lalla Takerkoust Dam	82	82
2) Wirgane Dam	17	17
3) Taskourt Dam	0	24
4) Moulay Youssef Dam*1	46	46
(2) Rivers (Seguia)	252	233
(3) Inter-Basin Water Diversion from the Basin of Oum Er Rbia through the Rocade Canal*2	120	120
2. Groundwater	564	

Note: *1: A part of Skhrat and Bouida Areas were taken into consideration.
*2: Annual Flow estimated at 114Mm^3 with transportation loss (6Mm^3/year).
*3: Amount of available groundwater is based on the results of simulation

3.9 Groundwater Simulation in the Haouz Plain and Zoning

3.9.1 Groundwater Simulation in the Haouz Plain

(1) Scenarios for basic simulation

Underground water simulation it did in order in the future to presume the available water resource quantity in the Haouz Plain. Scenario of two kinds below was set at the time of the execution of simulation.

Continuation Scenario:

It is the scenario that acts as basis of the exam. It is assumed that the situation where the present water use will continue and the preventive measures won't be taken. (For the water supply, the measures to take, as the prevention of the water leakage, etc. are already considerations in the forecasting of the water demand.)

Maximum Demand Scenario:

For the critical situation, it is assumed that the situation where 100% of the quantity of necessary water will be used by every sector. (For the water supply, the measures to take, as the prevention of the water leakage, etc. are already considerations in the forecasting of the demand in water.)

The detailed condition which is set in each scenario is as follows.

For the "**Continuation**" scenario, the present observed conditions of groundwater abstraction and groundwater recharge were continued up to 2021:

- same level of water demand (irrigated surfaces and crop water satisfaction) in the GH sectors fixed as the average value calculated from set up of the sectors;
- continuation of the observed 2% increase of groundwater abstraction in the PMH sector;
- same high level of evaporation (15% of the irrigation waters as estimated in a first approach for the 1993/04 period, see Supporting Report G for details) in agriculture, resulting from the present

irrigation practices;
- planned increase of the water demand for golf courses;
- conservation of the surface water potential as the average value of the past 35 years;
- same rainfall as the average value of the past 35 years (including the Wirgane Dam additional resource);
- conservation of the flood infiltration rates as estimated for the 1993/2004 period.

A “**Maximum Demand**” scenario was simulated, which illustrated the impact of a possible increase in the water demand for agriculture. All the conditions of the “**Continuation**” scenario were kept, except:

- the water demand in the GH sectors was increased in order to cover 100% of the planned irrigated surfaces and an 100% of crop water satisfaction (end of the 20% water stress);
- the water demand in the PMH sectors was increased in order to cover 100% of crop water satisfaction (end of the 20% water stress);

Table below summarized the scenario hypothesis:

Detailed hypothesis for the main parameters of the two scenarios

	Scenarios	
	Continuation	**Maximum Demand**
Irrigated areas		
GH	40.514 ha	46.883 ha
PMH	135.190 ha in 2006/07	135.190 ha in 2006/07
	162.863 ha in 2020/21	162.863 ha in 2020/21
Drip irrigated surfaces		
GH		
N’Fis right bank	-	-
Other sectors	-	-
PMH	0 ha	0 ha
Water stress conditions	20%	0%
Growth rate of PMH irrigated by groundwater	2%	2%
Surface water availability (MCM/year)	501 up to 2007/08 518 up to 2009/10 522 up to 2020/21	501 up to 2007/08 518 up to 2009/10 522 up to 2020/21
Golf courses water demand	Up to 15 golf courses from 2015 (19.7 MCM/year)	Up to 15 golf courses from 2015 (19.7 MCM/year)
Rainfall	282 mm/year	282 mm/year
Flood infiltration rate	about 25%, based on flood regime	about 25%, based on flood regime

(2) Definition of indicators for the scenarios assessment

Two types of indicators were defined and measured at the target year (end of the 2020/21 agricultural campaign) in order to evaluate the results of the simulations and thereby the impact of the scenarios application: indicators of the groundwater resource availability and indicators of economic impacts.

In order to evaluate the changes in the availability of the groundwater resource, three indicators were selected:

- The changes in the gross surface where the depth of the water table is higher than the average depth of boreholes (about 50 m according to the last boreholes inventories conducted by the ABHT). Beneath these areas (hereafter known as Change50), 50% of the boreholes will dried out and should then be deepened (mostly new drilling nearby the dried out one);
- The total groundwater balance from 2006 to 2021 and the annual balances for 2006/07 and 2021/21: A negative balance indicates that part of the abstracted groundwater is taken from the stock.
- The average depth of the groundwater table: According to the constructed model, the average groundwater level was about 41.4 m. Changes in this parameters will give an overview of the changes in the wet aquifer volume (common indicator with economic impact);

In order to understand the economic impact of each of the scenarios, three indicators were selected:

- As well as an indicator for the groundwater resource availability, the average depth of the groundwater table may also be considered as an economic indicator. Changes in the piezometric levels will significantly impact the cost of the groundwater abstraction, directly proportional to the groundwater table depth;

- "Change 50" area: 50% of the boreholes will dried out and should then be deepened (mostly new drilling nearby the dried out one);
- The number of boreholes that will dry out by 2021. This figure is estimated to 100% of the boreholes in the dry aquifer sector, and 50% of the boreholes in the Change50 sectors (see above). In order to preserve the present irrigation conditions, all of these boreholes needs to be substitute.

(3) Overview of the simulation results

The results of the simulation are indicated as piezometric maps in Fugure 3.9.1 and 3.9.2. The Table below gives the values of each of the indicators for the scenarios.

Indicators values obtained from groundwater flow simulations (simulated period from 2006/07 to 2020/21)

			Continuation	Maximum Demand
Indicates related to Groundwater	Surface "Change50"(ha)		29,000	97,000
	Groundwater Balance (Mm^3)	Whole period	-1,310	-3,440
		2006/07	-39	-126
		2020/21	-121	-263
Economic Indicators	Average depth of the groundwater table (m): 41.4m at present (Economic Impact: Million dh)		41 (3,757)	48 (7,605)
	Dried out aquifer surface (ha) (Economic Impact: Million dh)		9,100 (448)	44,000 (2,166)
	Number of dried out boreholes (Economic Impact: Million dh)		1,805 (253)	6,883 (964)
	Number of people losing jobs		4,306	20,821

For both scenarios, a large part of the Haouz plain aquifer dried out. For most of them, this dried out area is localized beneath a PMH sector north of the N'Fis GH sectors. For the Maximum Demand scenario, the dried out area covers this sector and extends eastward to Marrakech city, it extends to the Marrakech Issil well field and in the eastern part of the plain.

3.9.2 Regional Characteristics and Measures for Groundwater and Management

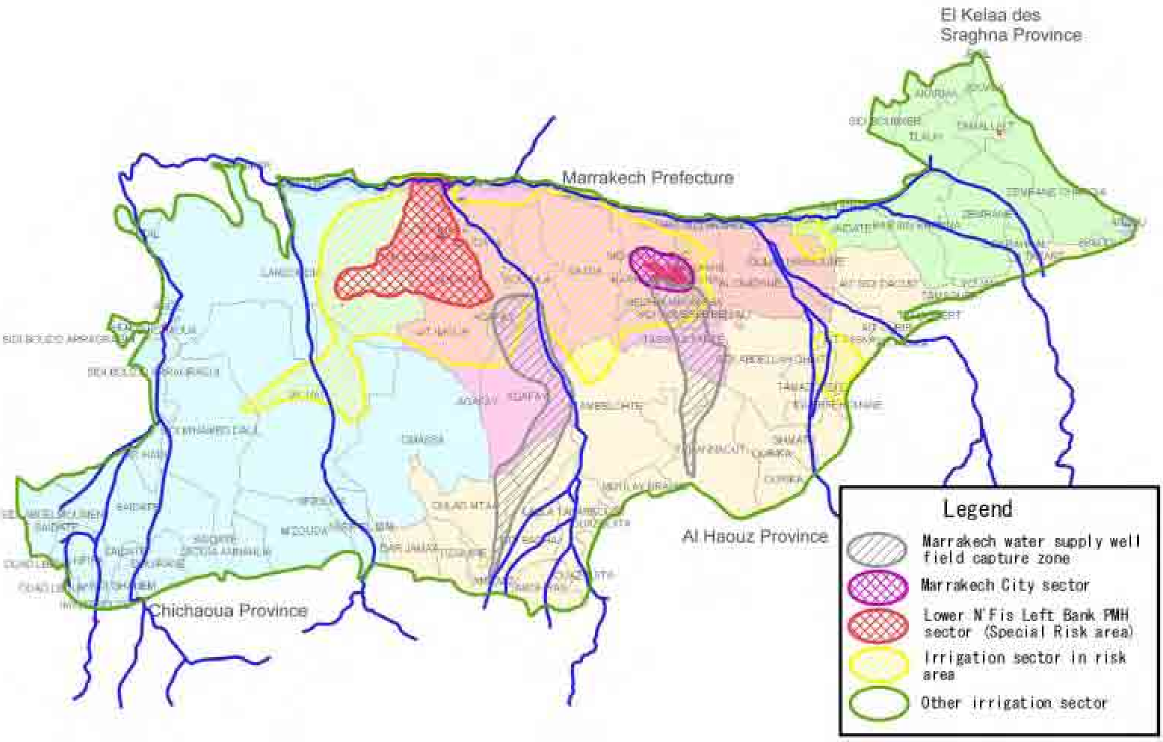
(1) Necessity of Zoning in Groundwater Management

For managing groundwater in the Haouz Plain, it is necessary to have two aspects, the one is aspect of global water balance in the whole aquifer, and another is the aspect of regionalized water use such as regional characteristics and situation of aquifer, socio-economic importance and position of groundwater in the region, and regional demand and its characteristics. These regional characteristics shall be considered in setting regional priority, formulating and selecting countermeasures in region, and conducting appropriate regional water management. In the Study, the Haouz Plain was divided into several zones based on the concept described below.

(2) Concept and Setting up of Zoning for Groundwater Management

Based on the changes in the groundwater table between the present situation (August 2006) and the target year one (August 2021) evaluated through the groundwater flow model, a Haouz plain zoning may be proposed. Three sectors may be defined: areas where the groundwater table will dramatically drop; areas where the drawdown will be limited; and between the last two, areas where the groundwater table will significantly but not dramatically drop. The exact drawdown values used to define the "dramatic", "significant" and "limited" limits should be fixed regarding the passed changes in the water table: a drawdown higher than 1 m/year is dramatic and only occurred in very specific sectors, and 0.5 m/year is still significant. In most of the Haouz plain, less than 0.5 m/year can be considered as limited regarding the last 30 years evolution. A forth sector can be added to these three: the areas where the aquifer will dry out, whatever the drawdown.

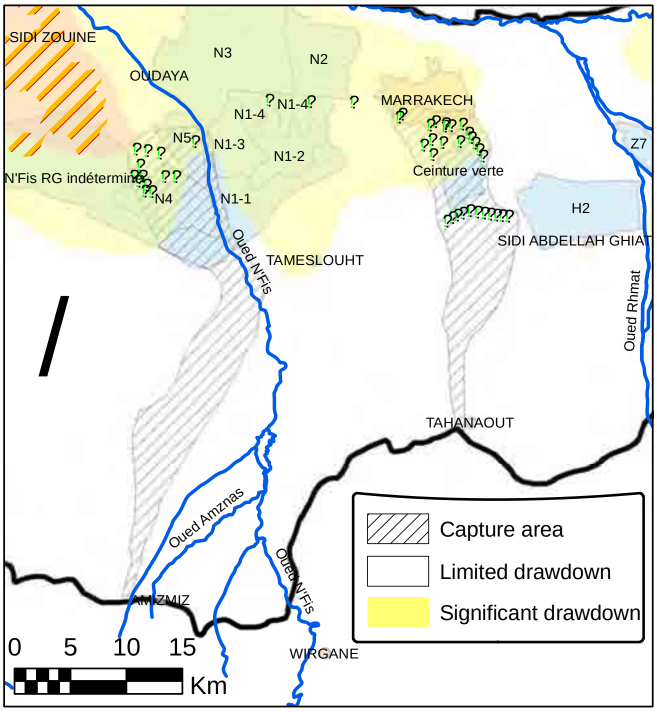
Based on various factors including the form of water use in GH and PMH sectors, water use in urban areas (i.e. Marrakech city, golf course development areas) as well as the estimated decrease in groundwater table, the Haouz Plain is categorized into the following 5 zones.



Zoning of the Study Area based on the Results of Simulation

1) Marrakech water supply well field capture zone

None of the groundwater development scenarios significantly modify the captures zones of the Marrakech well fields: the capture zone of the N'Fis well field extend to the South along the N'Fis oued, and then reach the Amizmiz sector; a unique capture zone may be defined for the Issil, Aguedal, Ourika, Menara and Drain well fields, which reach Tahanaout Southward. These two sectors are strategic areas for the Marrakech City water supply. They should be protected regarding the quality (any contaminant entering the aquifer in these zones will reach the abstraction wells) and regarding the quantity (the well fields are expected to face significant drawdown).



Capture zone of the main Marrakech water supply well fields (situation in 2021, "Continue" scenario

2) Marrakech City sector

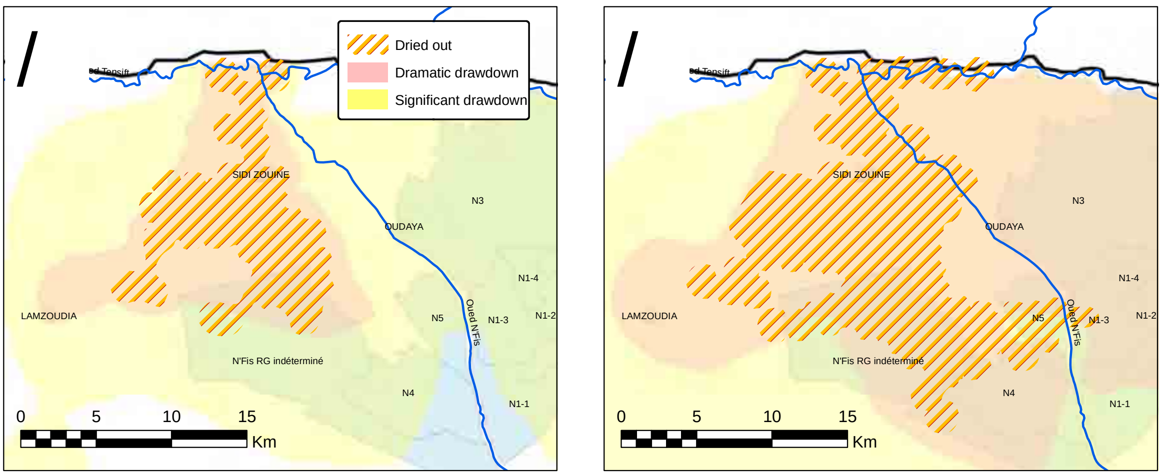
The groundwater development beneath the Marrakech City sector (meaning the urban and semi-urban area) was important in the last 10 years. It is expected to significantly increase in the near future: up to 15 golf courses projects are identified for a total water demand of over 19 MCM/year, dozens of hotels with gardens and pools are constructed every year, the Municipality services increase the irrigated grassy areas along the main streets (mainly with new drilled wells), many individuals drill their own well for the swimming pool supply…

The groundwater development scenarios show that this sector will face a significant drawdown within the next 15 years if no specific countermeasures are borrowed. The Issil Marrakech supply well field will dry out if the golf courses water demand is satisfied with the groundwater (Maximum Demand scenario).

3) Lower N'Fis Left Bank PMH sector (Special Risk area)

Whatever is the development scenario, a Special Risk area may be identify in the lower N'Fis Left Bank PMH sector. The extension of this sector differs from one scenario to another but all the simulations shows that most of this sector will faced a dramatic drawdown and will certainly dried out.

"Continuation" scenario **"Maximum Demand" scenario**



Expected drawdown from 2006 to 2021

4) Irrigation sector in risk area

The sectors where the expected drawdown within the next 15 years will be significant and where the groundwater is used for agriculture may be called Risk Area regarding the abstraction capacity. Indeed, some major economic negative impacts are expected in the agricultural sector in case of significant drawdown.

This Risk Area will nearly cover the whole Haouz plain in case of important increase of the groundwater abstraction (Maximum Demand scenario) and then all of the GH sectors will face large negative impacts. In case of a continuation of the present groundwater abstraction development (Continuation scenario), the Risk Area will cover the N'Fis GH sectors. The PMH sectors located in the lower part of the Haouz plain are in the Risk Area. This risk area is set from oued El Mal at the West to Marrakeck at the East in case of a continuation of the present groundwater abstraction development (Continuation scenario).

5) Other irrigation sector

Everywhere else, the Haouz plain will face a drawdown within the next 15 years limited from 0.1 m/year to 0.5/ m/year. None of the tested development scenarios lets expect a null (or positive) change in the water table.

Table 3.2.1 Availability of Rainfall Data of ABHT Observation Network

Nom de la Station	Code de la Station	Du	Au	Remarques
ABADLA	N° 008	1969/1970	2005/2006	
AGHBALOU	N° 6193	1968/1969	2005/2006	
AGOUNS	N°902	1996/1970	2005/2006	
AMENZAL	N°1004	1997 April	2005/2006	
AREMD	N°1182	1999 April	2005/2006	
CHICHAOUA	N°2601	1995/1996	2005/2006	
IGUIR N'KOURIS	N° 4299	1973/1974	2005/2006	
ILOUDJANE	N° 4222	1989/1990	2005/2006	
IMINE EL HAMMAM	N° 4432	1969 March	2005/2006	
Bge. LALLA TAKERKOUST	N° 8969	1962/1963	2005/2006	
MARRAKECH	N° 5229	1970/1971	2005/2006	1972/1973 Manque des Données
SIDI BOUOTHMANE	N° 6770	1989/1990	2005/2006	
SIDI HSSAIN	N°6826	1998 Jan	2005/2006	
SIDI RAHAL	N° 6976	1967/1968	2005/2006	
TAFERIAT	N° 7352	1983 Jan	2005/2006	1986 April -1987 Oct Manque des Données La location de l'indication de la pluie a changé en 8/10/1997
TAHANAOUT	N° 7512	1971 April	2005/2006	
TALMEST	N° 7660	1985 April	2005/2006	
TAZITOUNT	N°7994	1999 May	2005/2006	
TIOURDIOU	N°8411	1996/1997	2005/2006	
TOURCHT	N°8804	1997 March	2005/2006	

Source: ABHT

Table 3.2.2 Availability of Discharge Data of ABHT Observation Network

Rivier	Station	Code	Du	Au	Remarques
R'DAT	SIDI RAHAL	44/54	1963 Dec	2005-2006	
N ' FIS	IMINE EL HAMMAM	1566/53	1966 -1967	2003-2004	
N ' FIS	IGUIR N'KOURIS	510/62	1974 -1975	2004-2005	
AMEZMIZ	SIDI HSSAIN (R'HA D 'AZILAL)	2431/53	1988 Feb	2003-2004	
OURIKA	AGHBALOU	2089/53	1969 -1970	2005-2006	
ZAT	TAFERIAT	1562/53	1962 Mar	2005-2006	
KSOB	ADAMNA	111/51	1970 -1971	2005-2006	
IGROUNZAR	IGROUNZAR	400/52	1965 -1966	2003-2004	72 Feb - '75 Jan Manque des données
ZELTEN	ZELTEN	401/52	1975 May	2003-2004	
TENSIFT	ABADLA	1675/44	1969 Apr	2005-2006	
TENSIFT	TALMEST	189/43	1970 -1971	2003-2004	
RHERHAYA	TAHANAOUT	1565/53	1962 Apr	2005-2006	
EL MAL	SIDI BOUOTHMANE	1976/53	1984 Dec	2005/2006	
SEKSAOUA	ILOUDJANE	628/52	1975 -1976	2005-2006	
CHICHAOUA	CHICHAOUA	451/52	1971 Feb	2004-2005	
IGOUZOULEN	IGOUZOULEN	404/51	1997 -1998	2003-2004	
IMLIL	AREMD	3604/53	1999 Mar	2003-2004	
OURIKA	TAZITOUNT	3603/53	1999 Mar	2003-2004	
R'DAT	SEGUIA : AFIAD	832/45	1970 -1971	2003-2004	

Source: ABHT

Table 3.2.3 Surface Water Resources of Tensift Basin and Observed Data of Last 10 Years

Name of river	Effective area of Basin (km^2)	Contribution to water demand Mm^3 (Data 1970-2002)			Observed Data of Last 10 Years (Mm^3)									
		Min.	Average	Max.	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Discharge into Haouz Plain														
N'Fis (at Lalla Takerkoust)	1,692	12.7	174.8	504.5	262.6	221.7	37.5	186.2	12.7	81.9	88.3	130.0	NA	NA
R'dat (at Sidi Rahal)	569	3.5	72.8	264.0	2.3	1.5	2.5	1.4	0.3	0.4	0.9	4.1	2.1	2.3
Zat (at tafriat)	516	16.8	103.9	278.7	1.9	3.4	1.3	5.8	0.7	0.5	1.5	2.5	1.3	0.4
Ourika (at Aghbalou)	503	14.5	155.8	618.5	86.7	74.7	76.3	102.2	14.5	95.6	65.9	124.9	84.8	65.8
Rheraya (at Tahanaout)	225	2.6	47.8	117.1	27.8	40.4	16.6	34.4	2.6	18.1	14.9	21.4	21.4	21.0
Lahr (at Herrisane)	65	0.3	9.9	25.8										
Assif El Mal (at Sidi Bou Othman)	517	0.8	35.9	113.0	46.4	13.7	8.9	50.8	0.8	11.3	11.5	7.1	7.2	24.2
Chichaoua	1,317	10.9	66.8	230.6	84.5	23.0	0.3	36.9	3.2	4.7	4.4	3.9	0.5	NA
Transfer from Oum Er Rbia	-	160.0	300.0	300.0	106.3	111.2	100.0	90.8	74.5	56.7	82.1	108.6	142.8	130.2
Sub-total of Haouz Plain without transfer	5,404	62.1	667.7	2,152.2										
Sub-total of Haouz Plain with transfer	-	222.1	967.7	2,452.2										
El Hallouf	185	0.0	1.4	4.6										
Mramer	150	0.0	1.8	4.6										
Other effective basins	2,241	9.2	84.2	269.1										
Other semi-effective basins	1,396	0.9	12.8	36.6										
Without transfer	9,376	72.2	767.8	2,467.0										
With transfer	-	232.2	1,067.8	2,767.0										

Source: Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift, ABHT, 2004
Observed Data of Last 10 Years: ABHT

Table 3.2.4 Planned and Actual Distribution of Rocade Canal

(Unit : Mm³)

Items	PD1976 Planned		Actural Record 96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	Average
Use within Lakhdar River Basin													
PMH Lakhdar	3,000ha	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	5.1	
Seguia Tagharghourt		4	4.1	4.1	3.2	2.8	1.2	0.8	1.1	1.7	2.3	1.4	
B1 Canal - Upper Tessaout (Yagoubia)	5,000ha	16	1.4	16.5	15.8	15.3	7.6	5.6	11.3	13.4	19.3	19.7	
B2 Canal - Upper Tessaout (Sud El Kelaa)	1,500ha	5	9.5	11.1	10.8	3.1	1.5	1.0	2.5	0.8	8.8	7.1	
Portable Water El Kelaa (ONEP)			1.9	1.9	1.7	1.6	1.9	2.0	2.7	2.4	2.5	2.5	
Sub-total		54	16.8	33.6	31.6	22.8	12.1	9.5	17.5	18.3	36.9	35.9	23.5
Ratio to PD1976			*31%*	*62%*	*58%*	*42%*	*22%*	*18%*	*32%*	*34%*	*68%*	*66%*	*43%*
Use after Transferred to Tensift River Basin													
Central Haouz Sectors	20,000ha	144	0.0	4.6	15.9	35.5	19.3	7.8	20.4	27.5	33.5	26.2	
Portable Water Marrakech (ONEP)		40	34.6	32.3	30.5	32.4	30.5	29.8	37.2	38.9	43.6	46.2	
Golf Course			1.9	1.9	1.9	1.9	1.3	1.0	1.3	1.2	1.2	1.3	
Lower N'Fis River Right Bank Sectors	17,000ha	112	62.9	68.5	60.5	49.2	19.4	15.3	18.8	37.0	59.9	52.9	
Seguia Targua & Aslejour			6.9	8.5	7.1	7.3	4.1	2.7	4.4	4.0	4.7	3.7	
Sub-total		296	106.3	111.2	100.0	90.8	74.5	56.7	82.1	108.6	142.8	130.2	100.3
Ratio to PD1976			*36%*	*38%*	*34%*	*31%*	*25%*	*19%*	*28%*	*37%*	*48%*	*44%*	*34%*
Loss			43.1	42.5	39.4	37.4	14.1	11.5	7.1	4.2	0.5	6.6	
Total			123.1	149.4	147.5	149.1	86.7	66.2	99.6	126.9	179.7	168.0	
Outflow at Sidi Driss Dam		350	166.3	191.8	186.8	186.5	100.8	77.6	106.8	131.1	180.2	172.6	150.1
Ratio to PD1976			*48%*	*55%*	*53%*	*53%*	*29%*	*22%*	*31%*	*37%*	*51%*	*49%*	*43%*

Source : ORMVAH

Table Planed and Actual Water Distributiuon of Lalla Takerkoust Dam

Table 3.2.5 Planned and Actual Water Distribution of Lalla Takerkoust Dam

(Unit : Mm³)

Items	PD1976 Planned		Actural Record 96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	Average
Seguias de l'hyp. Constante			12.9	13.0	10.1	12.7	7.2	5.0	8.9	9.1	9.3	8.4	
Seguias in N'Fis Left Bank			117.2	74.1	18.1	36.8	3.6	13.3	27.1	21.2	21.1	19.5	
Seguias in N'Fis Right Bank			13.3	10.9	0.0	7.0	0.0	0.7	6.2	5.7	2.5	3.4	
Secteur N1-1 (P2)			16.5	22.7	22.4	20.0	11.0	7.4	13.6	14.3	15.8	12.9	
Secteur N4 (P1)			-	-	-	1.0	0.5	2.7	9.5	11.5	11.8	10.4	
Portable Water Marrakech (ONEP)			-	-	0.5	4.5	0.8	4.4	3.2	2.7	4.1	6.4	
Total of Withdrawal			159.8	120.9	51.1	81.9	23.1	33.4	68.5	64.5	64.5	61.0	
Loss			-	-	1.6	4.7	2.6	3.1	9.0	10.6	7.8	4.7	
Outflow at Lalla Takerkoust Dam		85	123.5	112.3	52.6	86.6	25.7	36.5	77.5	75.1	72.3	65.7	72.8
Ratio to PD1976			*145%*	*132%*	*62%*	*102%*	*30%*	*43%*	*91%*	*88%*	*85%*	*77%*	86%

Source : ORMVAH

Table 3.2.6 Water Intake from Rivers by Seguia Systems

Sub-basin	Effective area of basin (km^2)	Average annual discharge 1985-2001	Average water intak by seguias (Mm^3)		Ratio of water intake to discharge
R'dat	569	71.2	44.8	1985-2001	62.9%
Zat	516	99.0	49.5	1985-2001	50.0%
Ourika	503	177.4	93.1	1985-2001	52.5%
Rheraya	225	50.4	26.0	1985-2001	51.7%
Lahr	65	9.9	5.4	Estimated by average ratio	54.3%
El Mal	517	36.0	19.5		
Chichaoua	1,317	35.7	19.3		
Total	5,404	479.6	257.7		54.3%

Remarks: Seguia systems in N'Fis river is counted in the table of Dam supply.

Source: Etude hydrologique des prelevements au fil de l'eau dans le bassin du Tensift, 2003

Table 3.2.7 Estimation of Water Intake by Seguia Systems 93/94-03/04

(Mm^3)

Name of sub-basin		Ratio of water take by seguias	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	Average
R'dat	River[*1]		106.3	32.8	234.0	72.2	46.0	77.6	44.2	8.1	12.6	27.4	127.7	71.7
	Seguias[*2]	62.9%	***64.5***	***42.0***	***52.6***	***61.5***	***62.6***	***77.7***	***22.6***	***36.5***	***7.9***	***17.2***	***80.3***	***47.8***
Zat	River		135.3	61.5	199.0	60.9	108.2	41.3	183.2	20.5	16.8	46.4	79.2	86.6
	Seguias	50.0%	***84.2***	***38.0***	***54.1***	***36.9***	***38.4***	***33.2***	***38.8***	***11.7***	***8.4***	***23.2***	***39.6***	***36.9***
Ourika	River		287.0	100.6	211.9	86.7	74.7	76.3	102.2	14.5	95.6	65.9	124.9	112.8
	Seguias	52.5%	***119.5***	***72.7***	***110.1***	***79.8***	***88.1***	***66.8***	***65.3***	***7.6***	***50.2***	***34.6***	***65.6***	***69.1***
Rheraya	River		64.3	30.6	101.5	27.8	40.4	16.6	34.4	2.6	18.1	14.9	21.4	33.9
	Seguias	51.7%	***34.2***	***17.5***	***37.8***	***24.3***	***24.5***	***17.6***	***20.2***	***2.9***	***9.3***	***7.7***	***11.0***	***18.8***
Lahr	River		N/A[*3]											9.9
	Seguias	54.3%												***5.4***
El Mal	River		50.1	9.8	75.7	46.4	13.7	8.9	50.8	0.8	11.3	11.5	7.1	26.0
	Seguias	54.3%	***27.2***	***5.3***	***41.1***	***25.2***	***7.4***	***4.8***	***27.6***	***0.4***	***6.1***	***6.3***	***3.9***	***14.1***
Chichaoua	River		6.9	14.8	115.1	84.5	23.0	0.3	36.9	3.2	4.7	4.4	3.9	27.1
	Seguias	54.3%	***3.8***	***8.0***	***62.5***	***45.9***	***12.5***	***0.2***	***20.0***	***1.7***	***2.6***	***2.4***	***2.1***	***14.7***
Total of River Discharge			659.9	260.0	947.1	388.4	315.9	230.9	461.5	59.6	168.9	180.5	374.0	367.9
Total of Estimated Watre Take by Seguias			***338.7***	***188.9***	***363.5***	***279.0***	***239.0***	***205.7***	***199.8***	***66.2***	***89.9***	***96.8***	***207.9***	***206.8***

Remarks *1:River - Annual discharge of river, *2:Seguia - Water taken by seguia system in the river

*3: Due to lack of data, average discharge of river 9.9Mm^3 which is average 1970-2002 was applied to all year.

[shaded cell] Estimated by river flow-intake ratio of sub-basins.

Source: Etude hydrologique des prelevements au fil de l'eau dans le bassin du Tensift, 2003

Table 3.2.8 Water Quality Indicators of Selected Measurement Points by ABHT

NOM_OUED	NOM_POINT	DATE	Class	DBO_5 Mg/l	DCO Mg/l	O_2D Mg/l	P_Tot Mg P/l	NH^+_4 Mg NH_4/l	Coliform per 100m
Tensift	Station Abadla	2005/10/11	Bad	7.2	66	10	0.2	1.01	0
	Amont Marrakech	2004/7/8	Very Bad	161	558	0	8.65	68.4	800X10^4
	Aval Marrakech	2005/10/7	Very Bad	83	227	0	3.41	46.6	1.3x10^4
	Aval décharge Markech	1996/4/1	Bad	3.7	30	9.7	1.69	0.26	4800
Chichaoua	Aval Chichaoua	2004/7/15	Good	0.51	11.5	5.4	0.098	0.02	280
	Station Chichaoua	1998/2/6	Bad	2	9.6	8.4	0.76	0.007	950
Seksaoua	Station Iloudjane	2004/7/15	Bad	0.61	50	7.36	1.108	0.01	660
Zat	Station Taferiat	2005/10/6	Average	2.5	38	13.5	0.09	0.01	640
	Aval Ait Ourir	2004/7/13	Very Bad	125	322	0	5.71	39.6	1800X10^4
Imintanout	Aval Imintanout	2004/7/15	Very Bad	281	825	0	19.62	93.6	2000X10^4
Reraya	Station Tahanaout	1995/2/24	Bad	6.1	53	8.65	0.5	0.13	25
	Station Tahanout	2004/7/14	Average	0.91	8	8.48	0.014	0.005	4200
N'Fis	Station Imlil Hmam	2005/10/10	Bad	1.8	69	8.3	0.51	0.07	3.8X10^4
	Aval mine Guemassa	2004/7/13	Good	2.74	8	8.2	0.13	0.032	10
Ourika	Station Aghbalou	2005/10/7	Average	0.38	30	8.25	0.084	0.04	850
Amizmiz	Station Sidi Hssain	2004/7/14	Good	0.57	8	6.88	0.07	0.005	120
	Aval Amizmiz	2005/10/10	Bad	0.8	27	5.6	0.1	0.13	4.2X10^4
Rdat	Station Sidi Rahal	2005/10/6	Bad	2.4	42	10.32	0.09	0.08	240
	Aval Sidi Rahal	2004/7/9	Very Bad	133	365	0	12.85	54	530X10^4
Canal de Rocade		1993/6/23	Good	2	6	6.6	0.13	0.04	20

Source: ABHT

Table 3.3.1 Provisional Groundwater Quality Standard Proposed by ABHT

Water Quality Grade	Conductivity	Oxidizable Matter (KMnO4)	Chloride (Cl-)	Anmonium Nitrogen (NH4+)	Nitrate Nitrogen (NO3-)	Faceal Coliform Count
	(μs/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(nos/100ml)
Exellent	<400	<3	<200	<0.1	<5	<20
Good	400 – 1,300	3 – 5	200 – 300	0.1 – 0.5	5 – 25	20 – 2,000
Medium	1,200 – 2,700	5 – 8	300 – 750	0.5 – 2	25 – 50	2,000 – 20,000
Bad	2,700 – 3,000	>8	750 – 1,000	2 – 8	50 – 100	>20,000
Very bad	>3,000	-	>1,000	>8	>100	-

Source: ABHT

Table 3.3.2 Result of Groundwater Quality Test of 72 Wells in Haouz Plain (1991-2004)

Water Quality Parameters	Conductivity	Oxidizable Matter ($KMnO_4$)	Chloride (Cl^-)	Anmonium Nitrogen (NH4+)	Nitrate Nitrogen (NO_3-N)	Faecal Coliform Count
unit	Cond. (μs/cm)	mg/L	mg/L	mg/L	mg/L	nos./100mL
Maximum Value	14,071	2,485	5,530	50.4	251	8,600,000
Average Value	1,839	13	378	0.5	28	24,829
Minimum Value	290	0	11	0.0	0	0

Groundwater Quality Grade	Conductivity	Oxidizable Matter ($KMnO_4$)	Chloride (Cl^-)	Ammonium Nitrogen (NH4+)	Nitrate Nitrogen (NO_3-N)	Faecal Coliform Count	Total Number of Samples	Ratio in each Grade
Excellent	4	314	174	351	37	202	1082	46%
Good	183	28	67	32	226	147	683	29%
Medium	145	15	111	4	82	33	390	17%
Bad	14	0	6	5	31	0	56	2%
Very Bad	50	11	39	5	21	12	138	6%
Number of Samples	396	368	397	397	397	394	2349	100%

Source: ABHT

Table 3.3.3 Estimate of the Preferential Infiltration along the Riverbeds from 1993 to 2004

Oueds flood (MCM)	Agricultural campaign										
	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
Imintanout*	47.3	15.6	122.0	26.8	34.0	0.9	63.6	1.8	8.7	14.5	12.4
Seksaoua	42.9	14.2	110.7	24.3	30.8	0.9	57.7	1.6	7.9	13.2	11.3
El Mal	50.1	9.8	75.7	46.4	13.7	8.9	50.8	0.8	11.3	11.5	7.1
N'Fis	159.7	81.8	485.0	254.4	225.0	52.9	159.5	25.7	37.0	80.6	94.1
Rherhaya	64.3	30.6	101.5	27.8	40.4	16.6	34.4	2.6	18.1	14.9	21.4
Ourika	287.0	100.6	211.9	86.7	74.7	76.3	102.2	14.5	95.6	65.9	124.9
Zat	135.3	61.5	199.0	60.9	108.2	41.3	183.2	20.5	16.8	46.4	79.2
R'Dat	106.3	32.8	234.0	72.2	46.0	77.6	44.2	8.1	12.6	27.4	127.7
Total flood volume (MCM)	892.9	346.9	1539.9	599.4	572.8	275.4	695.5	75.8	207.9	274.4	478.1
Volume of infiltration along the oueds (MCM)	223.2	86.7	385.0	149.9	143.2	68.9	173.9	18.9	52.0	68.6	119.5

* Estimated value

Source: ABHT

Table 3.4.1 Number of Wells from Inventories and Number of Authorized Wells

Commune	Nb of wells from inventories				Authorisations ABHT (2001)
	EAU GLOBE	PROJEMA 3/2002	PROJEMA 8/2002	Total	
Agafay		180	9	189	99
Ait Hadi			9	9	1
Ait Imour		501		501	397
Al Ouidane	334			334	1285
Ghmate	897			897	723
Gmassa			333	333	108
Lamzouida			20	20	104
Loudaya		453	582	1035	823
Majjat			20	20	81
M'Zouda			8	8	2
Oulad Hassoun	234			234	1737
Oulad Mtaa			88	88	123
Saada		618	40	658	664
Saaidate			255	255	6
Sid Zouine		127		127	102
Sidi Abdellah Ghiat	888			888	1012
Sidi Badhaj			142	142	57
Sidi Bouzid Arragragui			245	245	10
Sidi Mohamed Dalil			18	18	27
Souihla		619	16	635	394
Tameslouht	406		129	535	506
Tassoultante	427			427	441
Total				**7598**	**8702**

Table 3.4.2 Detailed Interpolated Rainfall over the Agricultural Sectors

Average rainfall (mm)	Agricultural campaign										
	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
Whole plain	289	304	446	380	298	251	223	153	214	262	299
N'Fis (irrigated sectors), CV, H2, N4, R1, R3, Z1	235	248	363	309	242	204	181	124	174	213	243
N'Fis Left bank	204	215	315	268	210	177	158	108	151	185	211
N5	193	204	299	254	199	168	149	102	143	175	200
R1 aval	303	320	469	399	313	264	234	160	225	275	314
Z7	306	323	473	403	316	267	237	162	227	278	317
Tessaout Amont (Tensift basin)	334	352	516	440	345	291	258	177	248	303	346
PMH sector	293	305	446	383	299	255	228	156	218	263	305

Source: ABHT

Table 3.4.3 True Evapo-transpiration in the GH Sectors (Agricultural Campaign 2002/03)

Sectors		Evapo-transpiration (m^3) from remote sensing data
Central Haouz	N'Fis (irrigated sectors), CV, H2, N4, R1, R3, Z1	163 029 079
	N'Fis Left bank	28 695 795
	N5	8 300 000
	R1 aval	2 900 000
	Z7	5 100 000
Tessaout Amount (for acreage included in the Tensift basin)		43 692 530
Total		251 717 404

Source: An estimate of the Evapo-transpiration was conducted within the SudMed Project in partnership with the ABHT: ETR data, 500m resolution

Table 3.4.4 Estimate of the Groundwater Abstraction Under the GH Sectors

	Central Haouz																				Tessaout Amont				Total [4]
	Irrigated N'Fis				N'Fis RG				N5				R1aval				Z7								
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]	
93/94	163.0	89.4	54.0	19.7	28.7	-	8.7	20.0	8.3	-	2.2	6.1	2.9	-	1.2	1.7	5.1	-	2.1	3.0	43.7	55.8	21.1	0.0	50.5
94/95	163.0	101.8	57.0	4.3	28.7	-	9.2	19.5	8.3	-	2.3	6.0	2.9	-	1.3	1.6	5.1	-	2.2	2.9	43.7	62.0	22.3	0.0	34.3
95/96	163.0	76.6	83.5	2.9	28.7	-	13.5	15.2	8.3	-	3.3	5.0	2.9	-	1.9	1.0	5.1	-	3.2	1.9	43.7	45.9	32.6	0.0	26.0
96/97	163.0	79.4	71.2	12.5	28.7	-	11.5	17.2	8.3	-	2.8	5.5	2.9	-	1.6	1.3	5.1	-	2.7	2.4	43.7	64.4	27.8	0.0	38.8
97/98	163.0	95.9	55.7	11.4	28.7	-	9.0	19.7	8.3	-	2.2	6.1	2.9	-	1.3	1.6	5.1	-	2.1	3.0	43.7	73.5	21.8	0.0	41.8
98/99	163.0	98.8	47.0	17.2	28.7	-	7.6	21.1	8.3	-	1.9	6.4	2.9	-	1.1	1.8	5.1	-	1.8	3.3	43.7	50.8	18.4	0.0	49.9
99/00	163.0	105.7	41.8	15.5	28.7	-	6.7	22.0	8.3	-	1.7	6.6	2.9	-	0.9	2.0	5.1	-	1.6	3.5	43.7	53.3	16.3	0.0	49.6
00/01	163.0	50.3	28.6	84.2	28.7	-	4.6	24.1	8.3	-	1.1	7.2	2.9	-	0.6	2.3	5.1	-	1.1	4.0	43.7	30.6	11.2	2.0	123.7
01/02	163.0	33.3	40.1	89.7	28.7	-	6.5	22.2	8.3	-	1.6	6.7	2.9	-	0.9	2.0	5.1	-	1.5	3.6	43.7	22.3	15.7	5.7	129.8
02/03	163.0	62.2	49.0	51.9	28.7	-	7.9	20.8	8.3	-	2.0	6.3	2.9	-	1.1	1.8	5.1	-	1.9	3.2	43.7	29.4	19.2	0.0	84.0
03/04	163.0	90.4	55.9	16.7	28.7	-	9.0	19.7	8.3	-	2.2	6.1	2.9	-	1.3	1.6	5.1	-	2.2	2.9	43.7	53.7	21.9	0.0	47.0

[1] Water demand (MCM), [2] Suface water allocation (MCM), [3] Efficient rainfall (MCM), [4] groundwater abstraction (MCM)

Table 3.4.5 Distribution of Surface Water by Irrigation Sector

		1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999
Central Haouz	Golf	1 751 143	1 891 840	1 897 344	1 892 172	1 871 424	1 892 160
	P3*	36 793 169	37 315 949	29 292 381	31 586 122	34 959 309	31 660 419
	P4*	37 986 757	39 496 118	29 088 512	31 321 374	33 580 947	28 826 533
	CV*	0	0	0	0	4 631 088	8 959 833
	R1*	0	0	0	0	0	0
	R3*	0	0	0	0	0	0
	Z1*	0	0	0	0	0	0
	H2*	0	0	0	0	0	6 968 336
	N1-1 (P2)**	14 593 084	24 981 165	18 227 783	16 479 461	22 725 274	22 364 681
	N4 (P1)**						
	Total	89 373 009	101 793 232	76 608 676	79 386 957	95 896 618	98 779 802
Tessaout Amont	Total***	159 472 205	177 259 096	131 087 373	183 883 307	210 075 214	145 043 873
	Without easetern Haouz(estimation	55 815 272	62 040 684	45 880 581	64 359 157	73 526 325	50 765 356

		1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005
Central Haouz	Golf	1 886 976	1 262 304	1 025 568	1 290 960	1 157 760	1 232 673
	P3*	26 773 254	10 697 169	7 927 302	9 964 712	17 131 432	26 408 625
	P4*	22 465 174	8 675 456	7 398 833	8 791 412	19 909 135	33 517 914
	CV*	8 172 300	2 864 227	2 895 930	2 812 632	4 160 475	5 435 486
	R1*	9 905 741	5 652 432	925 807	4 644 974	6 658 875	8 251 302
	R3*	5 320 246	4 786 710	917 681	4 329 361	5 484 066	6 959 372
	Z1*	0	0	112 058	3 488 975	5 153 618	6 086 084
	H2*	12 135 047	6 022 205	2 979 965	5 100 810	6 035 898	6 722 972
	N1-1 (P2)**	19 995 299	11 047 841	7 359 629	13 577 927	14 302 152	15 751 294
	N4 (P1)**	958 694	507 614	2 738 650	9 468 332	11 541 987	11 805 449
	Total	105 725 755	50 253 654	33 255 855	62 179 135	90 377 638	120 938 498
Tessaout Amont	Total***	152 405 563	87 320 346	63 819 382	83 970 161	153 454 793	166 606 991
	Without easetern Haouz(estimation	53 341 947	30 562 121	22 336 784	29 389 556	53 709 178	58 312 447

* source: ORMVAH, Bilan Hassan I-Sidi Driss.xls

** source: ORMVAH, Bilan Takerkoust.xls

*** Traditional + Ameliorated (source : ABHT, restitutions_ORMVAH.xls)

Table 3.4.6 Estimated Groundwater Abstraction in the Haouz Plain Aquifer

Groundwater abstraction purposes	Agricultural campaign										
	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
Irrigation in GH sectors	48.8	32.5	23.4	36.6	40.0	48.4	48.3	122.5	128.2	82.4	45.3
Irrigation in PMH sectors	200.2	202.2	137.9	177.0	230.9	265.7	292.4	349.6	323.2	305.5	287.8
Marrakech drinking water supply	15.0	13.3	11.6	9.4	10.4	15.1	12.2	16.3	12.9	9.8	9.6
Other drinking water supply	7.2	7.4	7.4	7.4	7.5	7.6	8.2	8.0	7.9	8.1	8.3
Livestock drinking water supply	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Other (urban areas)	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.7	2.0	1.9	7.1
Total (MCM)	**273.3**	**257.3**	**182.1**	**232.3**	**290.8**	**338.7**	**363.0**	**499.0**	**475.0**	**408.5**	**358.9**

Table 3.5.1 SAU and Irrigable Area of the Study Area

(Unit: ha)

Area	Physical Area	SAU	Irrigation Area	Irrigation managed by ORMVAH			Irrigation managed by DPA		
				Large scale irrigation system (GH)	Small and medium irrigation system (PMH)		Regular water	Seasonal water	Flood water supply
					Improved Seguia	PMH			
ORMVAH	300,428	238,120	164,741	54,308	21,329	89,104			
N'Fis and Haouz Central[*1]	284,663	223,725	153,139	48,560	19,129	85,450			
Upper Tessaout	15,765	14,395	11,602	5,748	2,200	3,654			
DPA Marrakech	56,117	20,721	8,896				2,250	2,431	4,216
DPA Chichaoua	229,279	108,895	29,118				6,627	8,875	13,617
Total	886,251	605,856	367,497	54,308	21,329	89,104	8,876	11,306	17,833

Source: ORMVAH, DPA Marrakech, DPA Chicaoua

Note: ORMVAH GH including PNI Seguia area (10,000ha) of Tamezergueleft and Jdida

ORMVAH PMH including a part of the pump sectors (N5, Z1 aval, Z7、2,525ha) of GH Haouz Central

Table 3.5.2 SAU and Cultivated Area under ORMVAH

(Unit: ha)

Item	Source	N'Fis and Haouz Central Irrigation Sectors	Tessouat Amont Irrigation Sector	Total ORMVAH Area in the Haouz Plain
SAU and Irrigation Sectors				
-Total	a)	223,725	14,395	238,120
-Rain fed	a)	71,786	2,793	74,579
-Total potential irrigaiton area	a)	153,139	11,602	164,741
-GH sectors (incl. PNI)	a)	48,560	5,748	54,308
-PMH (improved seguia)	a)	19,129	2,200	21,329
-PMH potential irrigation area	a)	85,450	3,654	89,104
Cultivated Area of 2003/04				
-Total cultivated area	(1) a)	166,785	12,646	179,430
-Cultivated area in GH sectors (irrigated)	(2) b)	34,766		
-Cultivated area in PMH	(3)=(1)-(2)	132,019		
-irrigated	(4) c), a)	93,175		
-Rain fed	(3) - (4)	38,844		
-Total Irrigated Area		127,941	9,748	137,689
Remarks:		N1-1, N1-2, N2, N3, N4, ZR, H2, CV, R1, R3, Z1	Boudda, Skhirat	

Source

a) ORMVAH Monographie

b) Actualisation du PDAI

c) Estimation by Sudmed Data

PNI area is included in GH irrigation developed area.

Pump sectors of GH, that is N5, R1 Aval, and Z7 are included in PMH.

Table 3.5.3 Cultivation Area of the Study Area

(Unit : ha)

Area	Rainfed	Irrigated											Total
						Orchard						Irrigation area total	
	Cereals	Cereals	Legume	Forrage	Vegetable	Orchard Total	Olive	Apricot	Citrus	Grape	Others		
ORMVA (2003/04)	41,707	56,804	794	9,140	5,792	65,194	47,045	6,115	4,224	3,593	4,216	137,723	179,430
DPA Marrakech (Average of last 5 years)	10,157	5,892	93	264	432	2,215						8,896	19,053
DPA Chichaoua (2005/06)	36,145	17,353	446	563	828	9,929	5,998	873	0	0	3,058	29,118	65,263
Total	88,008	80,050	1,332	9,967	7,052	77,338	53,043	6,988	4,224	3,593	7,274	175,738	263,747

Remarks: Rainfed area is assumed to be used only for cereal cultivation.
Source: ORMVAH, DPA Marrakech, DPA Chicaoua

Table 3.5.4 Crop Water Requirement used by ORMVAH in the Haouz Plain (RAZOKI, 2001)

Type of crops	Crop	Crop Water Requirement (m3/ha)
Orchard	Olive	6,750
	Citrus fruits	10,500
	Apple	6,000
	Apricot	5,250
	Almond	5,250
	Grape	3,000
Annual crops	Wheat	5,250
	Barley	4,500
	Mais	7,200
	Alfalfa	12,800

Source: Apport de la télédétection pour l'estimation des volumes d'eau pompés au niveau de la plaine du Haouz, Abourida Aahd et al
Remarks: The Crop Water requirement shown in the table indicates the gross value including the application efficiency of irrigation.

Table 3.5.5 Net Water Requirement in the Study Area

Area	Irrigation Area (ha)	Crop						Water Requirement
		Cereals	Legume	Forage	Vegetable	Olive	Other Orchard	
Net Crop Water Requirement (m^3/ha/year)		5,250	3,000	7,200	7,500	6,750	10,500	
Gross Crop Water Requirement (m^3/ha/year)		7,000	4,000	9,600	10,000	9,000	14,000	
ORMVA	137,689	41%	1%	7%	4%	34%	13%	1,224
Large Scale (GH) in N'Fis & Haouz Central Sectors	34,766	37%	0%	5%	5%	34%	19%	323
Small and Medium (PMH) in N'Fis & Haouz Central Sectors	93,175	42%	1%	7%	4%	34%	12%	821
GH & PMH in Lower Tessaout Sector	9,748	51%	0%	9%	6%	33%	2%	80
DPA Marrakech	8,896	66%	1%	3%	5%	12%	12%	74
Regular Water	2,250	0%	3%	9%	14%	37%	37%	24
Seasonal Water + Flood Water Supply	6,647	89%	0%	1%	2%	4%	4%	49
DPA Chichaoua	29,118	60%	2%	2%	3%	21%	13%	246
Regular Water	6,627	0%	4%	5%	7%	51%	33%	70
Seasonal Water + Flood Water Supply	22,492	77%	1%	1%	2%	12%	8%	176
Total	**175,704**							**1,544**

Water Requirement in m3/ha/year 8,790

Table 3.5.6 Estimated ETR (Real Evapotranspilation) in the Irrigated Area

Sectors	Area (ha)	Unit water consumtion (m^3/ha)	ETR (Mm^3)
N'Fis GH Sector			
N'Fis Right Bank	18,406	5,666	104
N'Fis Left Bank	5,350	5,364	29
Haouz Central GH Sectors			
H2	3,276	5,666	19
CV	1,277	5,666	7
R1	2,635	5,666	15
R3, Z1	3,181	5,666	18
GH Pump Sectors			
N5	1,400	5,929	8
R1 Aval	500	5,800	3
Z7	850	6,000	5
Upper Tessaout GH Sector			
Part of Bouida and Skirit	7,900	5,531	44
PMH Sectors			
PMH (Groundwater)	82,700	5,850	484
PMH (Surface water)	48,175	4,641	224
Total	175,650	5,460	959

Source: Sudmed project, arranged by the Study Team

Table 3.5.7 Evaluation of Irrigation Water Supply in the Study Area

Items	Unit	Value	Conveyence Efficiency	Value at the head of parcel
Amount of Irrigation Water Supply	Mm^3/year	879		757
Dam water	Mm^3/year	133	0.9	117
River water taken by Seguias	Mm^3/year	201	0.5	103
Supplied by Rocade Canal	Mm^3/year	67	0.9	59
Groundwater GH	Mm^3/year	118	1.0	118
Groundwater PMH	Mm^3/year	360	1.0	360
Water Supply by Rain	Mm^3/year			501
Basin Average Rainfall of Haouz Plain (2003/04)	mm/year	317		
Effective Rainfall	mm/year			285
Total Water Supply to Crops	Mm^3/year			1,258
Irrigation Water Supply per hector	m^3/ha/year			7,160
Estimated Irrigation Water Demand	m^3/ha/year			8,790
Deficit Ratio				18.4%

Table 3.5.8 Distribution Efficiency of GH Sectors in Haouz Central

CMV	Sector	Year			
		01/02	02/03	03/04	04/05
407	R1	0.93	0.89	0.92	0.90
422	R3	0.92	0.88	0.94	0.92
425	Z1	NA	NA	NA	NA
427	H2	0.93	0.92	0.93	0.95
430	N1-1, N1-4 Partial	0.83	0.82	0.86	0.87
432 + 434	CV	0.87	0.85	0.86	0.90
	N1-2, N1-3, N2, N3	0.74	0.78	0.81	0.82
	N1-4 Partial	NA	NA	NA	NA
431	N4	NA	0.92	0.93	0.86

Source: Ressources en Eau pour L'Irrigation des Perimetres de la Grande Hydraulique du haouz de Marrakech, ABHT

Table 3.5.9 Situation of Spread of Drip Irrigation in ORMVAH Area

CMV	Physical Area (ha) *1	SAU (ha) *1	Irrgable Area (ha) *1	Drip Irrigation Equiped Area (ha) *2	Ratio of Drip Irrigation to Irrigable Area	Dirp Irrigation Equiped Area *2		
						Out of GH Command Area (ha)	Within GH Command Area (ha)	Unknown (ha)
Within Tensift Basin								
406	24,275	22,995	14,131	-	-	-	-	-
407	23,895	22,425	9,550	690	7.2%	307	383	
408	15,120	14,164	5,003	146	2.9%	50	96	
422	43,125	38,004	22,680	989	4.4%	836	113	40
425	21,100	15,900	15,200	209	1.4%	165	44	
426	25,100	22,300	16,400	1,133	6.9%	1,133		
427	42,925	20,800	14,300	1,323	9.3%			1,323
429	55,200	19,680	8,575	175	2.0%	175		
430	20,700	15,650	6,250	321	5.1%	192	129	
431	41,000	29,750	21,300	1,330	6.2%	757	573	
432	30,200	26,700	24,200	1,640	6.8%			1,640
434	29,925	24,580	22,580	1,689	7.5%	816	874	
Subtotal	372,565	272,948	180,169	9,644	5.4%			
Out of Tensift Basin	275,829	216,616	97,576	765	0.8%	593	172	-
Total	648,394	489,564	277,745	10,536	3.8%	5,120	2,412	3,004

Source *1: Monographie de lacommune rurarale, Data of 2004/2004
*2: ORMVAH, Data of July 2006

Table 3.5.10 Application of Drip Irrigation System in a Sample CMV

Sample of CMV 427 SA Ghiat	
Surface Area (ha)	42,925
SAU (ha)	20,800
Irrigable Area (ha)	14,300
As of October 2006	

Crops	Area (ha)		Farmland (unit)	
Orchard				
-Olive	495.7	37%	30	39%
-Orange	337.0	25%	20	26%
-Apricot	163.5	12%	13	17%
-Grape	18.0	1%	3	4%
Subtotal of Orchard	1,014.2	77%		
Annual Crop				
-Flower	7.0	0.5%	1	1%
-Vegetables	296.5	22%	38	50%
-Forage Mais	6.0	0.5%	2	3%
Annual Crop Subtotal	309.5	23%		
Grand Total	1,323.7	100%	76	

Source: ORMVAH

Table 3.6.1 Constraints on the Long-term Development Program

Category	Problems
Ensure better governance of the water sector	• The complex organization of the sector does not encourage a clear, optimal shared strategy • Sector policy objectives are too ambitious when compared to the financial means available • There is a lack of consolidation mechanisms in the water budget as well as a lack of coherent resources allocation for sector priorities • River basin agency mission areas are too vast for their financial resources • Insufficient means and other difficulties have slowed the implementation of the 10-95 Water Law • There is a growing shortage of resources and a growing demand for water
Ensure that the population and economic sector's water demands are met in a sustainable manner	• Rural water supply from few groundwater resources results in high infrastructure costs • Perennial/long-term uncertainty of rural water supply autonomous management • All water flows are polluted by urban and industrial wastes • Legislation and standards for wastewater discharge are incomplete • High infrastructure costs related water treatment. Costs are high both for investment and operation • Lack of economic incentives for pollution control, and inadequate tariffs for subsector self-financing • Untreated industrial wastes • Little wastewater treatment operational know-how
Improve operators' performance to assure sustainable infrastructure and service quality	• Insufficient coordination in investment programming • ORMVA institutional framework does not encourage efficient management and sustainable irrigation system • The water irrigation system and prices levels do not encourage water economy and autonomy of water services • Absence of regulation system and homogeneous monitoring of operators • Poorly adapted structures and level of pricing mechanisms • Uneven management and operational capacities • Weak management autonomy of public operators • Gap between self-financing capacities and investment needs • Technical and financing obstacles to servings poor urban and peri-urban neighborhoods • Little financing available to support the extension of water supply in disadvantaged area • Sustained rural migration towards cities • Insufficient implementation of coherent priorities in the supply and urban development sectors

Source: World Bank, the Country Assistance Strategy for Morocco in 2005

Table 3.6.2 Number of Surveyees

Province	Marrakech		Al Haouz		El Kelaâ Sraghna	Chichaoua
Category of Area	ORMVAH	DPA/M	ORMVAH	DPA/M	ORMVAH	DPA/C
Surveys to AUEA	5	1	4	5	10	3
TOTAL AUEA	6		9		10	3
Surveys to farmers						
over 20 ha	3		1	1	2	2
10ha-20ha	2	1	1	1	1	1
5ha-10ha	5	1	2	3	7	1
below 5ha	5		1	5	7	3
Unanswered					2	
TOTAL farmers	15	2	5	10	19	7
TOTAL Survey	23		24		29	10

Table 3.8.1 Preliminary Groundwater Balance Estimate

	Agricultural campaign										
	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
Inflow											
Direct rain	*71*	*75*	*110*	*94*	*73*	*62*	*55*	*38*	*53*	*64*	*74*
Flood (oueds and seguias)	*223*	*87*	*385*	*150*	*143*	*69*	*174*	*19*	*52*	*69*	*120*
Lateral inflow	*216*	*216*	*216*	*216*	*216*	*216*	*228*	*240*	*240*	*240*	*240*
Reserve release	-	-	-	-	-	-	-	*207*	*135*	*40*	-
Total inflow	510	378	711	459	432	347	457	504	480	413	433
Outflow											
Drainage to oueds	*232*	*115*	*524*	*222*	*137*	*3*	*89*	-	-	-	-
Lateral outflow	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
Abstraction	*273*	*257*	*182*	*232*	*291*	*339*	*363*	*499*	*475*	*408*	*359*
Reserve filling	-	-	-	-	-	-	-	-	-	-	*69*
Total outflow	510	378	711	459	432	347	457	504	480	413	433

Table 3.8.2 Surface Water Resources of Tensift Basin

River basin	Name of river	Effective area of basin (km^2)	Contribution to water demand (Mm^3)					
			Data of 1935-1997[*1]			Data of 1970-2002[*2]		
			Min.	Average	Max.	Min.	Average	Max.
Tensift	Upstream from the Conjunction of Chichaoua River							
	N'Fis at Lalla Takerkoust	1,692	21	166	599	12.7	174.8	504.5
	R'dat at Sidi Rahal	569	12	84.5	277	3.5	72.8	264.0
	Zat at Tafriat	516	20	115	288	16.8	103.9	278.7
	Ourika at Aghbalou	503	15	159	618	14.5	155.8	618.5
	Rheraya at Tahanaout	225	13	53.5	123	2.6	47.8	117.1
	Lahr at Herissane	65	1	10	24	0.3	9.9	25.8
	El Mal at Sidi Bou Othman	517	11	54	152	0.8	35.9	113.0
	Chichaoua	1,317	12	73	252	10.9	66.8	230.6
	Transfer from Oum Er Rbia	-	160	300	300	160.0	300.0	300.0
	Total Upstream from the Conjunction of Chichaoua River							
	Without transfer	5404	105	715	2,333	62	668	2,152
	With transfer	-	265	1,015	2,633	222	968	2,452
	Downstream from the Conjunction of Chichaoua River							
	El Hallouf	185	0	1.5	5	0.0	1.4	4.6
	Mramer	150	0	2	5	0.0	1.8	4.6
	Other effective basins	2,241	10	92	294	9.2	84.2	269.1
	Other semi-effective basins	1,396	1	14	40	0.9	12.8	36.6
Total Tensift	Without transfer	9,376	646	2,855	7,943	72	768	2,467
	With transfer	-	646	2,855	7,943	232	1,068	2,767

Remarks: *1: Plan directeur pour le develppement des ressources en eau des bassins du tensift, 2001

*2: Actualisation de l'etat de connaissance des ressources en eau dans les bassins hydrauliques du tensift, 2004

Table 3.8.3 Present Use of Surface Water Resources

(Mm^3)

River	Source	Dam	Rivers	Transfer	Remarks
N'Fis	Lalla Takerkoust Dam	92.4[*2]			Average of 93/94-03/04
R'dat	Seguias		47.8		Average of 93/94-03/04
Zat	Seguias		36.9		Average of 93/94-03/04
Ourika	Seguias		69.1		Average of 93/94-03/04
Rheraya	Seguias		18.8		Average of 93/94-03/04
Lahr	Seguias		5.4		Estimated[*1]
El Mal	Seguias		14.1		Estimated[*1]
Chichaoua	Seguias		14.7		Estimated[*1]
Transfer from Oum Er Rbia Basin	Rocade Canal			101.1	Average of 93/94-03/04
Total		299		101	
Total of Surface Water without Tranfer		299			
Total of Surface Water with Tranfer		400			

Remarks

*1: Estimated by applying the average water withdrawal rate in the R'dat to Lahr river. Average of 93/94-03/04

*2: The value includes the water distributed by dam and a water taken by seguia systems in the downstream of the river.

Table 3.8.4 Estimation of Water Intake Demand: Water Supply

Estimation of Water Intake Demand : Water Supply

Communes/Items	2003	2004	2005	2010	2015	2020
Marrakech : RADEEMA						
Population (x 1,000)	821.69	840.18	859.51	963.00	1,071.58	1,160.09
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	26.23	28.23	29.16	33.59	39.84	43.69
Domestic : Public Taps	0.48	0.38	0.45	0.47	0.18	0.13
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	4.97	4.01	4.09	7.03	7.82	8.49
Industries	1.01	1.54	0.89	3.51	3.91	4.25
Others	-	-	-	-	-	-
Total	32.70	34.17	34.59	44.60	51.75	56.56
Annual Average Water Production (M. m3/year)	49.47	52.01	56.12	61.95	69.11	73.64
Annual Average Water Intake (M. m3/year)	51.94	54.61	58.93	65.05	72.56	77.32
Estimated Leakage Ratio (%)	34%	34%	38%	28%	25%	23%
11 Communes : ONEP						
Population (x 1,000)	91.5	94.9	97.6	112.4	127.4	144.4
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	1.24	1.35	1.64	1.99	2.36	2.78
Domestic : Public Taps	0.03	0.03	0.06	0.04	0.03	0.01
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	0.23	0.20	0.26	0.30	0.34	0.38
Industries	0.07	0.06	0.10	0.12	0.14	0.16
Others	0.04	0.03	0.04	0.04	0.04	0.05
Total	1.62	1.68	2.10	2.49	2.91	3.38
Annual Average Water Production (M. m3/year)	2.60	2.71	3.30	3.59	3.89	4.45
Annual Average Water Intake (M. m3/year)	2.73	2.85	3.46	3.77	4.09	4.67
Estimated Leakage Ratio (%)	38%	38%	36%	31%	25%	24%
Rural Area : Communes without ONEP Water Supply						
Population (x 1,000)	612.2	615.9	619.6	638.4	657.8	677.8
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	10.96	11.50	12.04	14.37	14.97	15.69
Domestic : Public Taps	-	-	-	-	-	-
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	-	-	-	-	-	-
Industries	-	-	-	-	-	-
Others	-	-	-	-	-	-
Total	10.96	11.50	12.04	14.37	14.97	15.69
Annual Average Water Production (M. m3/year)	12.17	12.77	13.38	15.97	16.64	17.43
Annual Average Water Intake (M. m3/year)	12.82	13.45	14.08	16.81	17.51	18.35
Estimated Leakage Ratio (%)	10%	10%	10%	10%	10%	10%
Grand Total : Study Area (Groundwater Simulation Area)						
Population (x 1,000)	1,525.4	1,551.0	1,576.7	1,713.8	1,856.7	1,982.3
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	38.43	41.08	42.85	49.95	57.17	62.16
Domestic : Public Taps	0.51	0.41	0.51	0.52	0.20	0.14
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	5.20	4.21	4.34	7.33	8.16	8.87
Industries	1.09	1.61	1.00	3.64	4.05	4.40
Others	0.04	0.03	0.04	0.04	0.04	0.05
Total	45.27	47.35	48.73	61.47	69.63	75.62

Table 3.8.5 Current Water Intake Permission Obtained for Water Use by Golf Course

Name of the Golf course	Area (ha)	Permitted Water Intake Quantity (Mm^3/year)		
		Rocade Canal	Groundwater	Total
ASSOUFID	220	1.0	0.22	1.22
PALM Golf sur	170	1.0	0.2	1.20
ATLAS GOLF ET RESORT	282	1.0	0.5	1.50
Total	672	3.0	0.92	3.92

Source: ABHT

Table 3.8.6 Water Intake Quantity Requested by the Golf Course Projects

Name of the Golf course	Area (ha)	Permitted Water Intake Quantity (Mm^3/year)		
		Rocade Canal	Groundwater	Total
LATSIS GROUP	140			1.5
JARDINS DE L' ATLAS	148			1.65
DOMAINE ROYAL PALM	250			1.5
TRITEL	220	1.5	0.5	2.0
STRATEGIC PARTNERS	NA	1.0	0.2	1.2
	628+	2.5+	0.7+	7.85

Source: ABHT

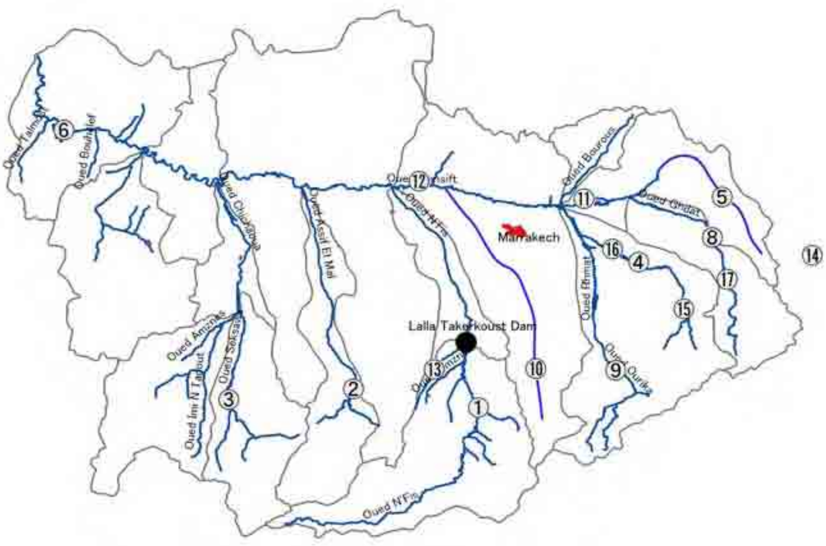
Table 3.8.7 Water Supply and Use of Study Area

(Unit : Mm^3)

	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	Average	Source
Supply	**1068**	**857**	**978**	**944**	**986**	**939**	**1012**	**935**	**878**	**853**	**918**	**942**	
Dam water of Lalla Takerkoust Dam	174.0	131.2	248.6	215.0	183.9	94.6	127.6	49.3	52.5	93.7	110.5	134.6	Table 3.3.5
River water taken by Seguias	333.3	183.5	358.1	273.6	233.6	200.3	194.4	60.8	84.5	91.4	202.5	201.5	Table 3.3.7
Transferred from Oum El Rbia Basin by Rocade Canal	112.1	115.6	98.2	106.3	115.8	115.9	126.4	74.5	56.7	82.1	108.6	101.1	Table 3.3.4
Groundwater abstraction	448.8	427.1	273.7	349.2	452.6	527.7	563.5	749.9	683.8	585.5	496.7	505.3	Table 3.5.6
Use	**1068**	**857**	**978**	**944**	**986**	**939**	**1012**	**935**	**878**	**853**	**918**	**942**	①
Irrigation	1007.9	798.0	919.3	883.6	926.6	875.7	945.5	869.9	813.6	785.2	849.7	879.5	①−②−③
Water Supply	52.0	51.1	50.9	52.2	51.0	54.5	58.1	56.5	55.7	59.1	60.3	54.7	② Table 3.5.6
Others (Urban)	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.2	8.3	8.3	8.3	③ Table 3.5.6

Table 3.8.8 Present Status of Dam Sites in and Around the Haouz Plain

Name of Dam and Rivers	Storage Volume / Regulating Volume (Mm^3)	Proposed service year in MP	Present Status	Remarks
Dams Proposed in the Master Plan for Development of Water Resources in Tensift Basin				
Wirgane- N'fis	72.0 / 17.0	2007	Under construction	The beginning of 2008 is scheduled to be completed.
Taskourt- El Mar	25. / 24.00	2006	Scheduled	The construction is scheduled to start at the beginning of 2007.
Boulaouane- Selasaoua	10.0 / 14.0	2010		No information
Ait Ziat- Zat	395 / 123.5	2009	Not decided	Large scale socio-economic impact was pointed out in the detailed study.
Herissane- Lahr	19.0 / 8.0	2011	Under the detailed study	Possibility of problem of water quality is pointed out. The affect of water quality is under studying.
Talmest- Tensift	250.0 / 66.0	2012	Rejected	Due to geological problem and leakage.
Ait Segmine- Rhzef	110.0 /	2008	Not scheduled	The detailed has not yet conducted. A large cost of compensation for socio-economic impact is pointed in the preliminary study.
Other Possible Dam Sites				
Imizer- R'dat	150.0 / 82.0		Rejected	Due to water quality of the R'dat River.
Timalizene- Ourika	110 / 102.5		Rejected	Due to large scale socio-economic impact.
Moulay Brahim- Rheraya	36.4 / 27.0		Rejected	Due to the technical reason of Stalinization.
Oulad Mansour- Tensift	131.0 / 23.0		Not scheduled	Large scale socio-economic impact was pointed out in the study.
Sidi Bouidel- Tensift	39.0 / 35.0		Rejected	Due to technical problem of leakage.
Amezmiz- Anougal	11.0 / 2.0		Not scheduled	The detailed study has been done.
Tiyoughza- Tessaout	121.0 / 53.0		Not decided	The detailed study is planned to be carried out.
Tinzzilliyt- Zat	123.0 /		Not decided	The detailed study has not yet done.
Guers- Zat	93.7 /		Rejected	No schedule for the detailed study.
Oumar- R'dat			Rejected	No schedule for the detailed study.



Source: DAH

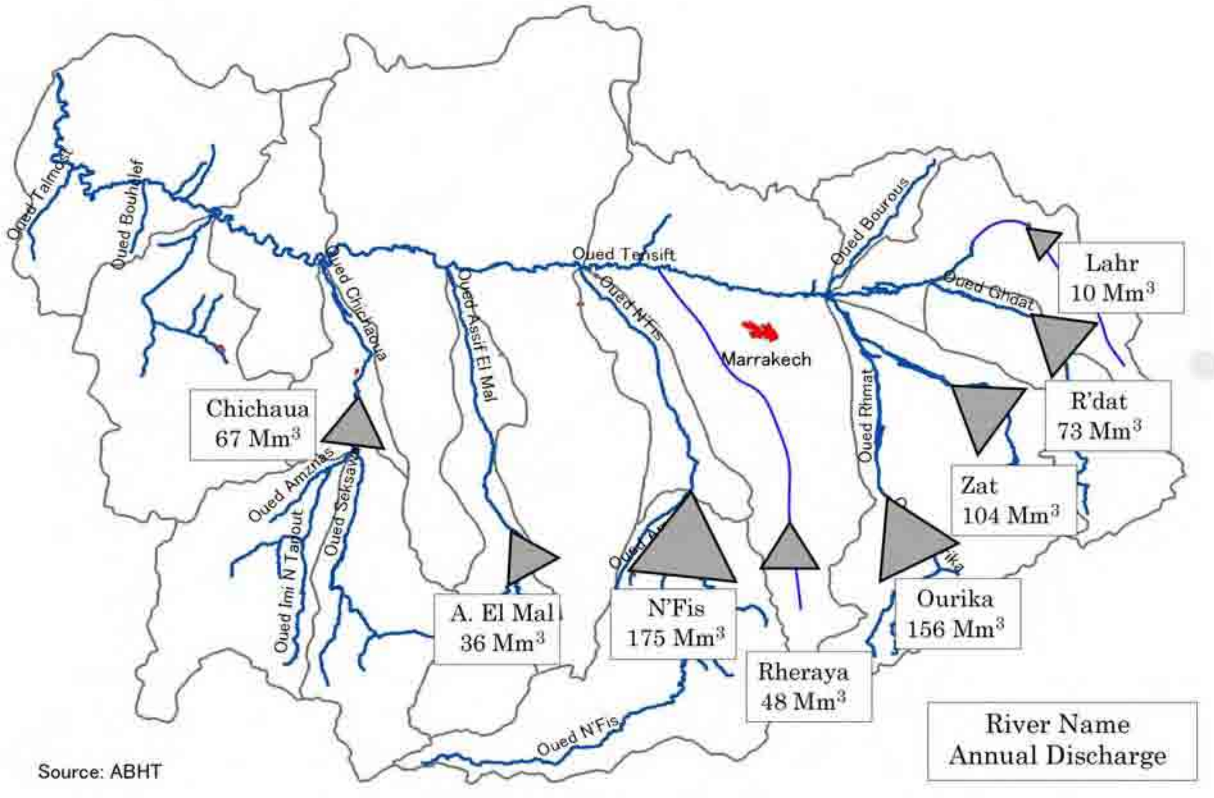
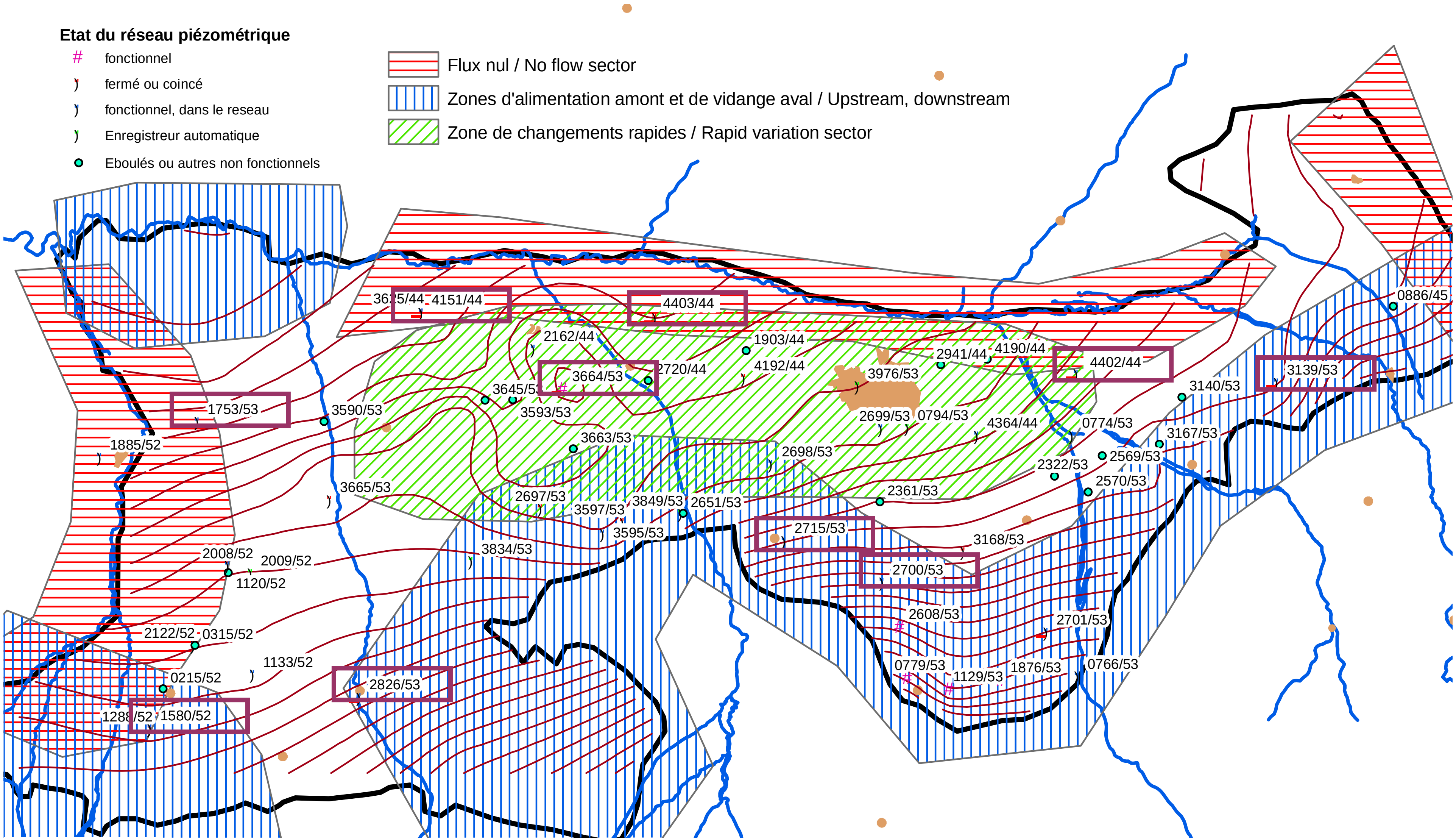
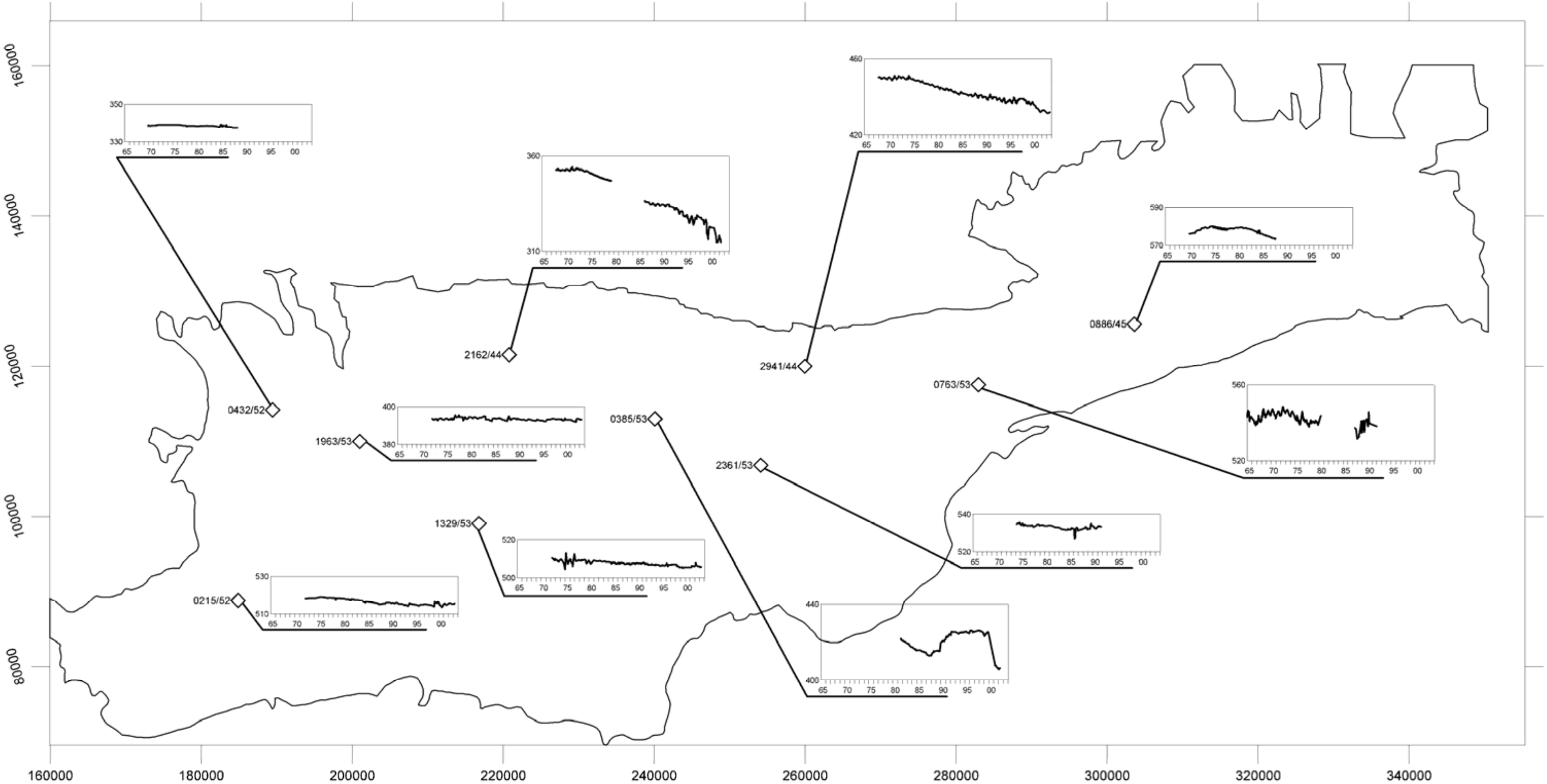


Figure 3.2.1 Outflow from Major Rivers (Average of 1970-2002)



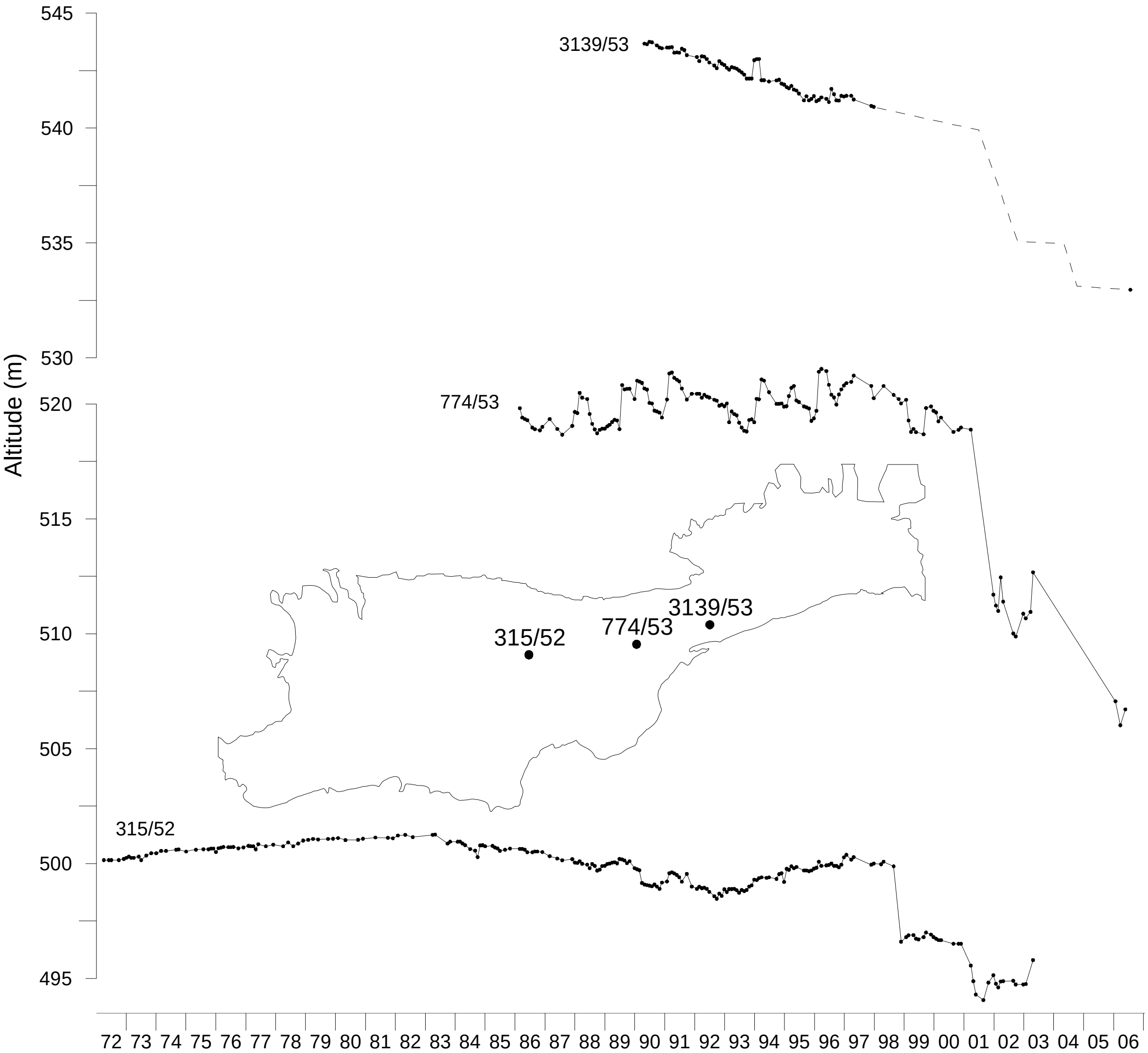
Source: ABHT

Figure 3.3.1 Location of Observation Wells of Which Automated Gauges are to be Installed



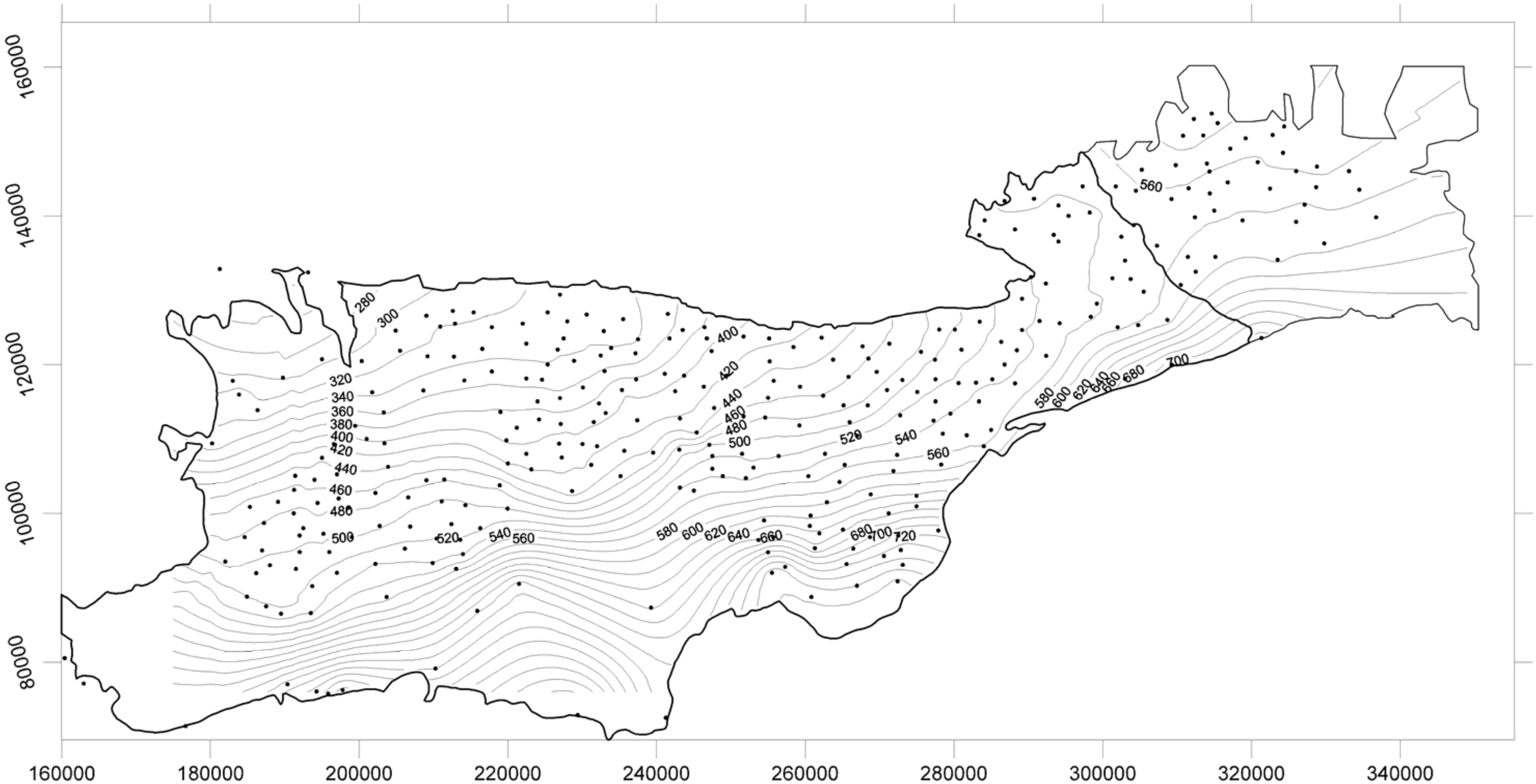
Source: ABHT

Figure 3.3.2 Piezometric changes in some places of the Haouz aquifer



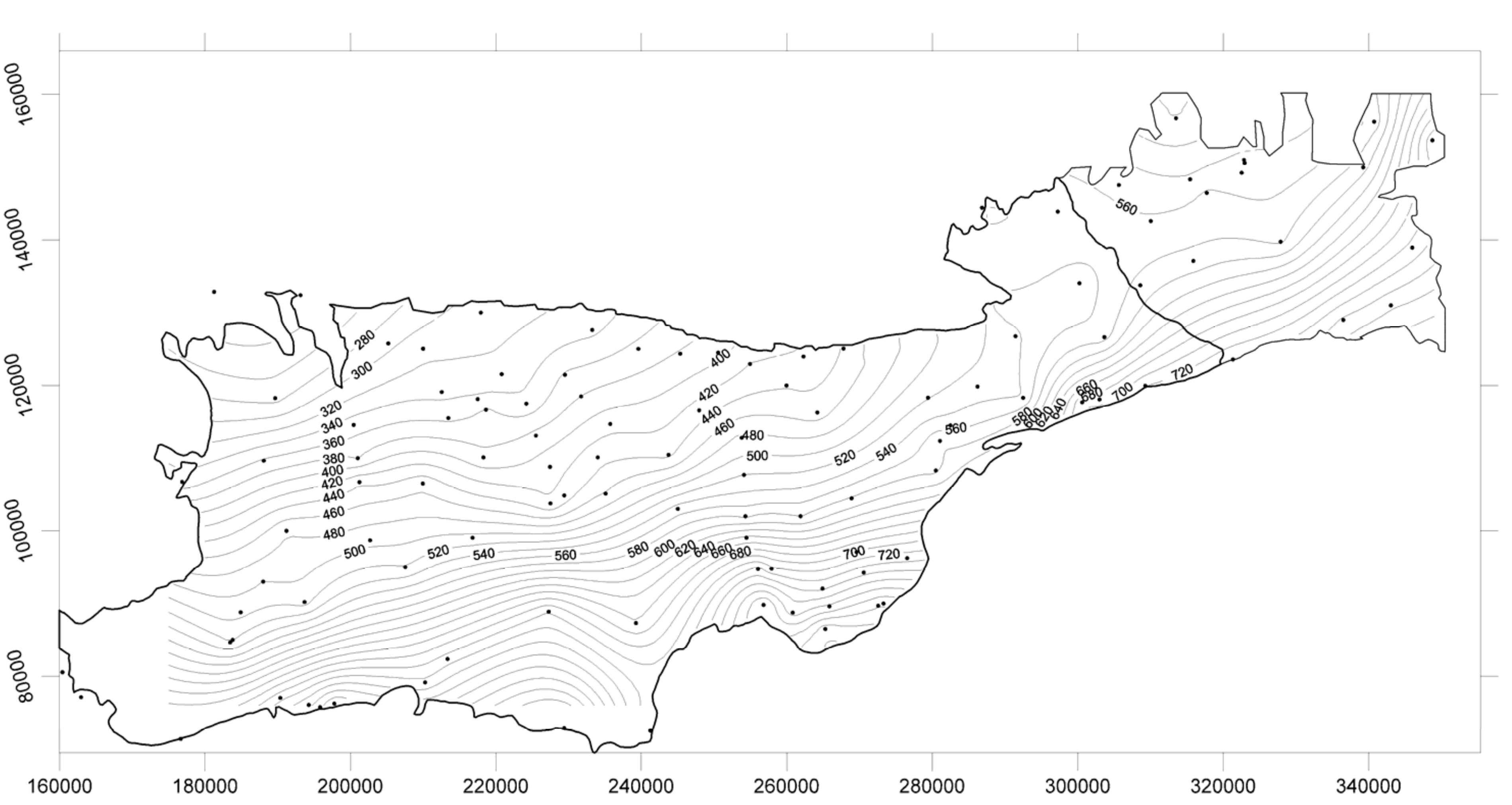
Source: ABHT

Figure 3.3.3 Piezometric Changes in Central Haouz



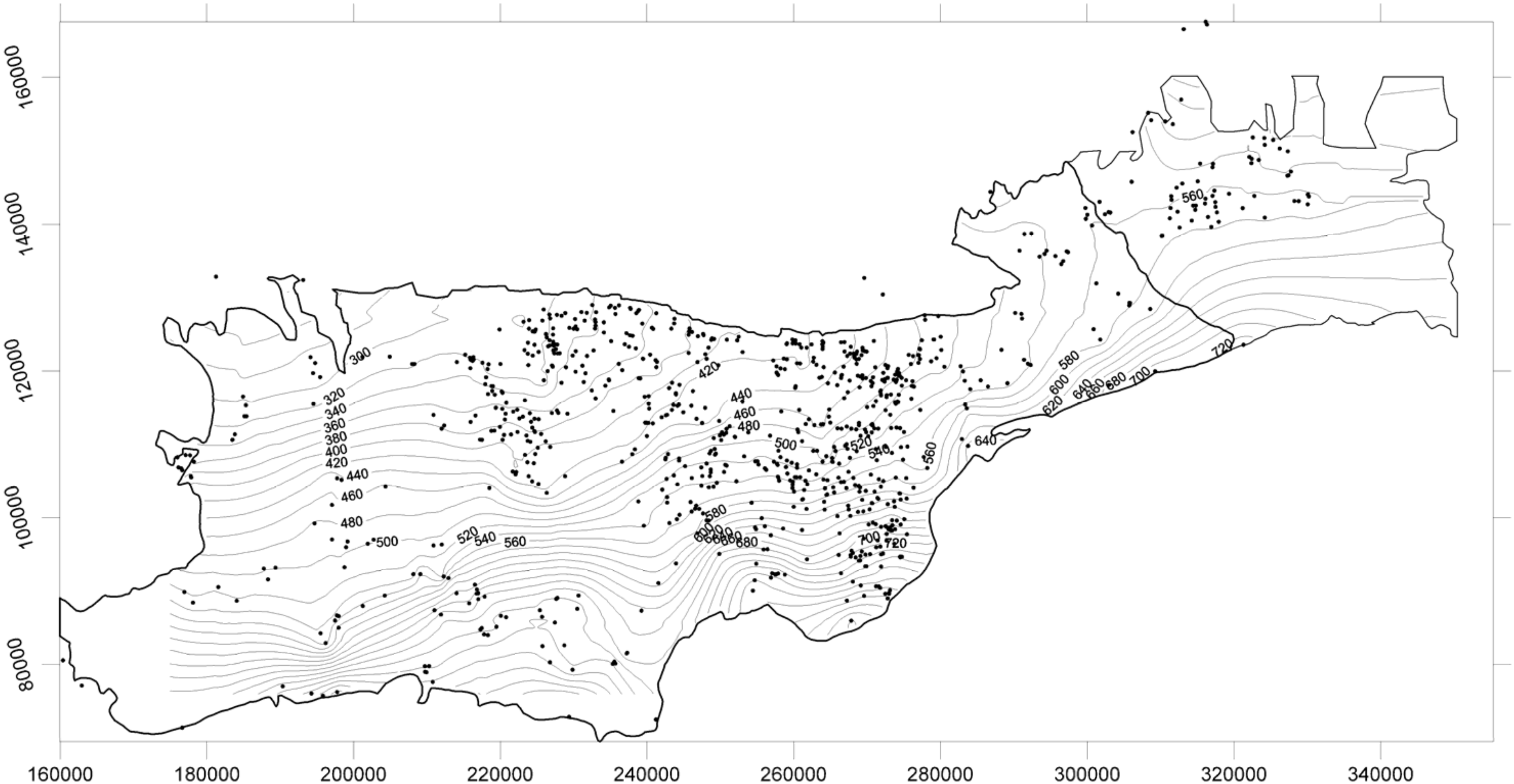
Source: ABHT

Figure 3.3.4 Piezometric map of the Haouz aquifer - 1986



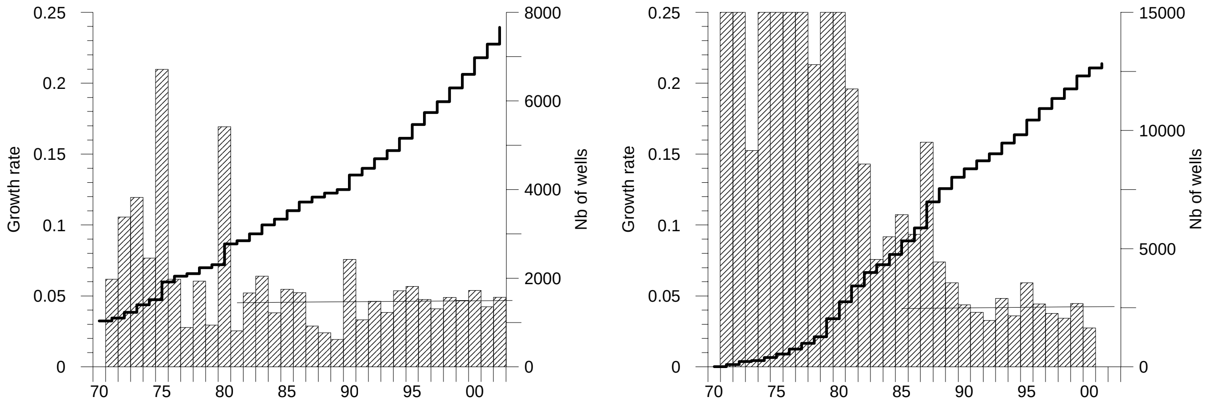
Source: ABHT

Figure 3.3.5   Piezometric map of the Haouz aquifer - 1998



Source: ABHT

Figure 3.3.6 Piezometric map of the Haouz aquifer - 2002



(

(a) Number of wells per year of drilling from the inventory conducted over 22 rural commune

(b) Number of wells per year of authorisation from the ABHT drilling request database

Source: ABHT

Figure 3.4.1   Growth of the Number of Wells per Construction Date

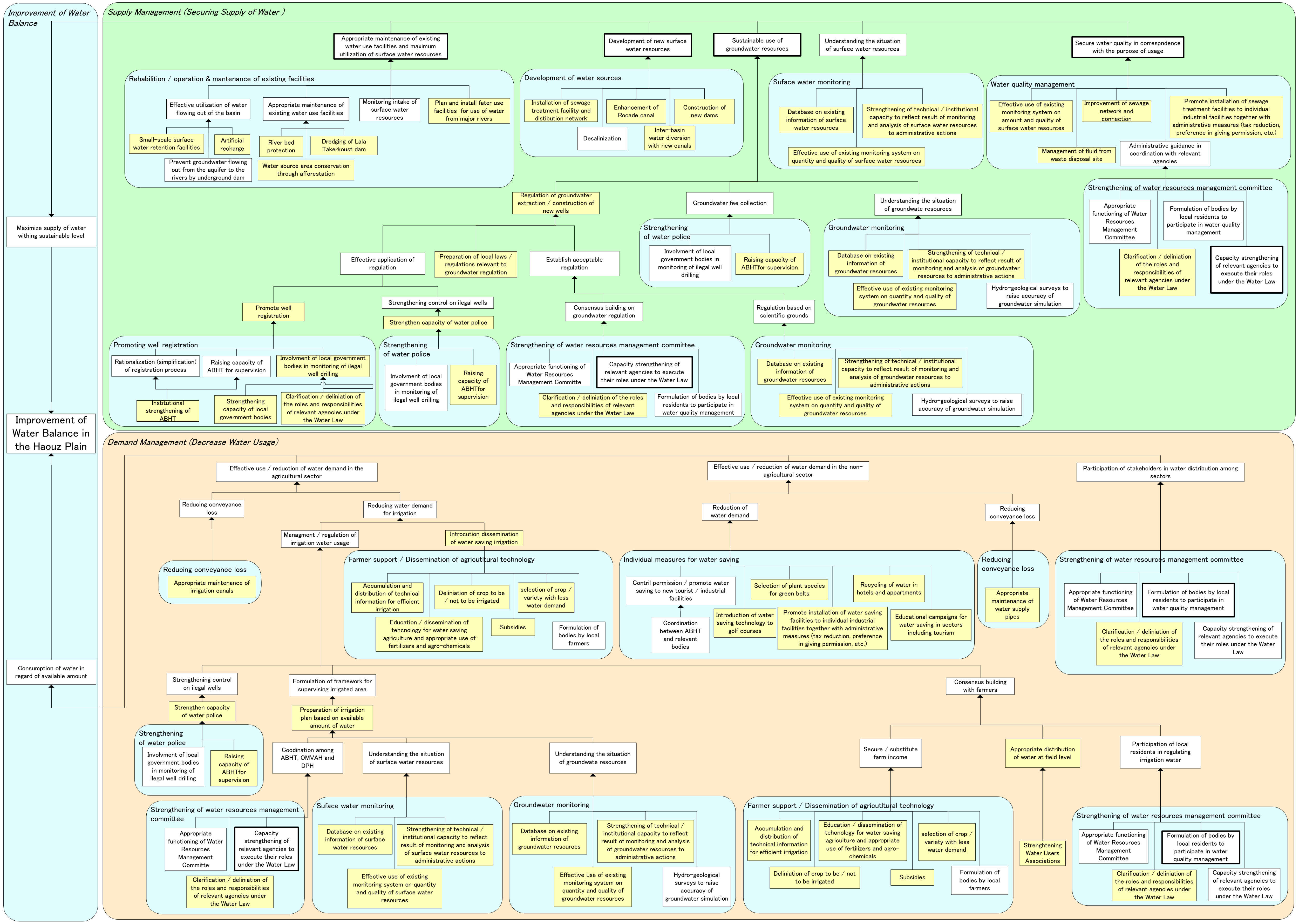
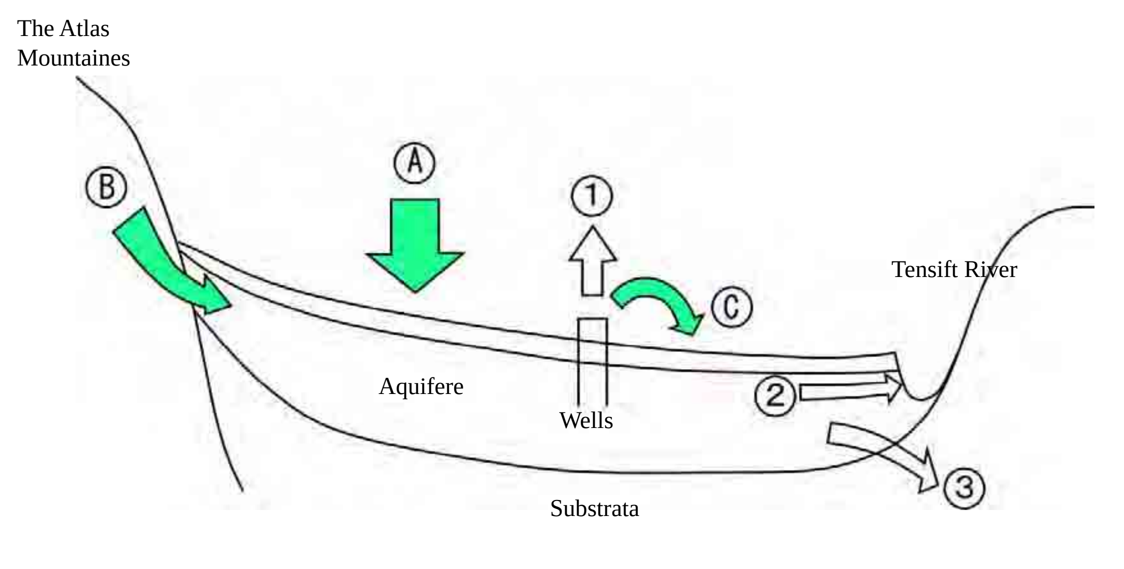


Figure 3.6.1 Problem Structure on Water Resources of Haouz Plain



Outflow of Groundwater	①	Extraction through Wells :	509 Mm^3/Year
	②	Outflow through Rivers & Seguias :	186 Mm^3/ Year
	③	Others (Outflow to lower aquifers) :	9 Mm^3/ Year
	Total OUtflow		704 Mm^3/ Year
Inflow into the Aquifer	Ⓐ	Infiltration from Precipitation :	262 Mm^3/ Year
	Ⓑ	Onflow from the aquifers of Mount Atlas, etc. :	
	Ⓒ	Excess Irrigation Water : 509-346=	163 Mm^3/ Year
	Total Inflow		425 Mm^3/ Year

Figure 3.8.1 Groundwater Balance Indicated in the Simulation Model of 2000/2001

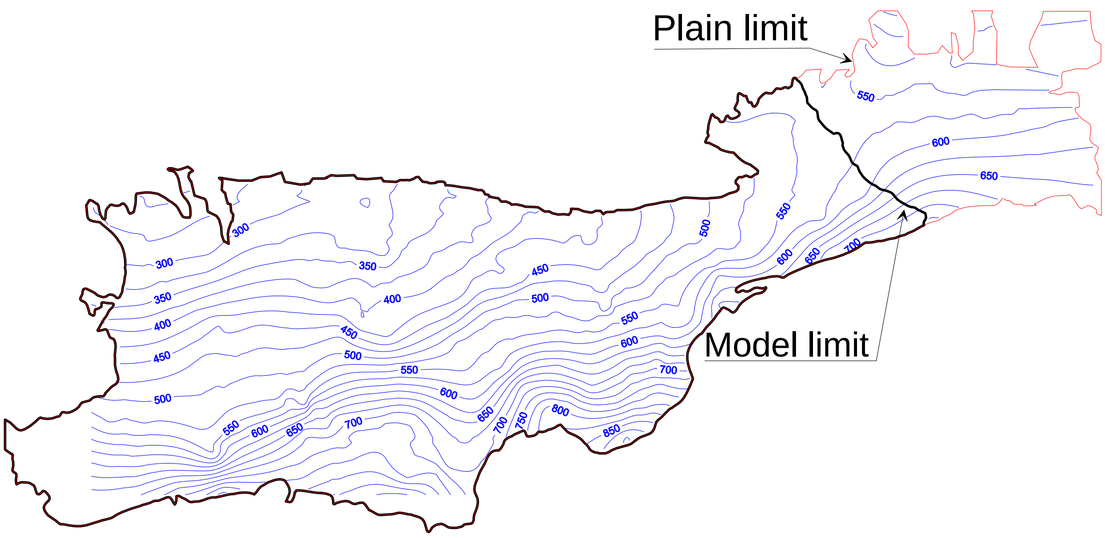


Figure 3.8.2 Piezometric Map within the Model Limit (2002)

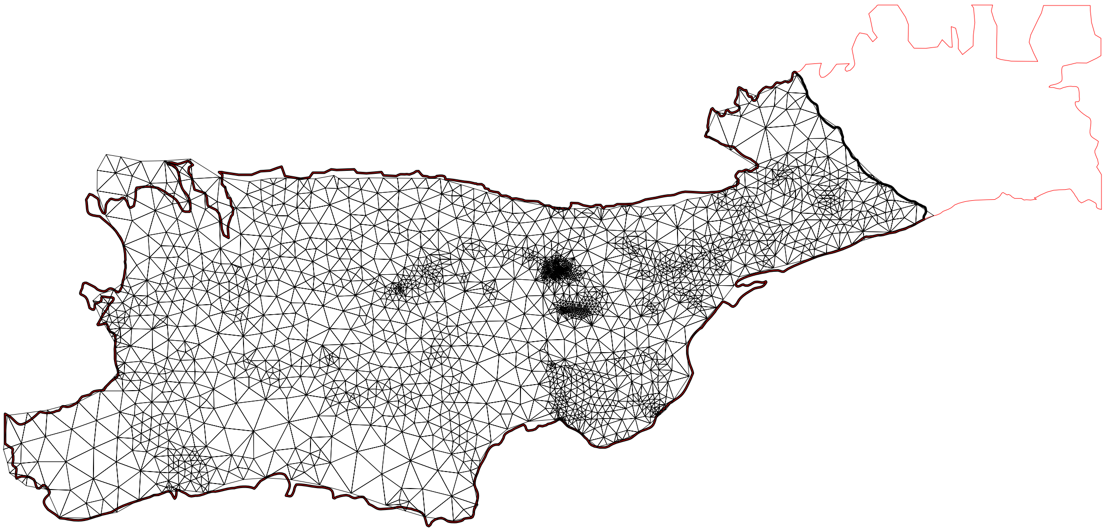


Figure 3.8.3 Model's Mesh

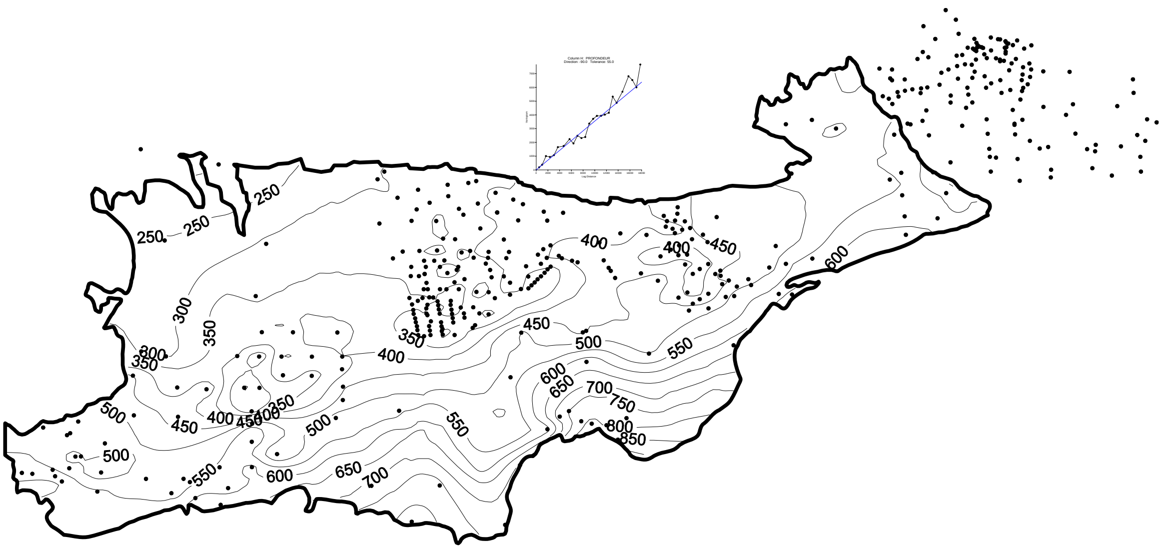


Figure 3.8.4 Substratum Map

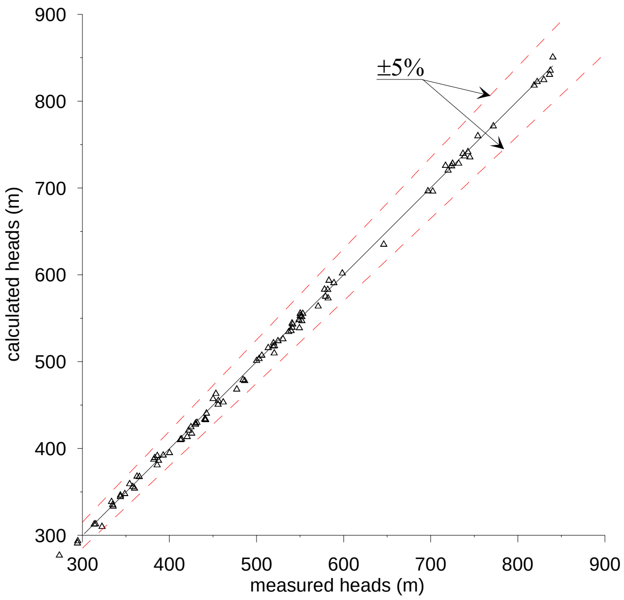


Figure 3.8.5 Measured Heads Versus Calculated Heads for Steady State Model（1997/98）

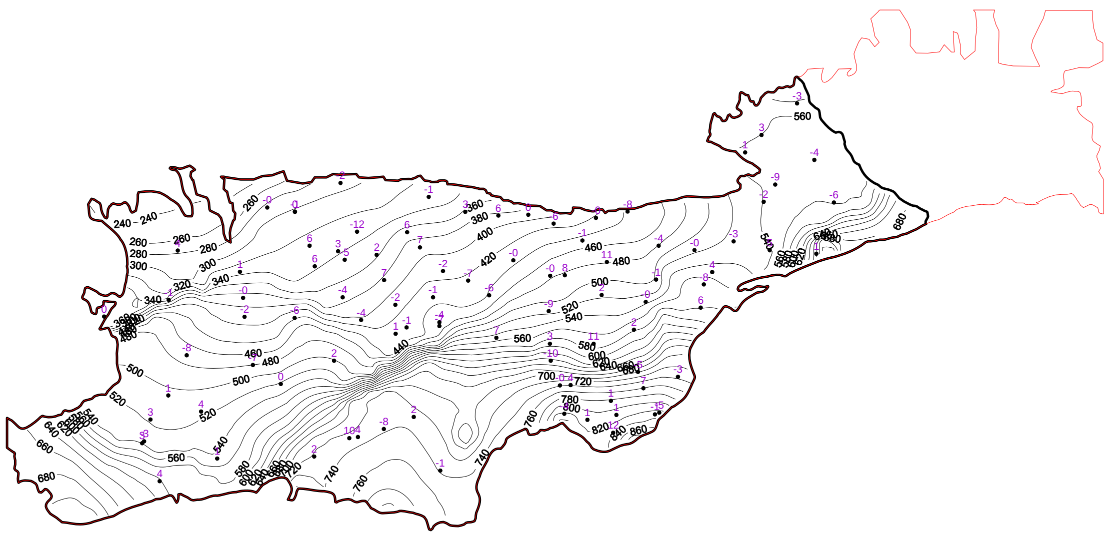


Figure3.8.6 Calculated Piezometric Map for Reference Situation (and Reference Points, with Indication of Difference between Measured and Calculated Hydraulic Head, in Meters)

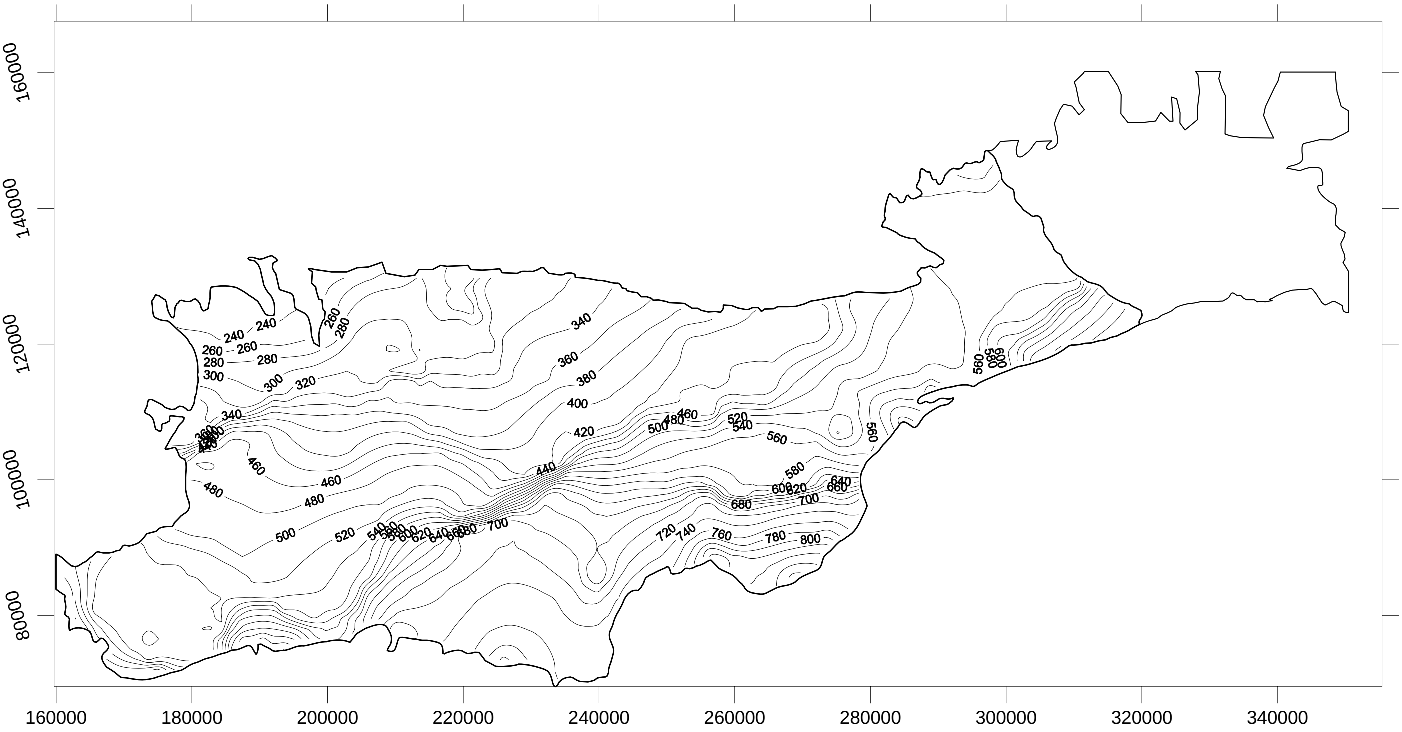


Figure 3.9.1 Piezometric Map in the Haouz Plain as of 2020 – Continuation Scenario

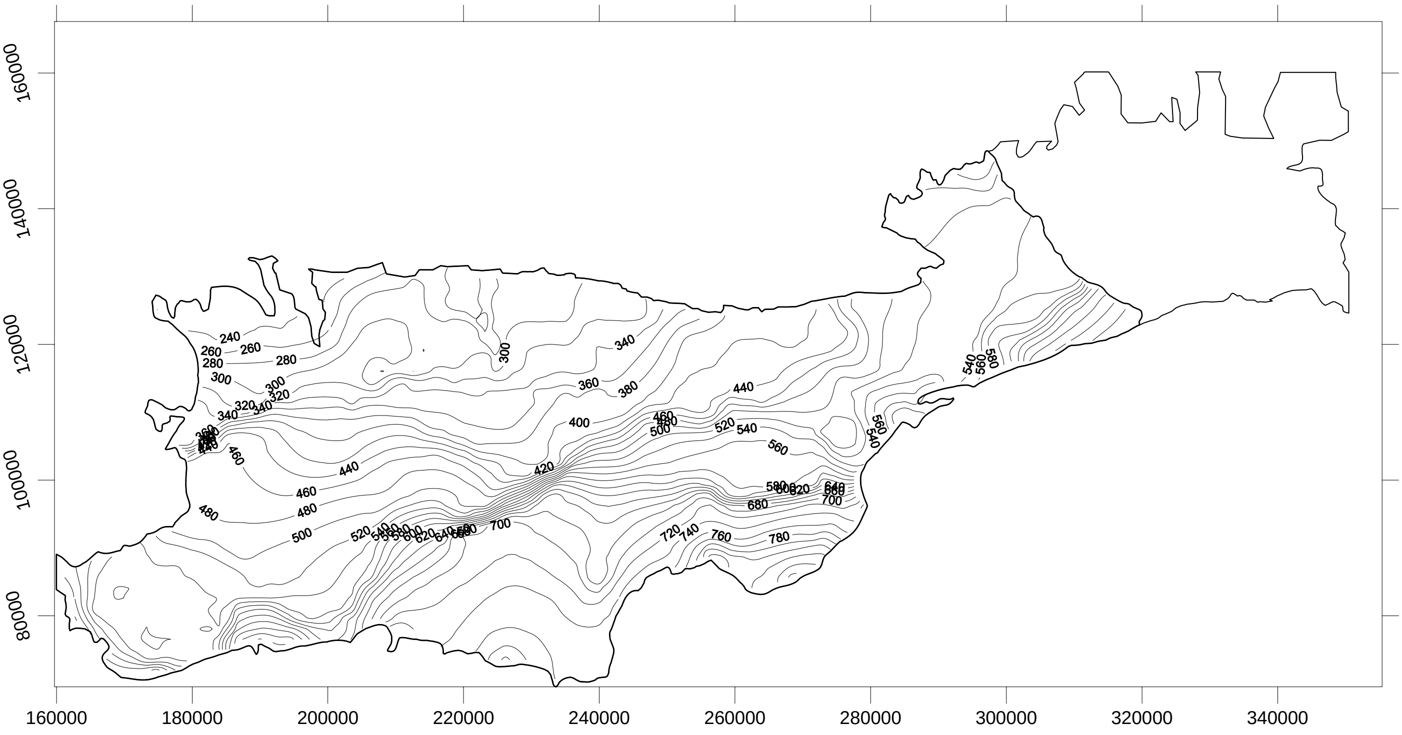


Figure 3.9.2 Piezometric Map in the Haouz Plain as of 2020 – Maximum Demand Scenario