

Delineation of Groundwater Protection Zones for Hidan Well Field

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Geowissenschaften
und Rohstoffe

On behalf of:



TECHNICAL REPORT NO.3

Delineation of Groundwater Protection Zones for Hidan Well Field

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Table of Contents

Table of Contents	III
List of Figures	IV
List of Tables	IV
Abbreviations	V
Executive Summary	2
1. Introduction	3
2. Description of the Working Area	5
2.1 Topography	5
2.2 Climate	8
2.3 Hidan well field	12
3. Geology	16
4. Hydrogeology	20
4.1 Hydraulic aquifer parameters	20
4.2 Groundwater movement	20
4.3 Surface Water - Groundwater interaction	23
4.4 Water Quality	25
5. Delineation of Protection Zones	30
5.1 Protection Zone 1	31
5.2 Protection Zone 2	32
5.3 Protection Zone 3	37
6. Potential Hazard Sites <i>by Dr. Harald Kirsch (GIZ)</i>	39
7. Recommendations	48
Literature	52
Annex 1: Well Sheets	55
Annex 2: Well logs for Hidan wells	71
Annex 3: Quality data from flash floods	79
Annex 4: Photos	80
Annex 5: Water Resources Protection Guideline	81
Annex 6: Inspection Form Sheets	95

List of Figures

FIGURE 1: LOCATION OF HIDAN WELL FIELD AND ALREADY DELINEATED PROTECTION ZONES	4
FIGURE 2: TOPOGRAPHICAL MAP OF WADI WALA AND WADI HIDAN	7
FIGURE 3: YEARLY RAINFALL RECORD OF CD 0006.....	8
FIGURE 4: MONTHLY AVERAGE RAINFALL FOR CD 0006 FOR THE PERIOD FROM 1954 - 2010	9
FIGURE 5: YEARLY RUNOFF IN WADI WALA UNTIL 2002.....	10
FIGURE 6: ISOYEHETES FOR THE CATCHMENT OF WADI HIDAN (ADAPTED FROM STEINEL (2012))	11
FIGURE 7: SPRING DISCHARGE AND GROUNDWATER ABSTRACTION FROM HIDAN WELL FIELD.....	12
FIGURE 8: AERIAL MAP OF HIDAN WELL FIELD.....	15
FIGURE 9: HYDROGEOLOGICAL MAP OF NORTHERN JORDAN	16
FIGURE 10: LITHOSTRATIGRAPHY AND HYDROGEOLOGICAL CLASSIFICATION OF ROCK UNITS	18
FIGURE 11: GEOLOGICAL MAP OF WADI WALA/HIDAN (BASED ON AL-HUNJUL (1995) AND SHAWABKEH (1996), SHEET NO 3153 III	19
FIGURE 12: GROUNDWATER CONTOURS OF THE A7/B2 AQUIFER	21
FIGURE 13: WATER LEVEL OF OBSERVATION WELLS IN HIDAN WELL FIELD	22
FIGURE 14: BREAKTHROUGH CURVE OF THE NACL TRACER	25
FIGURE 15: SURFACE WATER SAMPLING DURING A FLOOD EVENT.....	26
FIGURE 16: TURBIDITY VALUES IN HIDAN WELL FIELD (ALL WELLS).....	27
FIGURE 17: TOTAL COLIFORM VALUES IN HIDAN WELL FIELD	28
FIGURE 18: PIPER PLOT OF WATER SAMPLES FROM HIDAN WELLS.....	29
FIGURE 19: APPROACHES TO DELINEATE PROTECTION ZONES [SCHMOLL (2006)]	30
FIGURE 20: DISTANCES OF PROTECTION ZONE 1 AROUND A DRINKING WATER SUPPLY WELL.....	31
FIGURE 21: SIGNPOST FOR PROTECTION ZONE 1.....	32
FIGURE 22: SIGNPOST FOR PROTECTION ZONE 2.....	33
FIGURE 23: PROTECTION ZONE 2 FOR HIDAN WELL FIELD.....	36
FIGURE 24: PROTECTION ZONE 3 FOR HIDAN WELL FIELD.....	38
FIGURE 25: WATER PUMPING FROM WADI WALAH TO A VEGETABLE FARM NEAR ILLEGAL CAR WASH SITE (HEEDSITE14)	41
FIGURE 26: SOLID AND LIQUID WASTE DUMPED AT A SHEEP FARM (HEEDSITE10)	43
FIGURE 27: INSPECTION OF A VEGETABLE FARM BY A RANGER	43
FIGURE 28: POTENTIAL HAZARD SITES FOR HIDAN WELL FIELD.....	44
FIGURE 29: GRAZING SHEEP INSIDE PROTECTION ZONE 1.....	49
FIGURE 30: OPEN CABLE INSTALLATION AT THE WELL HEAD	49
FIGURE 31: ABANDONED WELL NEXT TO A DIRT ROAD	50
FIGURE 32: ILLEGAL WATER PUMP WITH DANGEROUS STORAGE OF DIESEL.....	51
FIGURE 33: SURFACE WATER POOL WITH INFLOW AND NO OUTFLOW, 150 M UPSTREAM OF HIDAN WELL FIELD	80
FIGURE 34: FLEXURE UPSTREAM OF HIDAN WELL FIELD	80

List of Tables

TABLE 1: PROPERTIES OF WELLS PUMPING FROM HIDAN WELL FIELD.....	14
TABLE 2: INSPECTION SITES HIDAN WELL FIELD (COORDINATES WGS 84 DECIMAL DEGREES)	45
TABLE 3: SURFACE WATER QUALITY ANALYSES	79

Abbreviations

asl	Above sea level
AWSA	Amman Water Sewerage Authority
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources), Hannover/Germany
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economic Cooperation and Development), Bonn/Germany
bgl	Below ground level
E.Coli	Escherichia Coli
GIZ	Gesellschaft für Internationale Zusammenarbeit GmbH, Eschborn, Germany
GPS	Global Positioning System
JVA	Jordan Valley Authority, Amman/Jordan
KfW	Kreditanstalt für Wiederaufbau , Frankfurt/Germany
MCM	Million Cubic Meters
MoH	Ministry of Health, Amman/Jordan
MoMA	Ministry of Municipal Affairs, Amman/ Jordan
MoU	Memorandum of Understanding
MWI	Ministry of Water and Irrigation, Amman/Jordan
NRA	National Resource Authority, Amman/Jordan
RDEP	Royal Department for Environment Protection
RSCN	Royal Society for the Conservation of Nature, Amman/Jordan
WAJ	Water Authority of Jordan, Amman/Jordan
WIS	Water Information System
WPZ	Water Protection zone
WRP	Water Resources Protection

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Executive Summary

Hidan well field is situated 18 km southwest of Madaba, in the deep incised wadi Hidan. It is the only water supply for the city of Madaba with a population of 70 000. Around 10 MCM/a are abstracted from the A7 aquifer. The climate in the region is characterized by long hot and dry summers and cold, wet winters. During the rainy season, the well field regularly has to be shut down due to bacteriological contamination and elevated turbidity. Possible sources of pollution are manifold, ranging from agricultural activities in the wadi to the improper disposal of waste water from households and animal farms.

The Wadi es Sir (A7) karstic limestone aquifer has good hydraulic properties with a permeability of up to 40 m/d. As groundwater flow and therefore also contaminant transport takes place in conduits and enlarged void spaces, much higher flow velocities can occur.

Within the scope of this study, protection zones for the Hidan well field are delineated. Protection zone 1 includes the direct surrounding of each well. The direct infiltration of surface water from the wadi into the groundwater could be proven by a tracer test. Hence, the influence of the surface water was considered for the delineation of protection zones 2 and 3. For protection zone 2, the groundwater velocity as well as a buffer zone around the wadi was considered. The shape of protection zone 2 comprises an area of 23.6 km². Protection zone 3 includes an area of 1,953 km² and consists of the entire surface water catchment.

Hazard sites have been investigated and mapped in cooperation with the Royal Dept. for Environment Protection (RDEP) / Rangers, based on a MoU between the Rangers and the MWI signed in Dec. 2011.

1. Introduction

The Technical Cooperation of BGR with different Jordanian agencies which started in 1959 has a long history. The Cooperation started with the NRA by compiling the first basic geological maps and by the assessment of the mineral resources potential [Margane et al. (2009)]. Afterwards the cooperation continued with the WAJ and later with the MWI.

Since the 90'ies aspects of groundwater quality became more important and MWI and BGR started to establish the first groundwater protection zones in the Middle East. This process led to the proposal of a national guideline for the delineation of groundwater protection zones [Margane and Sunna (2002)] in 2006 and an update of the guideline in 2011 with the approval of the prime minister of Jordan (see Annex 4).

Since then, the topic of drinking water protection through the delineation of protection zones has been an important theme for the cooperation projects between BGR and MWI. Up to date, 17 drinking water protection zones have been delineated by MWI/BGR projects, including 8 well fields, 7 springs and 2 dam reservoirs (see Figure 1)¹.

The current BGR project “Water Aspects in Land Use Planning” not only delineates new protection zones but cooperates with the relevant authorities in enforcing water protection laws and considering water protection zones in land-use planning activities. The involvement of the Royal Department for Environment Protection (Ranger) is one key aspect and emphasizes the enforcement of restrictions given by the Water Resources Protection Guideline. Rangers are trained on water protection subjects, enabling them to act in case of

¹ Pella spring [Margane et al. (1999)], Qunayya spring [Subah et al. (2004)], Wadi Al Arab well field [Subah et al. (2006)], Rahoub spring [Margane et al. (2006)], Corridor well field [Borgstedt et al. (2007)], Mujib dam [Margane et al. (2008)], Hallabat well field [Margane et al. (2009)], Wadi Wala dam [Margane et al. (2009)], Lajun, Qatrana, Sultani and Ghweir well fields [Margane et al. (2010)], Wadi Shuaib springs (Baqqouria, Shreyyah, Hazzir and Azraq) [Margane et al. (2009)], AWSA well field [Gassen (2013)]

any violation within the protection zones. Another key aspect is the integration of water protection issues into land use planning via committees between MWI and MoMA with regular meetings, facilitated by the BGR project. Furthermore, the participation of local stakeholders in the protection of their drinking water resources is highlighted through a variety of awareness building measures, addressing pupils, religious dignities [Heise (2011)] and, as the very base of the society, local women.

The technical component of the project focuses on supporting MWI and WAJ with the delineation of groundwater protection zones for the AWSA well field in Azraq governorate and the Hidan well field in Madaba governorate.

This technical report provides the hydrogeological analysis for the delineation of the Hidan well field groundwater protection zones.

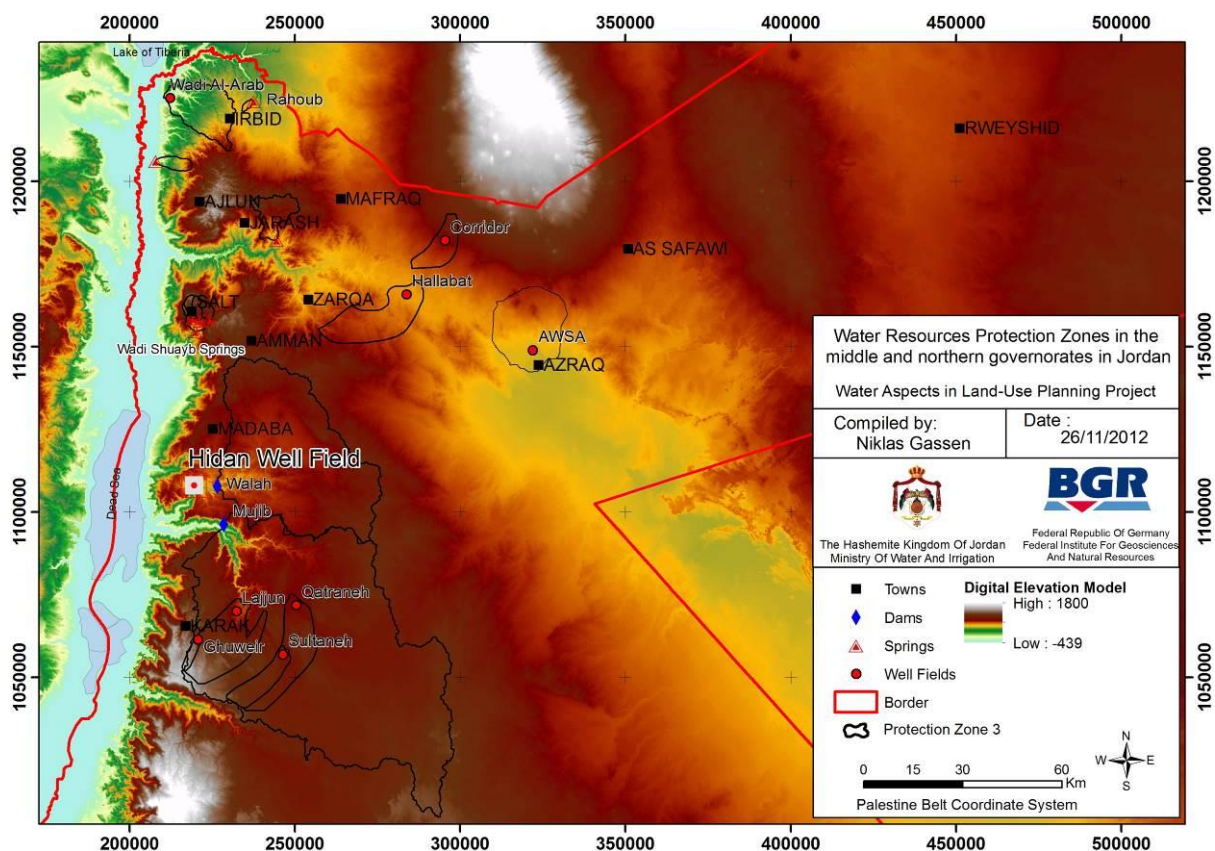


Figure 1: Location of Hidan well field and already delineated protection zones

2. Description of the Working Area

The Hidan well field is located 18 km southwest of the city of Madaba. The water supply of Madaba is provided to 100 % by the Hidan well field, with no available alternative water supply source. The ca. 70 000 residents of Madaba [World Bank (2005)] are therefore totally dependent on the water from the Hidan well field.

The Hidan well field is located inside wadi Hidan, which is called wadi Wala further upstream, and discharges into wadi Mujib which itself discharges into the Dead Sea. The wadi and its slopes are used for agriculture, favored by the perennial flow of water in the wadi, which is pumped to the field by diesel driven pumps. Main crops are vegetables and olive trees. Animal farming is also abundant. One small village is located within wadi Wala. Further villages are scattered around the slopes (see Figure 29).

The focus for the delineation of protection zones was mainly on the area around wadi Hidan and wadi Wala and its tributaries. It extends from PN 1,105,000 – 1,110,000 and PE 218,000 – 228,000 (Figure 2).

In the eastern part of the study area, the Wala dam was built in 2003 in order to collect rainwater and stabilize the water table by recharging the aquifer. For this purpose recharge wells were drilled downstream of the dam into the A7 aquifer. Further downstream, agricultural wells are supplying the local farmers with water. The Hidan well field is situated at the western end of the working area (Figure 2).

2.1 *Topography*

The catchment of wadi Hidan is characterized by a semi-arid to arid plateau to the east of Wala dam with an elevation of 700 to 900 m asl. In the western part, wadis cut deeply into the plateau, discharging towards the Dead Sea. The wadi Wala is characterized by moderate to steep slopes. Around the wala Dam, the wadi is incised up to 150 m deep, increasing

towards the well field to around 350 m. The eastern part of wadi Wala, close to the Wala dam, is characterized by moderate slopes formed by the chalk layers of the B1 formation.

Further downstream, at the beginning of wadi Hidan, the slopes steepen and the wadi turns into a small canyon with nearly vertical walls. The wadi widens up again in the area around the well field.

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Delineation of Groundwater Protection Zones for Hidan Well field

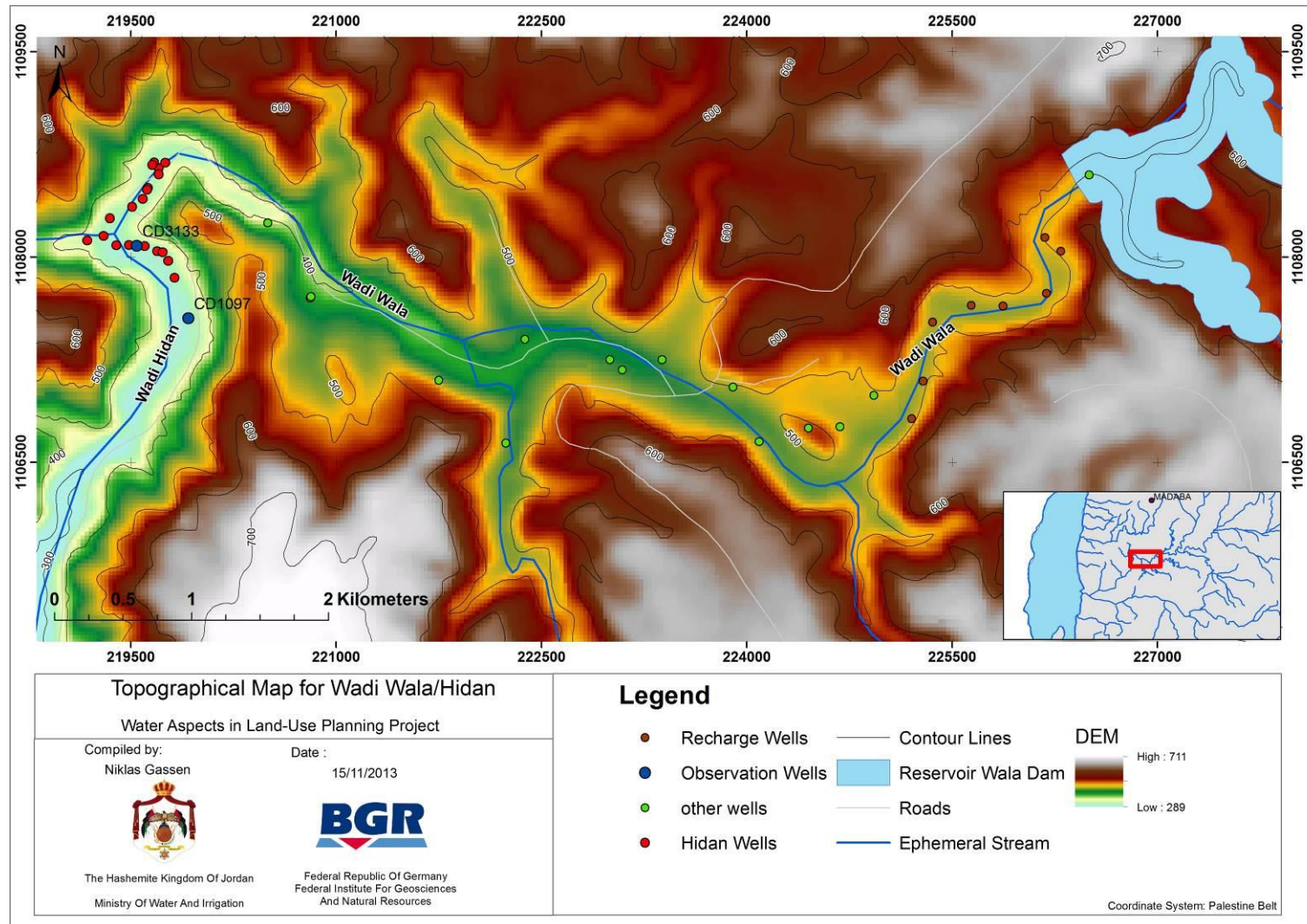


Figure 2: Topographical map of wadi Wala and wadi Hidan

2.2 Climate

Temperature

The climate in the study area is characterized by hot dry summers and cold wet winters. Temperatures can vary largely, both seasonal and diurnal. At Wala Station (CD0006) the average yearly temperature is 11.5 °C. Maximum temperatures of over 40 °C are common in summertime while minimum temperatures in wintertime can drop below 0°C.

Rainfall

Yearly rainfall amounts decrease from the western part of the catchment towards the well field (Figure 6). The long- term average for Wala rainfall station (CD0006) in wadi Wala is 214 mm/a. Inter-annual variations are strong, wet years can have rainfall amounts of up to 400-500 mm/a, while the amount in dry years stays below 100 mm/a (Figure 3).

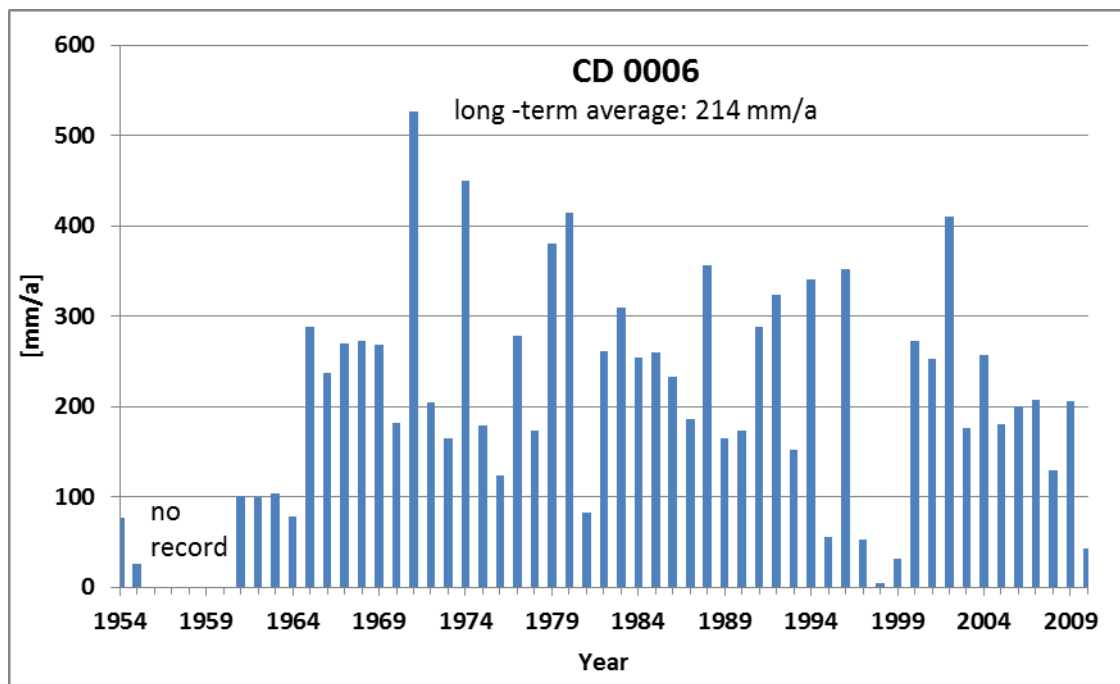


Figure 3: Yearly rainfall record of CD 0006

Rainfall occurs mainly during the rainy season, lasting from October until May. Most of the rainfall occurs between December and February, with January being the wettest month (Figure 4). The summer months, which range from June to September, are usually without any rainfall.

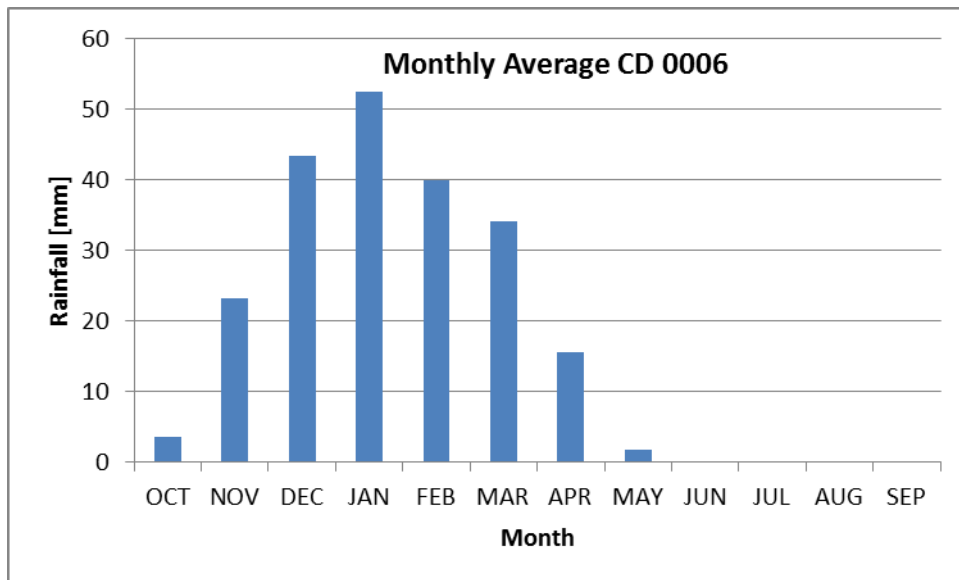


Figure 4: Monthly average rainfall for CD 0006 for the period from 1954 - 2010

Runoff

Runoff was measured in wadi Wala at runoff station CD 00036 from 1962 until 2002. Due to its location behind the Wala dam, no runoff measurement was recorded after 2002 as the construction of the dam changed the hydrologic regime of the wadi.

According to the measurements from CD 00036, long- term average yearly runoff for this time period was 26.5 MCM/a with minimum runoff of 0.22 MCM/a (1998) and maximum runoff of 166 MCM/a (1991) (Figure 5). The annual baseflow was calculated by the MWI to be around 3.4 MCM, varying between 1 and 16 MCM [Margane et al. (2009)]

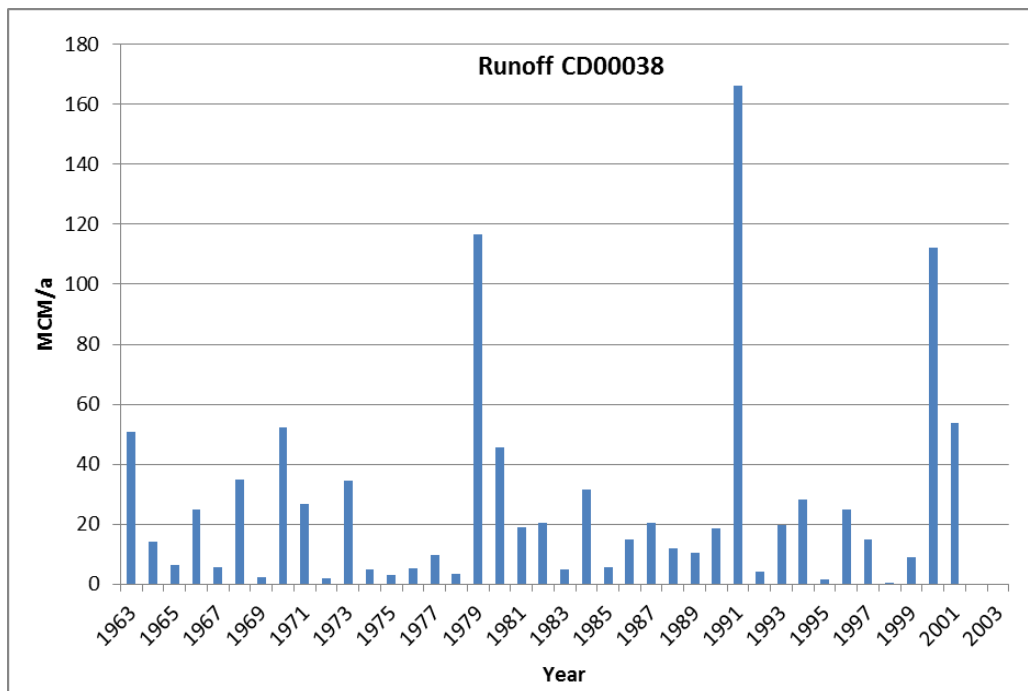


Figure 5: Yearly runoff in wadi Wala until 2002

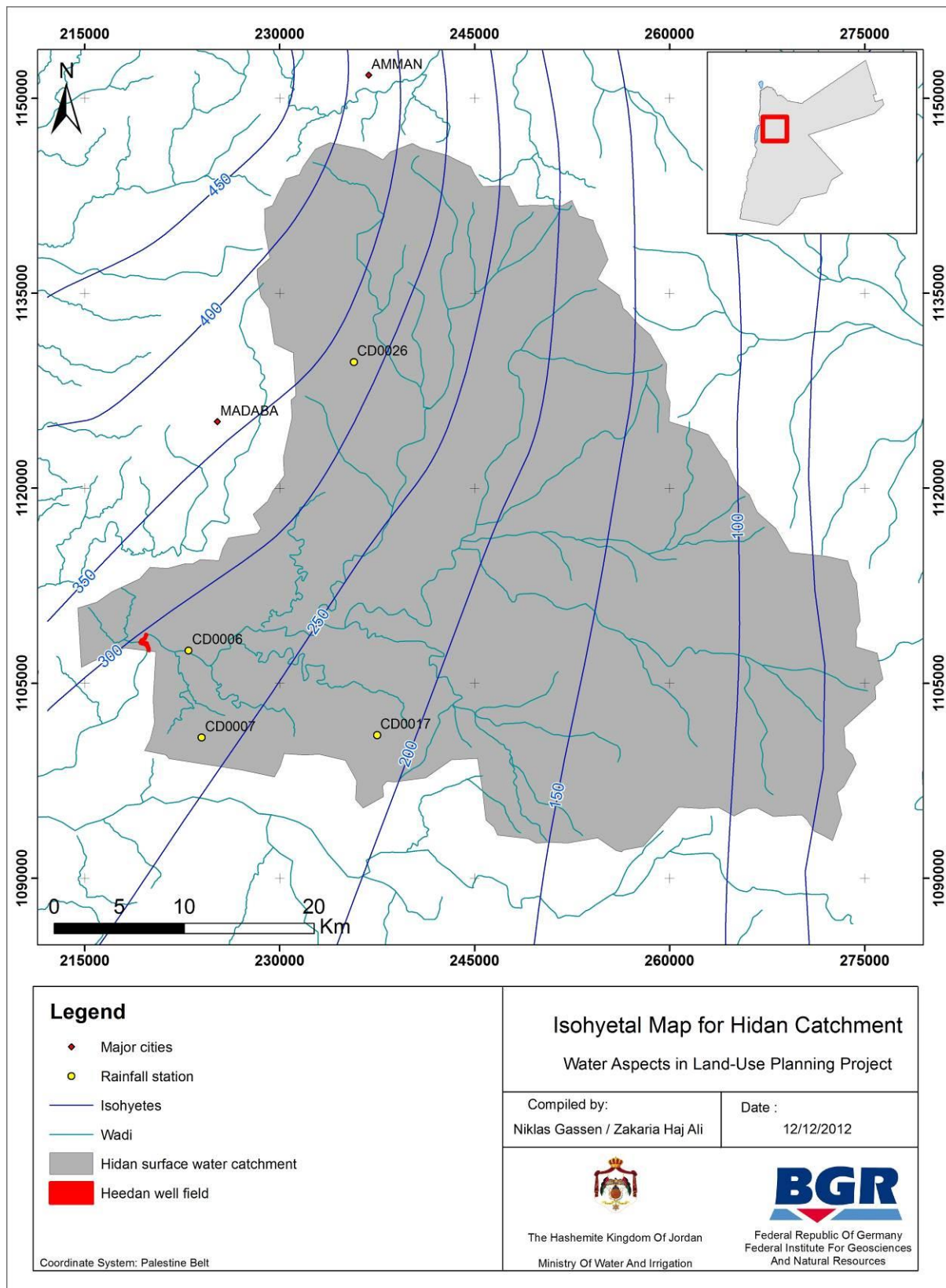


Figure 6: Isoyehetes (mm) for the catchment of wadi Hidan (adapted from Steinel (2012))

2.3 *Hidan well field*

Hidan well field is abstracting around 10 MCM/a from the A7 limestone aquifer (Figure 7). The first wells were drilled in 1989. Pumping from the well field started in 1990. With increasing abstraction rates, spring flow from CD0540, located in the vicinity of the well field, decreased and finally ceased in 1995 (Figure 7).

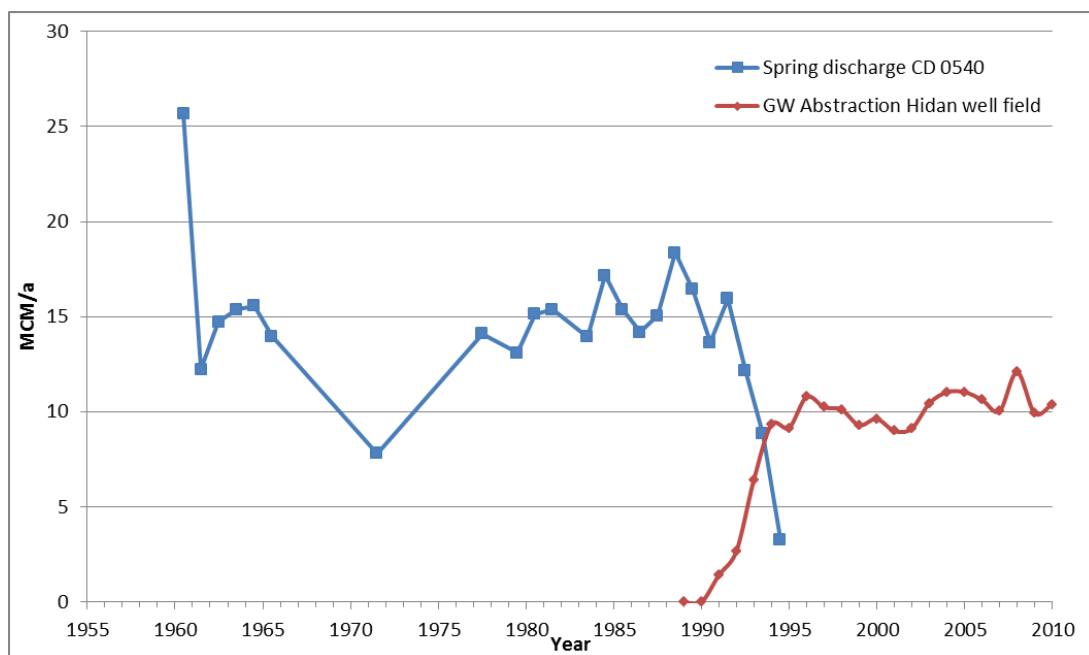


Figure 7: Spring discharge and groundwater abstraction from Hidan well field

The well field consists of 17 pumping wells, 5 capped wells and 2 observation wells. This includes the wells CD 1019 (Wala 9), CD 1093 (Wala 4), CD 1094 (Wala 5) and CD 3387 (Wala 5a), which are misleadingly stated as Wala wells. Well depth ranges between 30 m bgl and 293 m bgl, depending on the depth to the aquifer. All pumping wells extract water from the A7 limestone aquifer.

Specific capacities of the wells range between low and high values of 0.3 and 431 m²/h respectively, with clear indications of well ageing (e.g. CD 3139). At CD 3139 the specific capacity decreased from 431 m²/h in 1989 to 9.5 m²/h in 2003.

Water from the well field is pumped to Hidan pumping station with a maximum rate of 600 m³/h. The pumping station is situated around 1.3 km east of the well field. Water is stored in a reservoir with a capacity of 6,500 m³. From there, water is pumped to Lib pumping station where an additional reservoir of 6,500 m³ exists. Lib pumping station supplies the city of Madaba with drinking water.

Observation wells are located within the well field (CD3133) and downstream of the well field (CD1097, Figure 2). Hydrographs are shown and discussed in Section 4.

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Delineation of Groundwater Protection Zones for Hidan Well field

Table 1: Properties of wells pumping from Hidan well field

STATION ID	STATION NAME	PALESTINE NORTH	PALESTINE EAST	ALTITUDE [masl]	WELL DEPTH [m]	AQUIFER	STATIC WATER LEVEL [mbgl]	SALINITY [μS/cm]	SPECIFIC CAPACITY [m ² /h]	T [m ² /d]	DRILLING ENDED (Test date)	STATUS
CD3131	HEEDAN NO 1	1108001	219664	358	197	B2/A7	3.1	730	0.3	5	31-Dec-89	not found
CD3132	HEEDAN NO 2	1107821	219755	341	148	B2/A7		749	5.6		31-Dec-89	used
CD3133	HEEDAN NO 2(OBS)	1108098	219524	346	59	B2/A7	4.5				31-Dec-89	Obs
CD3134	HEEDAN NO 3	1108040	219522	346	108	B2/A7	5.74	614	126.0	2482	31-Dec-88	capped
CD3135	HEEDAN NO 4	1108108	219460	360	108	B2/A7	5.4	570	301.3	9973	31-Dec-89	not found
CD3136	HEEDAN NO 5	1108051	219418	346	137	B2/A7	1.25	595	205.0	15599	31-Dec-89	used
CD3137	HEEDAN NO 6	1108107	219230	348	86	B2/A7	2.1	653	17.1	989	31-Dec-89	used
CD3138	HEEDAN NO 7	1108159	219280	351	56	B2/A7	1.2	563	91.6		31-Dec-89	used
CD3139	HEEDAN NO 8	1107943	219720	341	108	B2/A7		582	431.1		31-Dec-89	used
					second test 07.05.2003				9.5			
CD3140	HEEDAN NO 14	1108140	219274	346	63	B2/A7	1.6		166.9		5-Mar-91	not found
CD3141	HEEDAN NO 10	1108336	219441	351	81	B2/A7	2.63	621	13.0	960	31-Dec-89	used
CD3142	HEEDAN NO 11	1108393	219514	354	116	B2/A7	4.06	672	2.8		31-Dec-89	capped
CD3143	HEEDAN NO 12	1108471	219564	351	31	B2/A7	4				31-Dec-89	not found
CD3144	HEEDAN NO 13	1108652	219627	358	126	B2/A7	6.6		244.4		31-Dec-90	used
CD3243	HEEDAN NO 15	1108572	219627	357	130	B2/A7	5.3	672	171.1		28-Jul-91	used
CD3363	HEEDAN NO. 12A	1108464	219555	355	110	B2/A7	22.18		80.6	1920	15-Jun-99	used
CD3364	HEEDAN NO.16	1108680	219560	360	30	B2/A7	22.1		200.0		18-Jul-99	not found
CD3368	HEEDAN NO.16 A	1108641	219591	356	185	B2/A7	22.1		200.0	427	16-Jul-99	used
CD3394	HEEDAN 4A	1108012	219625	342	169						27-Mar-99	capped
CD3436	HEEDAN DEEP 1	1108045	219745	341	293	A4	19		8.8		28-Mar-00	capped
					second test 27.03.2003				5.5			
CD3437	HEEDAN DEEP 2	1108653	219679	370	250	B2/A7	42.6		302.0		11-May-00	used
CD3474	HEEDAN 12 B	1108451	219554	355	158	B2/A7	7		42.8		12-Feb-05	used
CD3475	HEEDAN .16 B	1108652	219596	356	185	B2/A7	12.45		0.2		31-Dec-05	used
CD3581	HEEDAN 6A	1108120	219181	352	142	B2/A7	20.2		285.7		24-Jan-12	used
CD1019	WALA NO 9	1108100	219375	350	106	B2/A7	10.15	538	163.0		16-Apr-85	used
CD1093	WALA NO 4	1107100	221750	423	204	B2/A7	23.4		1.5		27-Aug-84	used
CD1094	WALA NO 5	1107700	220810	425	237	B2/A7	44	860	4.6	46	14-Sep-84	capped
CD3387	WALA 5A	1107710	220815	425	161	A7	37.1		1.9		7-Apr-99	used

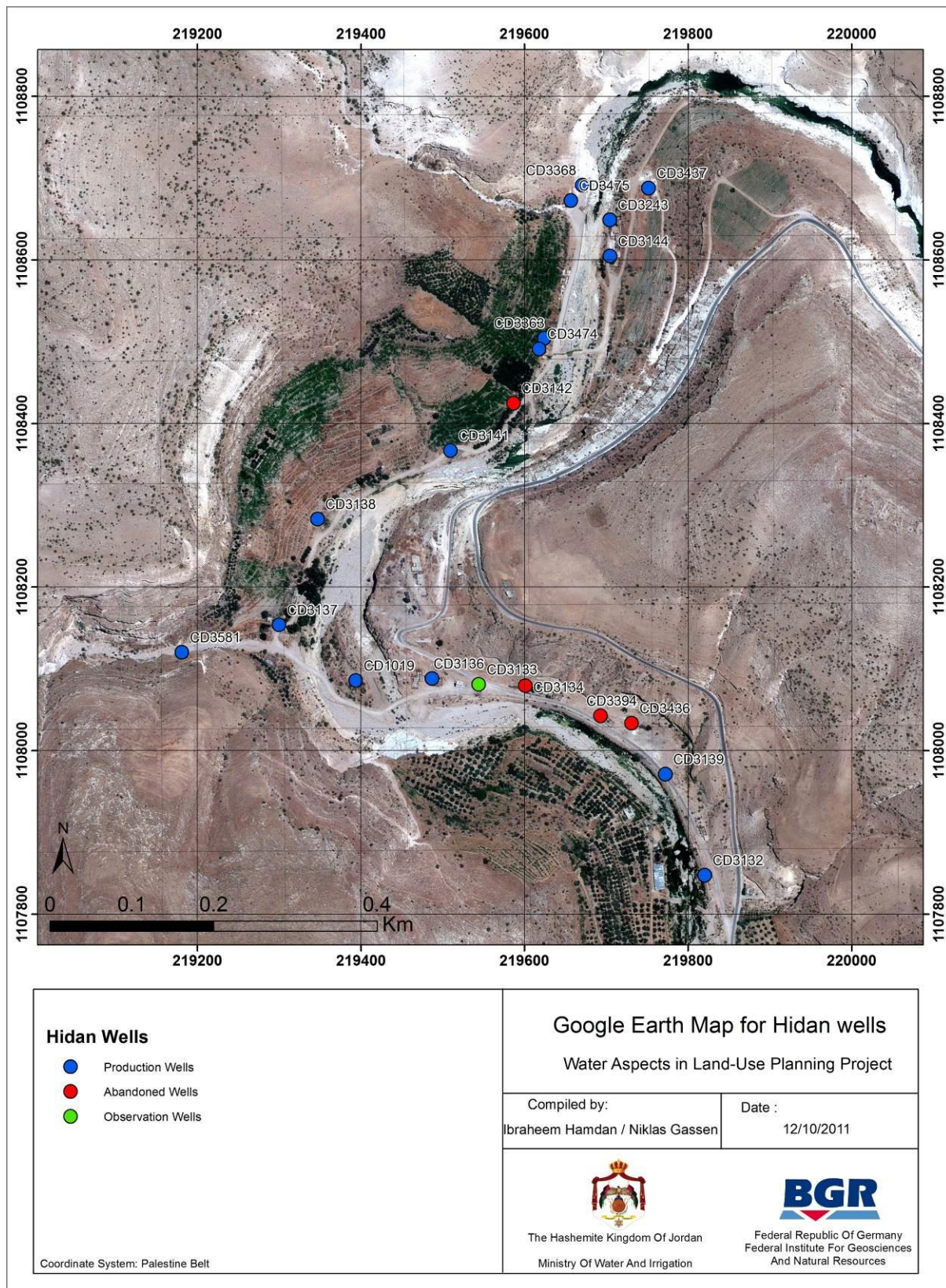


Figure 8: Aerial map of Hidan well field

3. Geology

The study area lies within the outcrop area of the important upper Cretaceous Amman/Wadi as Sir (A7/B2) aquifer (see Figure 9). The aquifer consists of massive limestone, dolomitic limestone and dolomite with intercalated beds of sandy limestone, chalk, marl, gypsum, chert and phosphorite [Margane and Sunna (2002)].

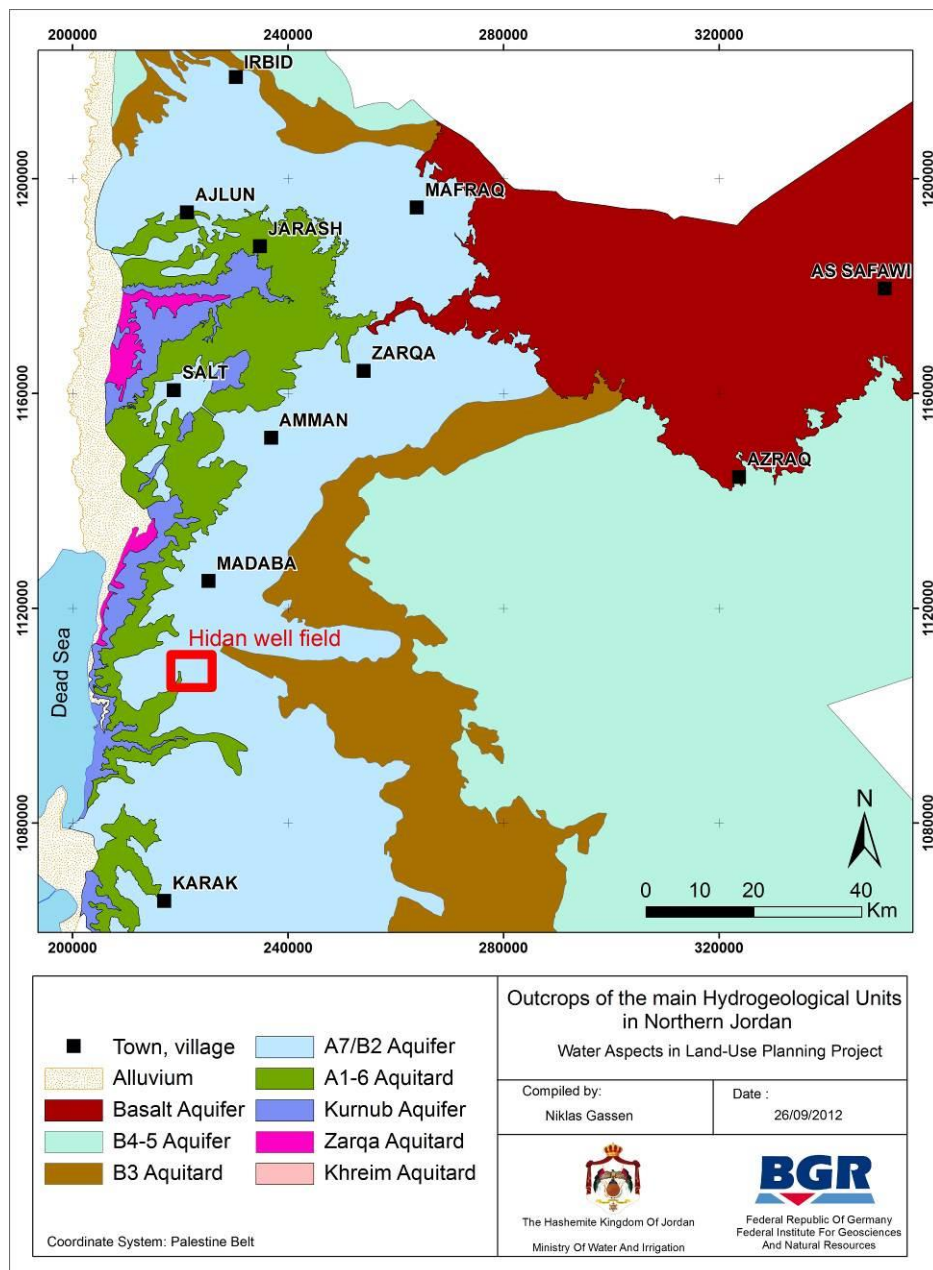


Figure 9: Hydrogeological map of northern Jordan

In the working area, the different formations of the A7/B2 aquifer complex have to be considered individually. Each single formation has different hydraulic characteristics and can act as an aquifer or aquitard within the aquifer complex. The A7 formation mainly consists of karstified limestone and dolomitic limestone. It is the most permeable layer and therefore considered as the local aquifer. [Coyne [et Bellier (2003)] divided the A7 formation itself into three different productive zones a, b, c, of which zone b was significantly more productive than a and c. The overlying Wadi Um Ghudran (B1) formation acts as a local aquitard. It consists of soft white to yellow chalk, marl, chert and fossiliferous limestone. The B2 formation consists of the Amman Silicified Limestone formation and the Al Hisa Phosphorite formation. The former consists of pale to dark grey and brown chert, intercalated with grey microcrystalline limestone, marl and phosphate, the latter comprises phosphorite, phosphatic chert, phosphatic limestone and marl [Margane et al. (2008)].

The aquitard underlying the Wadi as Sir formation is formed by the A3 to A6 formations. The aquitard consists predominantly of marls, mudstones, thin bedded nodular limestone and gypsum [Masri (2003)].

German-Jordanian Technical Cooperation – Water Aspects in Land-Use Planning
Delineation of Groundwater Protection Zones for Hidan Well Field

ERA	SYSTEM		EPOCH	GROUP	FORMATION	SYMBOL	LITHOLOGY	THICKNESS [m]	AQUIFER UNIT			
CENOZOIC	QUATERNARY		Holocene	JORDAN VALLEY (JV)	Alluvium	Qal	clay, silt, sand, gravel	> 300	ALLUVIUM (AQUIFER) BASALT (AQUIFER)			
			Pleistocene		Lisan	Jv3	marl, clay, evaporites					
	TERTIARY	Neogene	Pliocene		Samra	Basalt	Jv1-2	conglomerates		100 - 350		
			Miocene		Neogene	Jv1-2	sand, gravel					
			Oligocene									
		Paleogene	Eocene	Wadi Shallala	B5	chalky and marly limestone with glauconite	0 - 550	B4/5 (AQUIFER)				
			Paleocene	Umm Rijam	B4	limestone, chalk, chert	0 - 310					
			MESOZOIC	CRETACEOUS	Upper	BELQA (B)	Maastrichtian	Muwaqqar	B3	chalky marl, marl, limestone chert	80 - 320	B3 (AQUITARD)
							Campanian	Amman-Al Hisa	B2	limestone, chert, chalk, phosphorite	20 - 140	A7/B2 (AQUIFER)
Santonian	W. Umm Ghudran	B1					dolomitic marly limestone, marl, chert, chalk	20 - 90				
Coniacian	Wadi as Sir	A7					dolomitic limestone, limestone, chert, marl	60 - 340	A5/6 (AQUITARD)			
Turonian	Shueib	A5/6				marl, limestone	40 - 120					
Ajlun (A)	Hummar	A4				limestone, dolomite	30 - 100	A4 (AQUIFER)				
	Fuheis	A3				marl, limestone	30 - 90	A3 (AQUITARD)				
	Naur	A1/2				limestone, dolomite, marl	90 - 220	A1/2 (AQUIFER)				
	Lower	KURNUB (K)			Subeihi	K2	sandstone, shale	120 - 350	KURNUB (AQUIFER)			
Aarda					K1	sandstone, shale						
JURASSIC		ZARQA (Z)			Azab		siltstone, sandstone, limestone	0 - >600	ZARQA (AQUIFER)			
					Ramtha		siltstone, sandstone, shale limestone, anhydrite, halite	0 - >1250				
					Hudayb		siltstone, sandstone, limestone	0 - >300				

Figure 10: Lithostratigraphy and hydrogeological classification of rock units

According to the geological maps of NRA (Al-Hunjul (1995), Sheet No. 3153 II and Shawabkeh (1996), Sheet No 3153 III), the A7 formation crops out along the wadi floor. Field observations confirm this, with even longer stretches of A7 outcrops observed than stated by NRA. The slopes along the wadi are formed by the overlying Wadi Umm Ghudran formation, with 2 layers of chalk beds divided by a limestone bank. The Amman Silicified Limestone Formation can be clearly identified by alternating chalk and chert layers of several decimeters.

The structural situation around the well field is complex and could not be fully investigated within the scope of this study. An obvious flexure is located in a northeast – southwest direction close to Hidan pumping station. Several faults are observed in the direct vicinity of the well field (Figure 11).

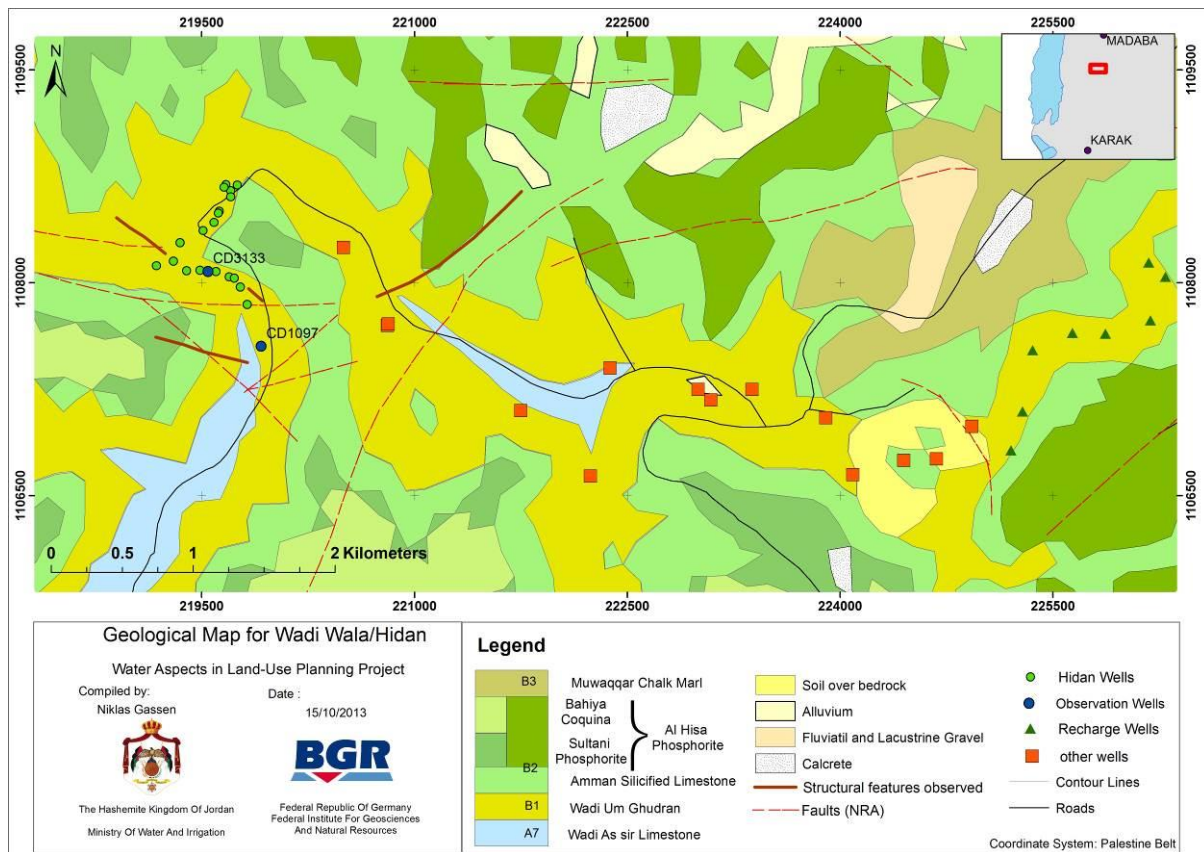


Figure 11: Geological map of wadi Wala/Hidan (based on Al-Hunjul (1995) and Shawabkeh (1996))

4. Hydrogeology

4.1 *Hydraulic aquifer parameters*

The mean transmissivity calculated from the available data from the WIS for all wells in the well field is 4,044 m²/d. Aquifer thicknesses are not available for each single well, hence a mean aquifer thickness of 100 m is assumed [Margane et al. (2009)]. Dividing the mean transmissivity by the mean aquifer thickness gives a mean hydraulic conductivity of 40 m/d (4.68 E-04 m/s).

[Abdulla and Al-Assa'D (2006)] derived hydraulic conductivities for the A7/B2 aquifer ranging from 0.001 to 40 m/d from a groundwater model. [Ta'any (2010)] gives permeability ranges from 0.12 m/d to 408 m/d for the A7/B2 aquifer. Pumping test analysis in the recharge wells of wadi Wala gave hydraulic permeabilities from 8.7 to 20.6 m/d [HOWARD HUMPHREYS & PARTNERS (1992)].

The large ranges of the available data show the heterogeneity in the hydraulic properties of the aquifer. This is common for a highly fractured or karstified aquifer like the A7 aquifer. Most data from literature consider the whole A7/B2 aquifer as one unit. The hydraulic conductivity derived from the WIS is used for this study, as it considers more specifically the properties of the local A7 aquifer.

4.2 *Groundwater movement*

The general trend of groundwater flow in the A7/B2 aquifer is directed from north east to south west [Margane et al. (2009)]. Close to the well field groundwater flow is diverted towards the wells due to a cone of depression, caused by the groundwater abstraction. Locally, the groundwater flow direction can differ due to the influence of structural features, especially in the vicinity of the well field. During a tracer test, 10 kg of Naphthionate injected

1 km east of the well field could not be recovered neither in the well field nor south east of it. Hence, the influence of structural features on the groundwater flow has to be considered.

Groundwater contours were interpolated by [Margane et al. (2009)] on a regional scale. More detailed contours can only be estimated due to the insufficient amount of available groundwater table measurements (Figure 12).

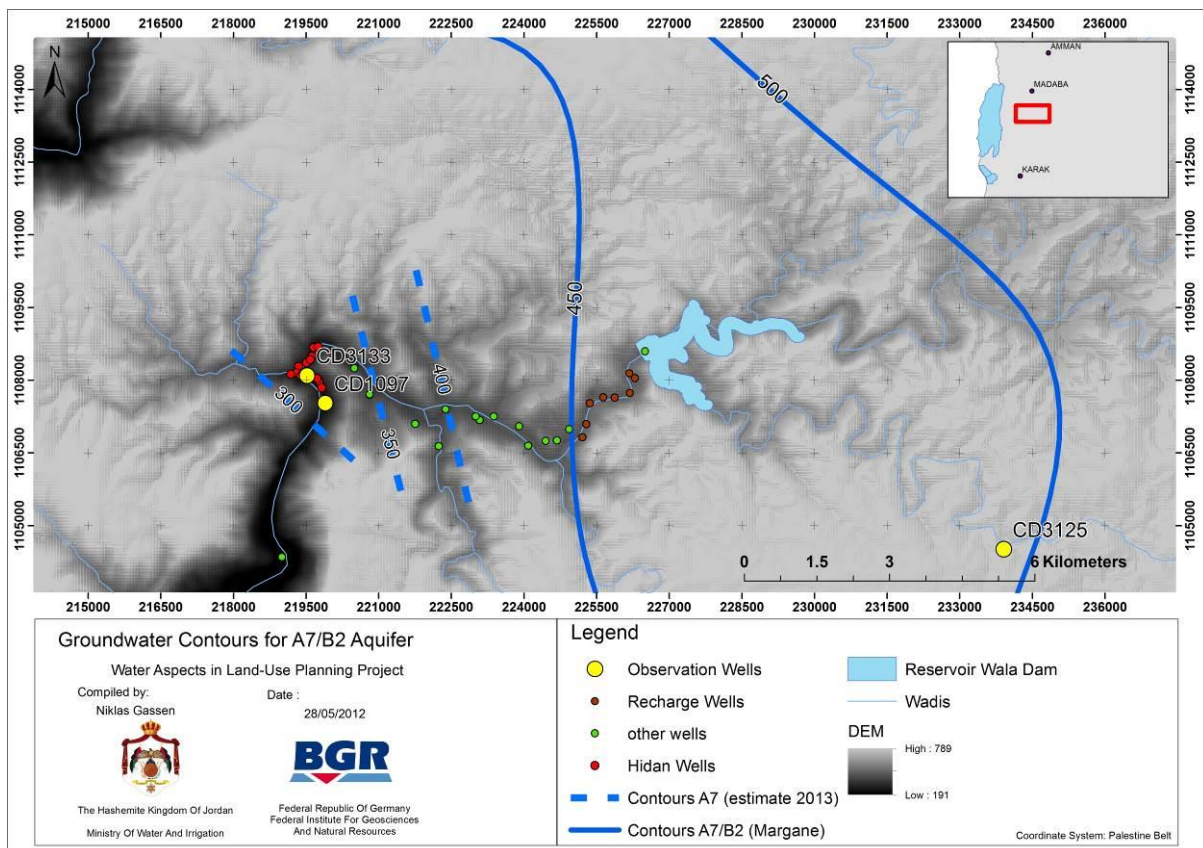


Figure 12: Groundwater contours of the A7/B2 aquifer

The estimated contour lines are based on data from the available monitoring wells as well as static water levels of the domestic wells. The available static water levels are not up to date, as they are usually only measured by the time of well construction. Hence, the estimated water contours can only give a rough idea about the general flow direction in the working area.

The hydrogeological conditions in the working area are significantly influenced by the impact of domestic and agricultural groundwater abstraction and artificial groundwater

recharge. Groundwater abstraction from Hidan well field started in 1991 with 1.4 MCM/a from 2 wells and increased to 10 -12 MCM/a until today from 17 wells (see Figure 7).

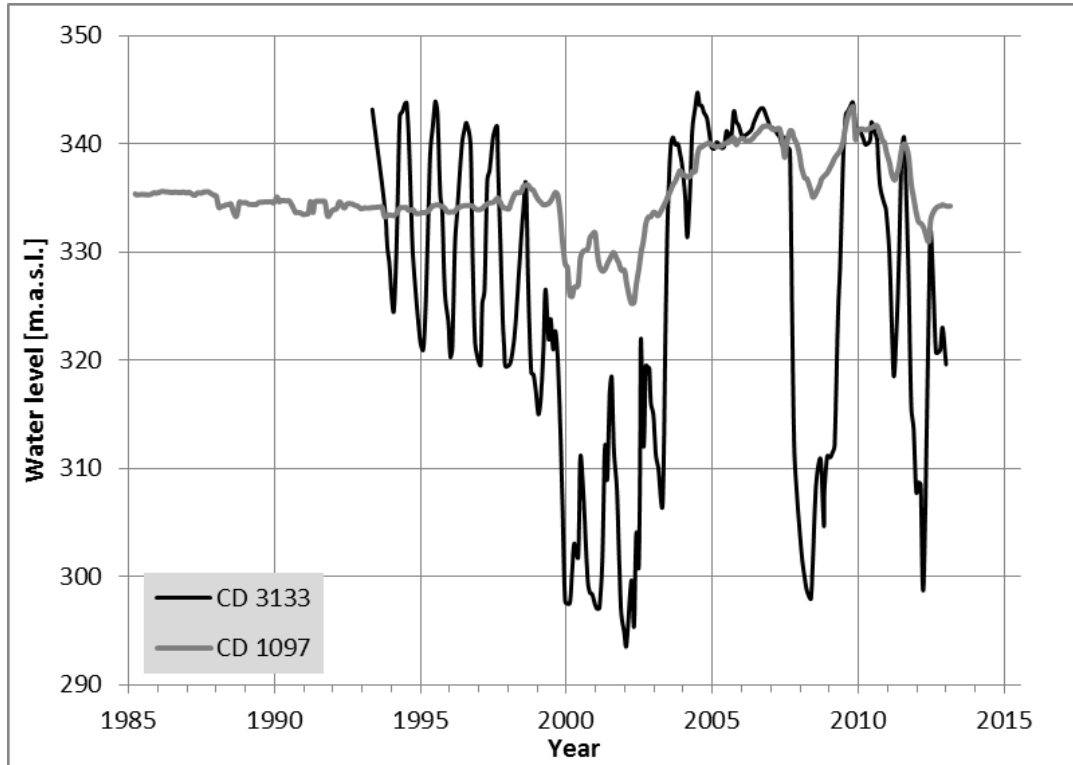


Figure 13: Water level of observation wells in Hidan well field

The increased abstraction from the A7 aquifer is reflected in the hydrographs of the monitoring wells CD 1093 and CD 3133 (Figure 13). The regional water table declined after the development of the Hidan well field and the following abstraction of groundwater. This trend was reversed after the construction of the Wala Dam in 2003. The purpose of this dam was to capture water for the dry season and to artificially recharge the wadi upstream of the well field. The Wala dam has therefore a significant influence on the hydraulic situation in the working area. Due to the managed aquifer recharge, the groundwater table was stabilized locally. Nevertheless, the accumulation of sediments in the dam reservoir decreases the infiltration capacity into the aquifer. Hence, several recharge wells downstream of the dam are used to directly infiltrate water from the reservoir into the aquifer since 2012. The effect of the injection of highly bacteriological contaminated water

from the reservoir on the water quality in the well field is unclear. If travel times to the well field are shorter than 50 days, the injection into the aquifer is not in agreement with the regulations on groundwater protection. Further information on the exact travel times in the groundwater regime could not be obtained by tracer tests carried out in 2013 based on the proposal by [Gassen and Stoeckl (2013)]. If the injected water discharges as surface water in the wadi, it might arrive within days at the well field, where it directly infiltrates to the groundwater (see Section 4.3).

4.3 *Surface water - groundwater interaction*

In order to investigate the influence of surface water infiltrating from the wadi on the water quality in Hidan well field, a tracer test with Sodium Chloride (NaCl) was carried out. 300 kg of NaCl were diluted in 2 m³ of water and flushed into a surface water pool close to the well field (see Figure 14), which is not permanently filled with water. The pool was filled with water from the washout of well CD3368 before the injection of the salt tracer. The electric conductivity of the surrounding wells was monitored permanently with CTD Divers. In addition, manual water samples were taken and analysed for major ions.

A tracer breakthrough curve for the chloride and sodium concentrations was monitored at CD 3243 within a few hours after injection (see Figure 15). This clearly proves the direct connection between surface water and groundwater. If surface water flow reaches the pool used for the tracer test, any contamination of the surface water appears in well CD3243 within hours.

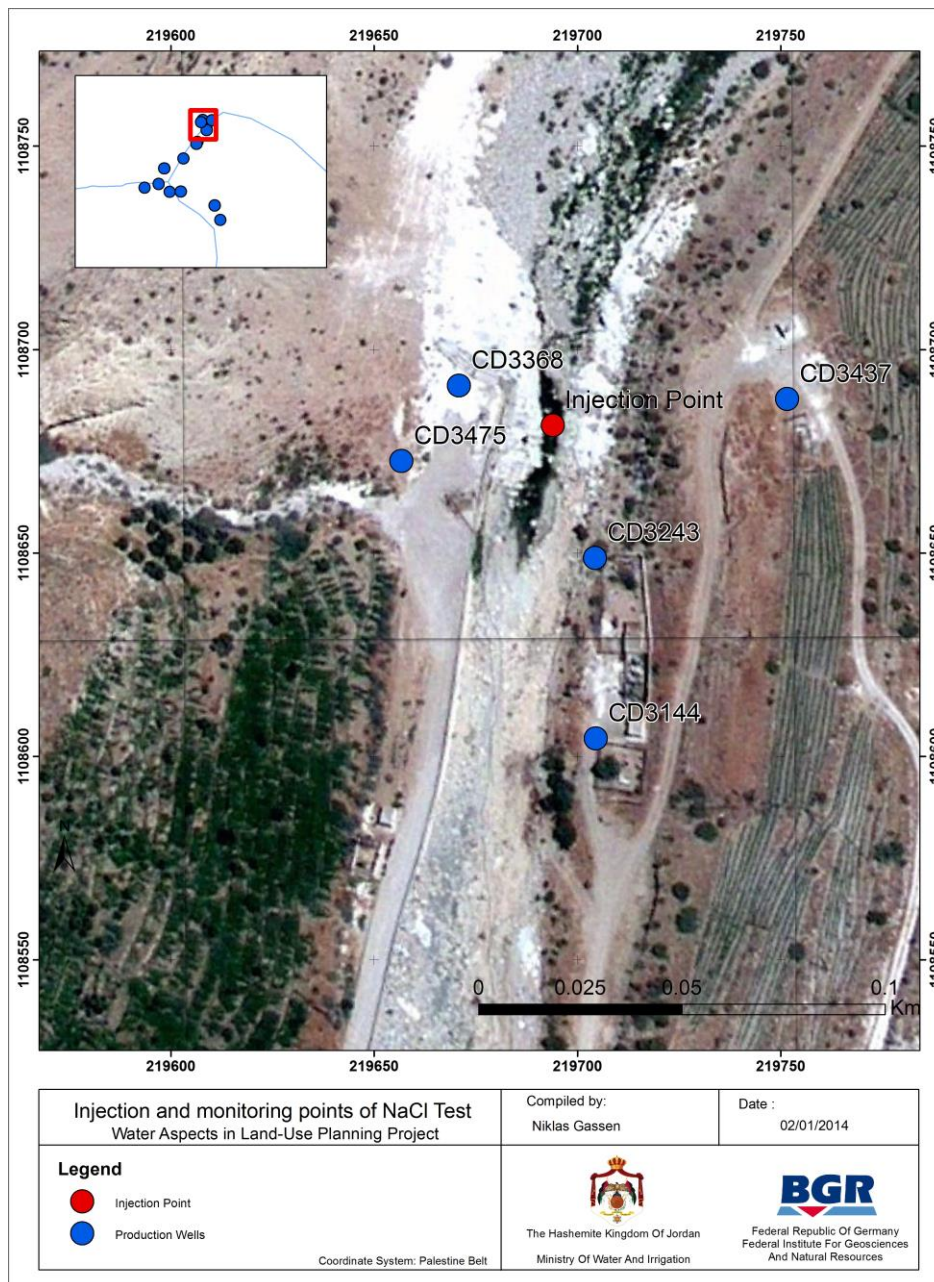


Figure 14: Injection point for the NaCl tracer test

This tracer test substantiates the existence of direct pathways of the surface water into the groundwater. Contaminated surface water therefore threatens the groundwater quality within the well field. This plays an important role for the delineation of protection zones.

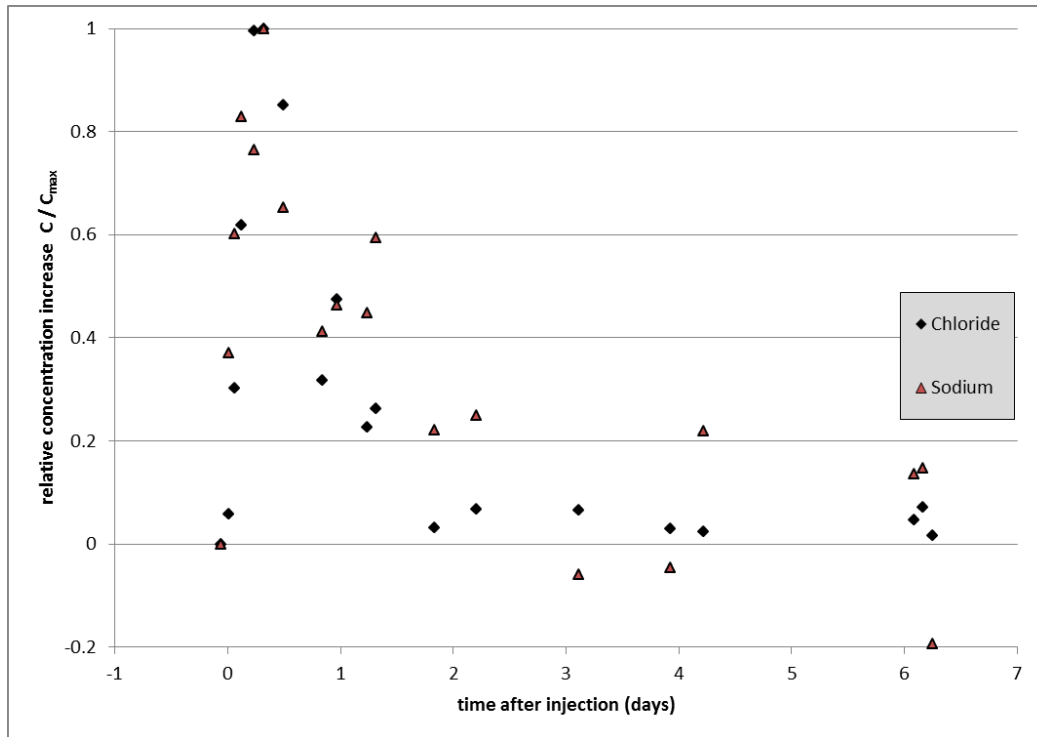


Figure 15: Breakthrough curve of the NaCl tracer in well CD 3243

4.4 Water Quality

Hidan well field is regularly suffering from bacteriological contamination and high turbidity. The location of the wells inside the wadi with a shallow groundwater table makes them very vulnerable to pollution. Contamination events can be correlated to rainfall events which are flushing liquid and solid waste from both human septic tanks as well as animal manure into the wadi. This contaminated floodwater easily infiltrates into the aquifer and arrives shortly after at the well field (see 4.3).

4.4.1 Surface water quality

Surface water samples were collected during two consecutive rain events by BGR/WAJ-Labs at different locations along wadi Hidan, wadi Wala and its branches. Exact locations of the

sampling points can be found in Figure 24. All samples were highly contaminated with E.Coli. Samples taken from the Wala reservoir showed highest counts of E.Coli. Results of the chemical analysis can be found in Annex 3.



Figure 16: Surface water sampling during a flood event.

It was not possible to narrow down a certain area of contamination, because all of the collected samples were contaminated, including samples from contributing side branches. Quantitative analysis was not possible as most of the highly contaminated samples were not further diluted in order to get exact coliform counts.

The comprehensive pollution of the surface water shows its hazard source for the pollution of groundwater and the necessity to include surface water protection measures into the delineation process.

4.4.2 Groundwater quality

The water quality section of WAJ Laboratory is responsible for a constant monitoring of the water quality in Hidan well field. Samples are taken from each production well in the well field, especially during the rainy season and are analyzed in the WAJ Laboratory. Results of the analyses are shown in Figure 17 and Figure 18.

Turbidity and total coliform values exceeding the guideline concentrations appear regularly in the well field. Unfortunately, a detailed spatial and temporal analysis is not possible as sampling intervals and patterns are highly variable.

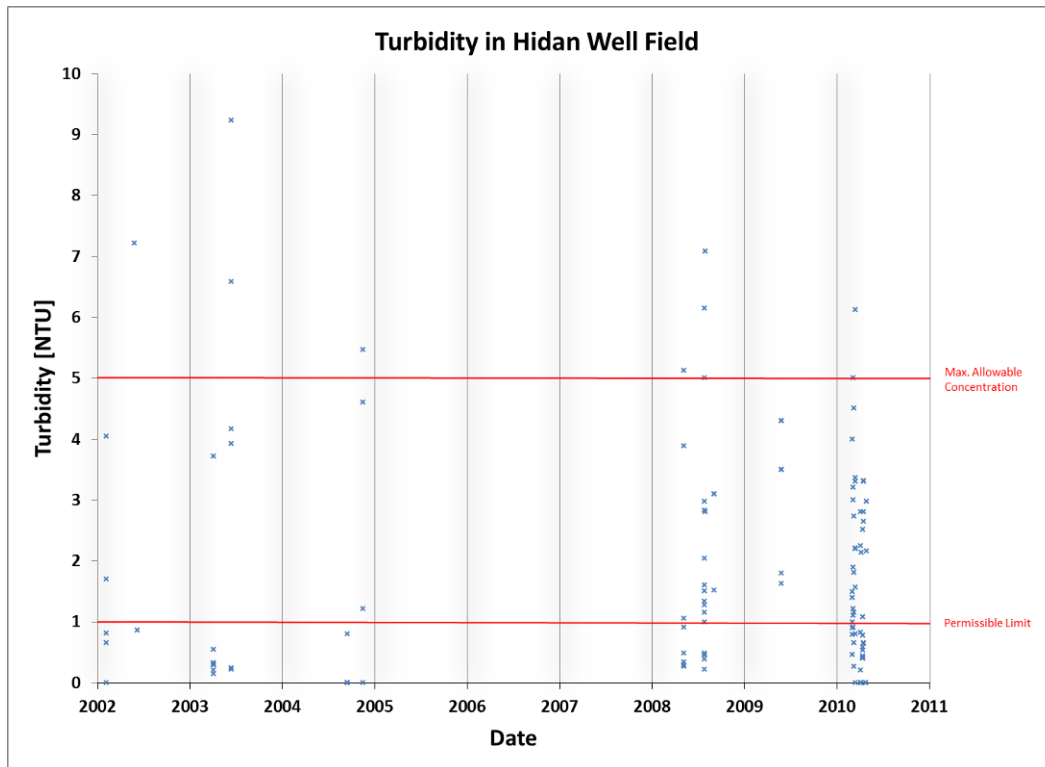


Figure 17: Turbidity values in Hidan well field (all wells)

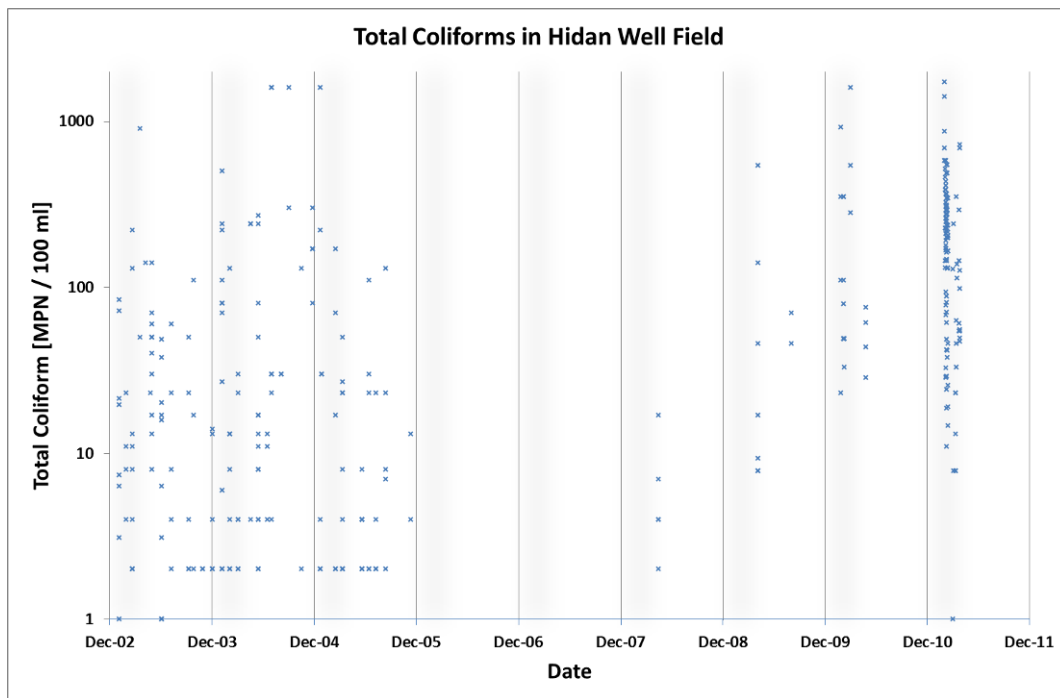


Figure 18: Total coliform values in Hidan well field

A representative sample from each well was chosen and displayed in a piper diagram (Figure 19). The water from all the wells show similar hydrochemical characteristics, as can be seen by the low variability in the piper diagram. It is classified as Ca-HCO₃ type. This confirms the origin from the same A7 limestone aquifer.

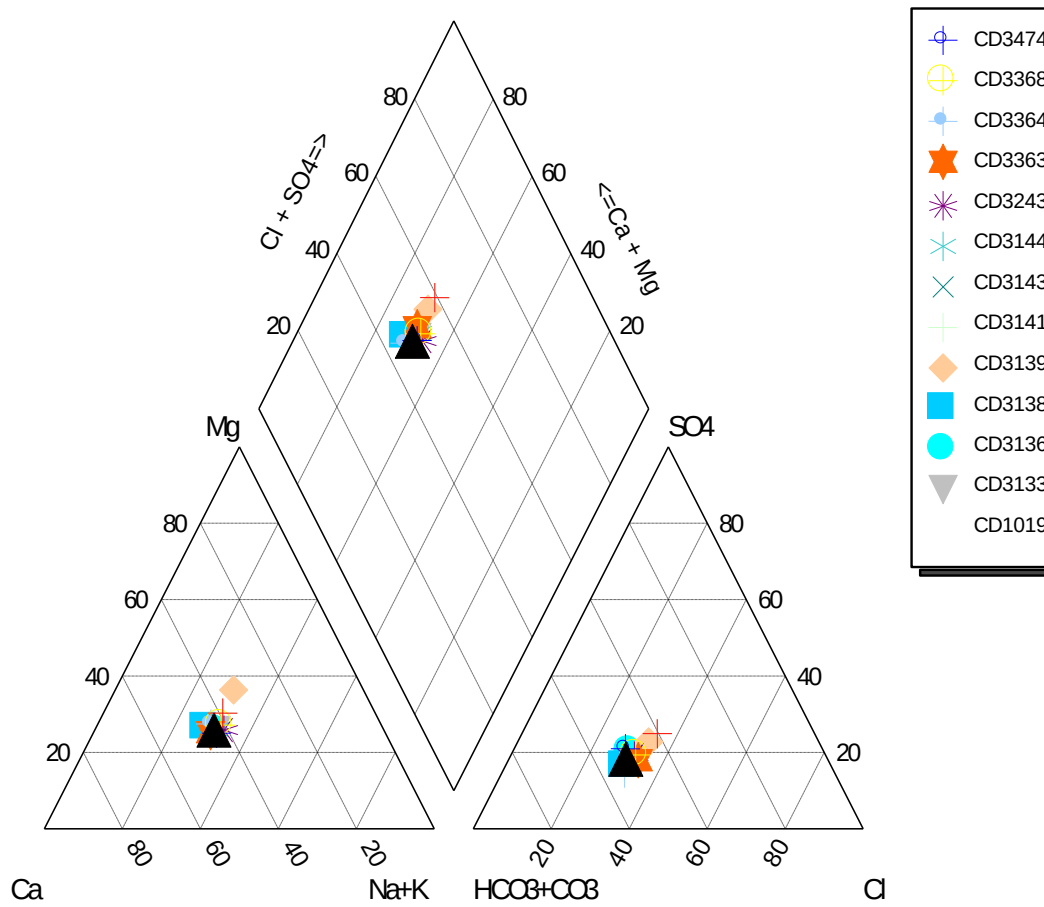


Figure 19: Piper plot of water samples from Hidan wells

5. Delineation of Protection Zones

Groundwater protection through the delineation of protection zones is an internationally applied method in order to maintain drinking water quality and to prevent the contamination of groundwater with hazardous substances. The delineation process is highly dependent on the available database and the possibility to apply the necessary hydrogeologic methods. In order to minimize restrictions to stakeholders within protection zones and to assure maximum protection of the water resource at the same time, they should be delineated with care and to the best knowledge. Protection zones can be delineated by simple estimations in case data availability is low or with sophisticated methods, including numerical groundwater models and tracer tests. The less information is available, the higher is the uncertainty of the delineated protection zones (Figure 20).

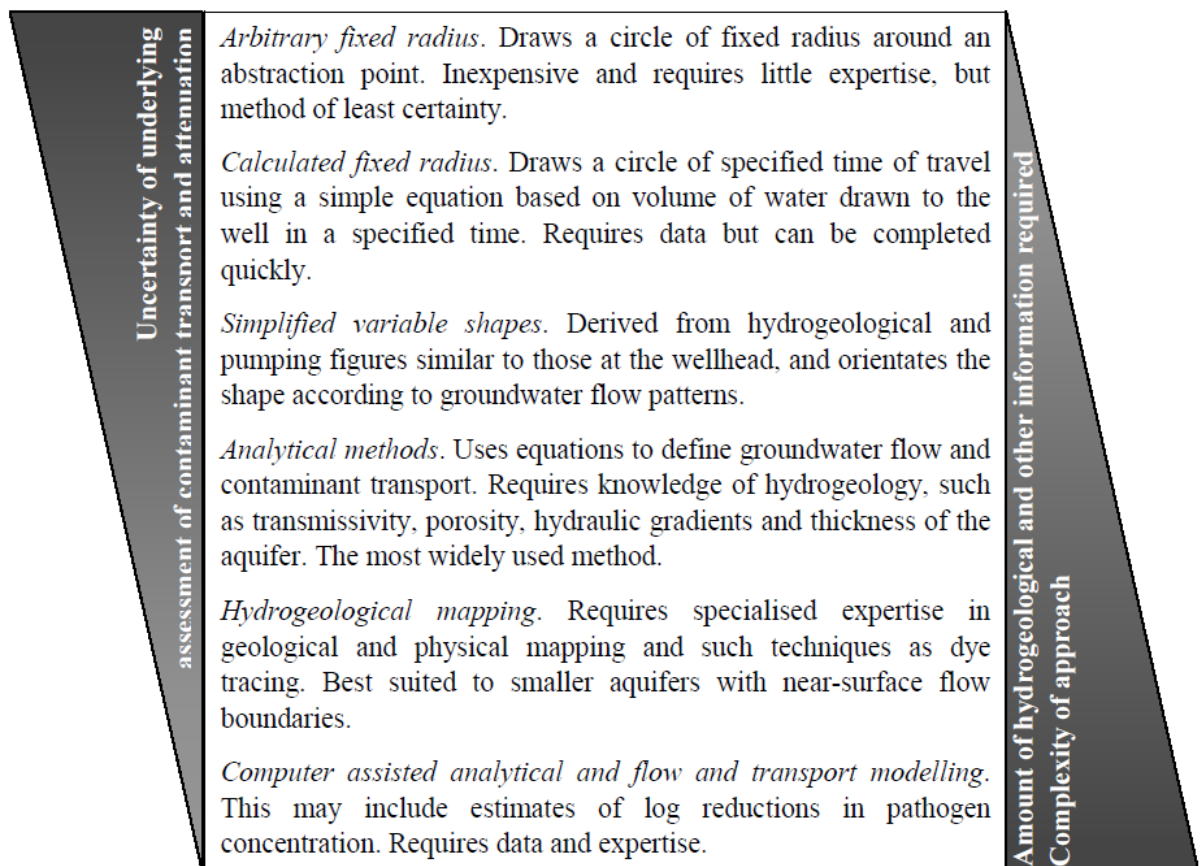


Figure 20: Approaches to delineate protection zones [Schmoll (2006)]

For the Hidan well field, tracer tests were planned [Gassen and Stoeckl (2013)] and partly conducted. Results of the tracer tests are included in the delineation of the protection zones.

5.1 Protection Zone 1

According to the Water Resources Protection Guideline (see Annex 5), protection zone 1 of a well has to reach at least 25 m upstream of the well (depending on the groundwater flow direction), 10 m downstream and 15 m to each side (see Figure 21). Protection Zone 1 should be completely fenced in and locked, allowing only authorized persons access to the well. Furthermore, protection zone 1 has to be marked accordingly with the corresponding signposts indicating restrictions and significance of zone 1 (see Figure 22).

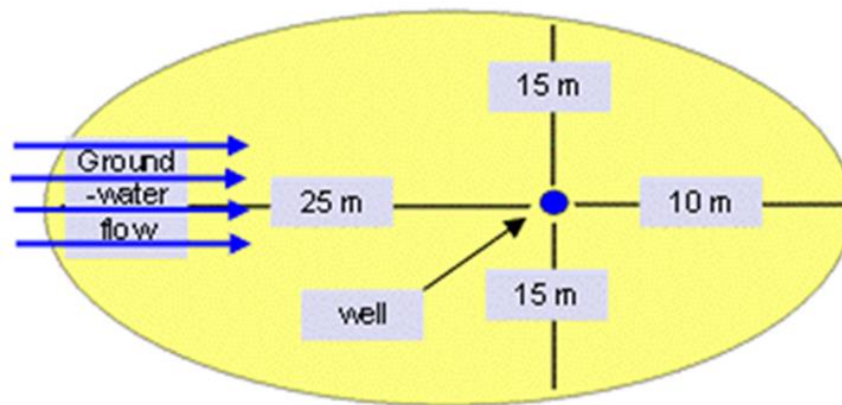


Figure 21: Protection Zone 1 around a drinking water supply well (Jordanian Water Resources Protection Guideline)



Figure 22: Signpost for Protection Zone 1

The actual status of protection zone 1 for each well was assessed during field trips. Recommendations for its modification and reparation measures are given for each well in Annex 1. The locations of some wells don't allow the strict application of the distances given in the Guideline as roads are included within the area. Hence, the recommended extent of protection zone 1 was modified in order to exclude constructional features like roads.

During the site selection for the drilling of new wells dimensional requirements for protection zone 1 should already be considered in order to not include any features like roads and therefore enhance the safety of the drinking water supply wells.

5.2 Protection Zone 2

Protection Zone 2 starts at the outer border of Zone 1 and ends at a virtual line from where the groundwater flow will take 50-days until it reaches the well. The 50 day line is based on the assumption that most pathogen bacteria die within a period of 40-60 days while traveling in groundwater. By preventing the entry of bacteriological contamination into the

groundwater within this 50 day line, it can be assumed that the water arriving at the wells is free of pathogen bacteria.

The following activities are allowed:

Residential areas: Connection to a local sewerage system or installation of a properly managed cesspit. Priority is given to the establishment of an appropriate sewerage network or a safe sub-surface disposal system (cesspools) following the by-law of sewerage network No.66 of 1994

Agricultural activity: Organic agriculture. In case of producing wastewater which is having an impact on the environment and on the water resources, obligation to implement environmental sound practices

Existing industries: In case of producing wastewater which is having an impact on the environment and on the water resources, obligation to implement environmental sound practices

Other activities: New establishments, extensions or changes are not licensed unless the responsible organization gives permission referring to the Jordanian legislation and related studies.



Figure 23: Signpost for Protection Zone 2

For the delineation of protection zone 2, the distance from which groundwater needs 50 days to arrive at a well, the so called 50 day line, is needed. In order to determine the 50 day line, travel times have to be calculated. For this purpose the estimation of the groundwater flow velocity is needed.

In karstic terrains, like in the working area, groundwater flow takes place in conduits and void spaces showing typically a non-linear behavior. The only method to reliably estimate flow velocities under such conditions are tracer tests (active or passive), which take these fast flow components of the aquifer into account.

Results from the conducted tracer tests do not reveal sufficient information on flow velocities. Therefore, the estimated groundwater flow velocity has to be handled with care. In addition to this, the influence of the surface water quality on the groundwater quality has to be considered. Results from a tracer test with sodium chloride confirmed that surface water infiltrates into the shallow groundwater through seepages along the wadi (see 4.3). This is supported by field observations of surface water pools with considerable inflow but no outflow (Figure 34). These surface water pools are located upstream of the well field, with variable size depending on the season and the amount of water abstracted by the farmers. In order to protect the well field from pollution from surface water, the groundwater protection zone 2 was combined with a surface water protection zone for wadi Hidan and wadi Wala, both with perennial streams.

For the delineation of the groundwater protection zone, the following calculation after [Langguth and Voigt (2004)] was applied:

The estimation of the maximum actual flow velocity $v_{\max}$ was applied after following formula:

$$v_{\max} = 2 * v_n$$

$$v_n = \frac{K * I}{N_0}$$

With: K = hydraulic permeability [m/d]

I = hydraulic gradient [-]

N_0 = assumed average effective porosity

With a mean hydraulic permeability of 40 m/d, a mean hydraulic gradient of 0.027 and an average effective porosity of 5 % [Margane et al. (2009)], a flow velocity v_n of 20.2 m/d is calculated:

$$v_n = \frac{40 * 0.027}{0.05} = 20.22 \text{ m/d}$$

$$v_{\max} = 2 * v_n = 40.44 \text{ m/d}$$

Hence, the distance of the 50 day line is $50 * 40.44 = 2,022$ m. According to the water protection guideline (see Annex 2), the maximum distance for protection zone 2 is 2,000 m upstream of the water source. A buffer of 1,000 m was applied in downstream direction of the wells. The resulting buffers of 2,000 m upstream and 1,000 m downstream of each production well (including Wala 4 + 5) were combined with a buffer of 350 m around the wadis, reaching from the dam site to the well field. The result is shown in Figure 24.

German-Jordanian Technical Cooperation – Water Aspects in Land-Use Planning
Delineation of Groundwater Protection Zones for Hidan Well field -

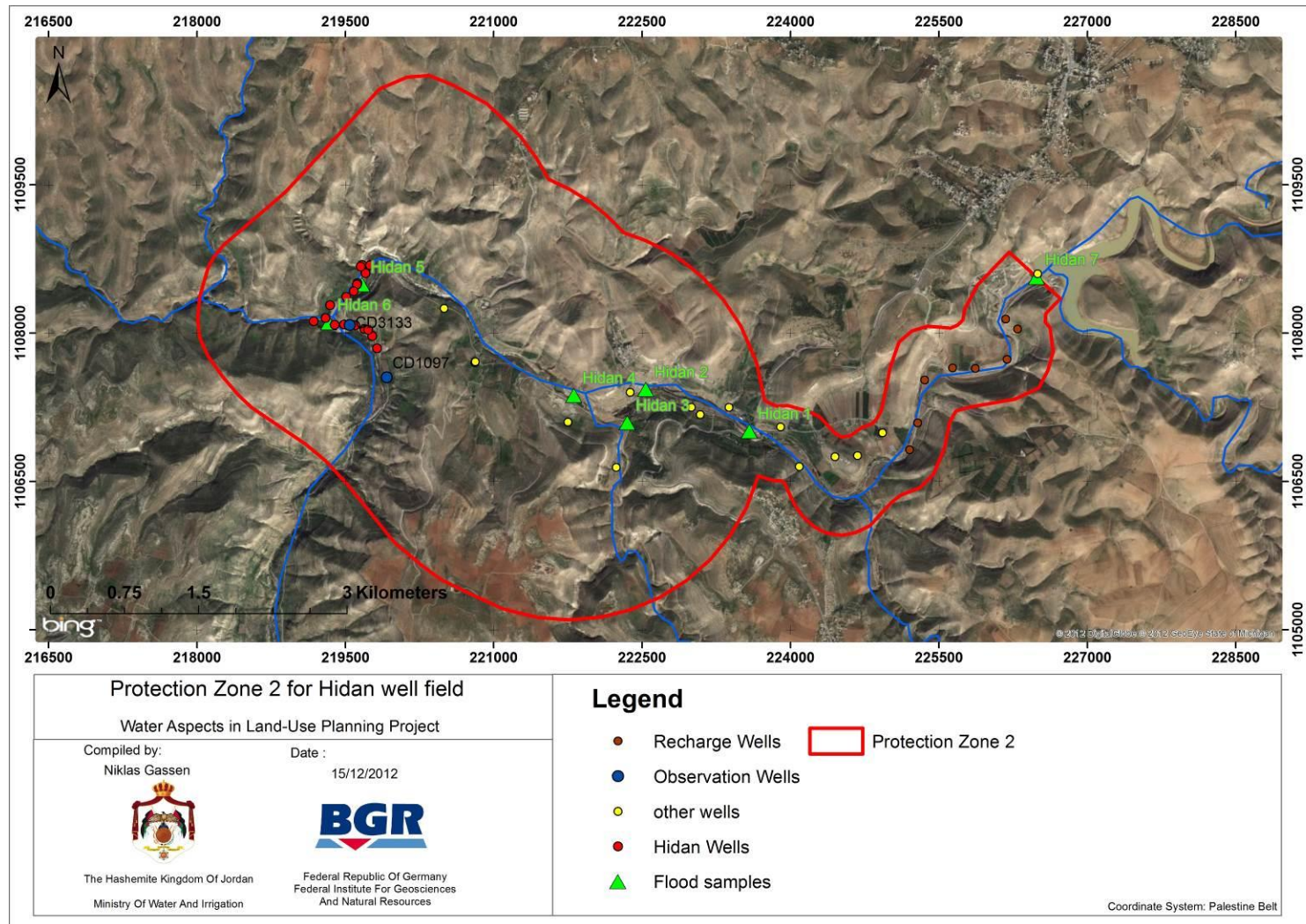


Figure 24: Protection Zone 2 for Hidan well field

5.3 *Protection Zone 3*

Zone 3 corresponds to the entire groundwater catchment of the well field. All development, agricultural, industrial, and social activities are allowed under the condition that they comply with the laws and by-laws applied in Jordan and environmentally sound practices.

In the case of Hidan well field, it has to be assumed that all surface water from the entire catchment eventually arrives at the well field. Therefore, the whole surface water catchment has to be considered for protection zone 3. The surface water catchment of Hidan well field is very similar to the already existing protection zone 3 of the Wala dam, defined by the surface water catchment of the Wala dam. Hence, the existing protection zone 3 was extended into the direction of the well field. From the analysis of existing groundwater contours [Margane et al. (2009)] it can be concluded that the groundwater catchment lies within the surface water catchment of Hidan well field. Therefore, groundwater protection zone 3 corresponds to of the surface water catchment of Hidan well field, as displayed in Figure 25.

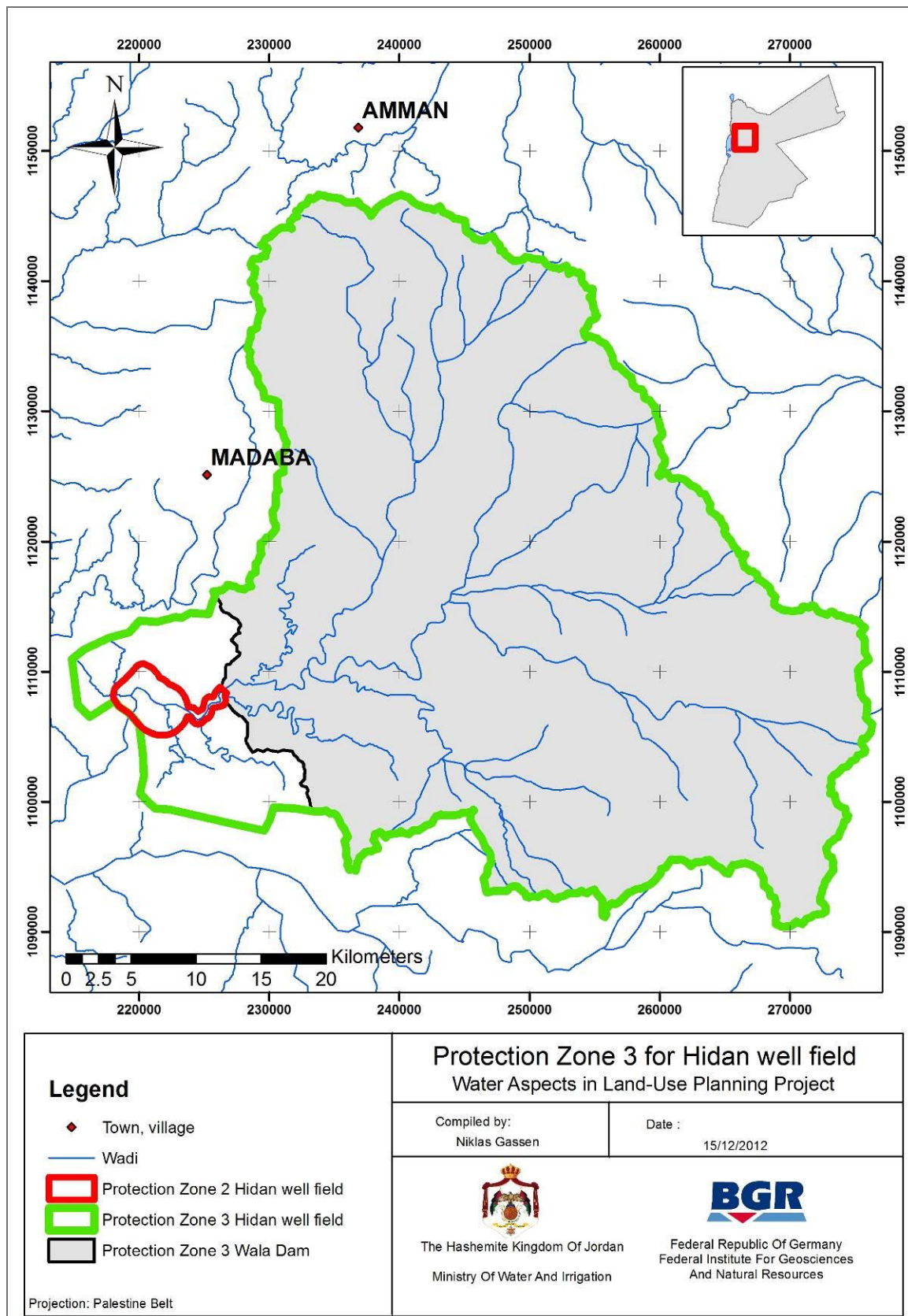


Figure 25: Protection Zone 3 for Hidan well field

6. Potential Hazard Sites *by Dr. Harald Kirsch (GIZ)*

The verification of hazard sites is still ongoing. Presently the following potential hazards are of main concern:

- Animal farms (mainly chicken, goat and sheep farms)
- Vegetable farms (incl. greenhouses)
- Manure dumping sites
- An illegal car wash place in the main wadi
- Residential areas not connected to a sewer system

The sites and their status are listed in Table 2; their geographical locations are shown in Figure 29. The process of site identification and a first risk assessment are described in the following sections.

Identification of hazardous sites

This process included a significant involvement of the staff of the Royal Dept. for Environment Protection (RDEP) / Rangers. Within the RDEP a special Water Resources Protection (WRP) Team has been operating since the beginning of 2010. This team worked together with a GIZ Adviser on the identification of hazard sites in the project area for the delineation of protection zones. The local branch office of Madaba, located 25 km NNE of Hidan well field, was involved in the field investigations.

The identification of potential hazard sites has been conducted stepwise since the end of 2011. The process included the following activities:

- First identification of hazard sites and of the boundary of WPZ 2 (draft) by BGR
- Visit of the WRP team to Madaba branch to inform the branch chief about the planned activities in Hidan, to create awareness about environmental violations that can harm water resources, and to refresh the field officers' knowledge in GPS application.
- Identification of further potential hazard sites inside and close to WPZ 2 (draft) by the Rangers WRP team with Google Earth and Wikimapia and conversion to ArcGIS shape files.
- Joint visit of Rangers WRP team and BGR staff to Madaba branch to:
 - introduce the new guidelines on Water Resources Protection officially effective in Jordan since November 2011. These guidelines are used to delineate and control the Water Resources Protection Zones (WPZ) 1, 2 and 3 regarding the specific and defined limitations of activities,
 - present the specific characteristics of the Hidan well field area,
 - introduce new procedures for the inspection of WPZ 1 and 2 which have been jointly tested earlier in other areas in Jordan (inspection forms see Annex 3).
- Two joint field trips of Rangers WRP team and BGR staff to practice the inspection of wells (WPZ 1) and facilities (WPZ 2) and to gather first relevant data regarding violations against the WRP guidelines.
- Inspection of Hidan wells (WPZ 1) by WAJ field team and Rangers liaison officer.
- Inspection of facilities in and close to WPZ 2 (draft) by Madaba field officers and identification of further sites through field surveys (Figure 28).
- Classification of facilities and potential hazards and geo-referencing (database and shape files) by Rangers WRP team supported by the GIZ adviser.

All relevant potential hazard points have been investigated. Not all of them turned out to be actual hazard sites.



Figure 26: Water pumping from wadi Wala to a vegetable farm near illegal car wash site (HeedSITE14)

Sites of concern that might have an impact on groundwater quality

As mentioned in previous sections of this report, all of the Hidan wells are located close to the riverbed along wadi Wala and wadi Hidan. Pollutants can enter the groundwater through seepages into the relatively shallow aquifer and through bank and bottom filtration. Hence the potential influx of pollutants into the surface water of the wadi and its tributaries needs to be considered.

The following areas and sites have been identified as potential sources for hazards.

- Animal farms (mainly outdoor goat and sheep and indoor chicken farms): There are 25 animal farms in the area, five of them are abandoned. They produce meat and in some cases milk products. Many of those facilities also grow olive trees on their premises, and some also vegetables. Chickens are treated with liquid sterilization agents. Solid waste is left on the ground (Figure 27), collected, then burned, or sold to other farms or used as fertilizer on-site. Liquid waste is in most cases collected in cesspits, but is sometimes also used to fertilize crops or discharged directly into the wadi. Besides direct

contamination the pathways of pollutants (e.g. N, P, E. Coli) into water resources are percolation into the soil- and groundwater, and surface runoff during high intensity rainfalls.

- Vegetable Farms (incl. greenhouses): Nine sites have been identified, one of them is abandoned. As a result of the field survey it can be assumed that most of the farms are using chemical fertilizers and pesticides. Pollutants can contaminate water resources by percolating into the soil- and groundwater and – in case of open fields - by surface runoff during high intensity rainfall events.
- Manure dumping sites (solid wastes): One large site identified close to a sheep barn, but not yet investigated.
- An illegal car wash place in the main wadi (liquid wastes): This point source of direct pollution of the water in the wadi is located upstream of the wells. It is used to clean all kinds of vehicles. A few meters downstream of the illegal car wash place, water is pumped to vegetable farms nearby (Figure 26). This spot is also very popular among the local population for recreational purposes, leaving a lot of litter behind.
- Residential areas not connected to a sewer system: Seven larger areas are located on slopes, ridges and plateaus upstream of the main surface waterways. It can be assumed that they have no connection to any sewer system. Waste water is stored in cesspits. From other areas in Jordan it is known that cesspits are often not emptied once they are full, and thus overflow. Consequently pollutants can contaminate water resources through surface runoff, but also by percolating into the soil- and lastly into the groundwater.



Figure 27: Solid and liquid waste dumped at a sheep farm (HeedSITE10)



Figure 28: Inspection of a vegetable farm by a Ranger

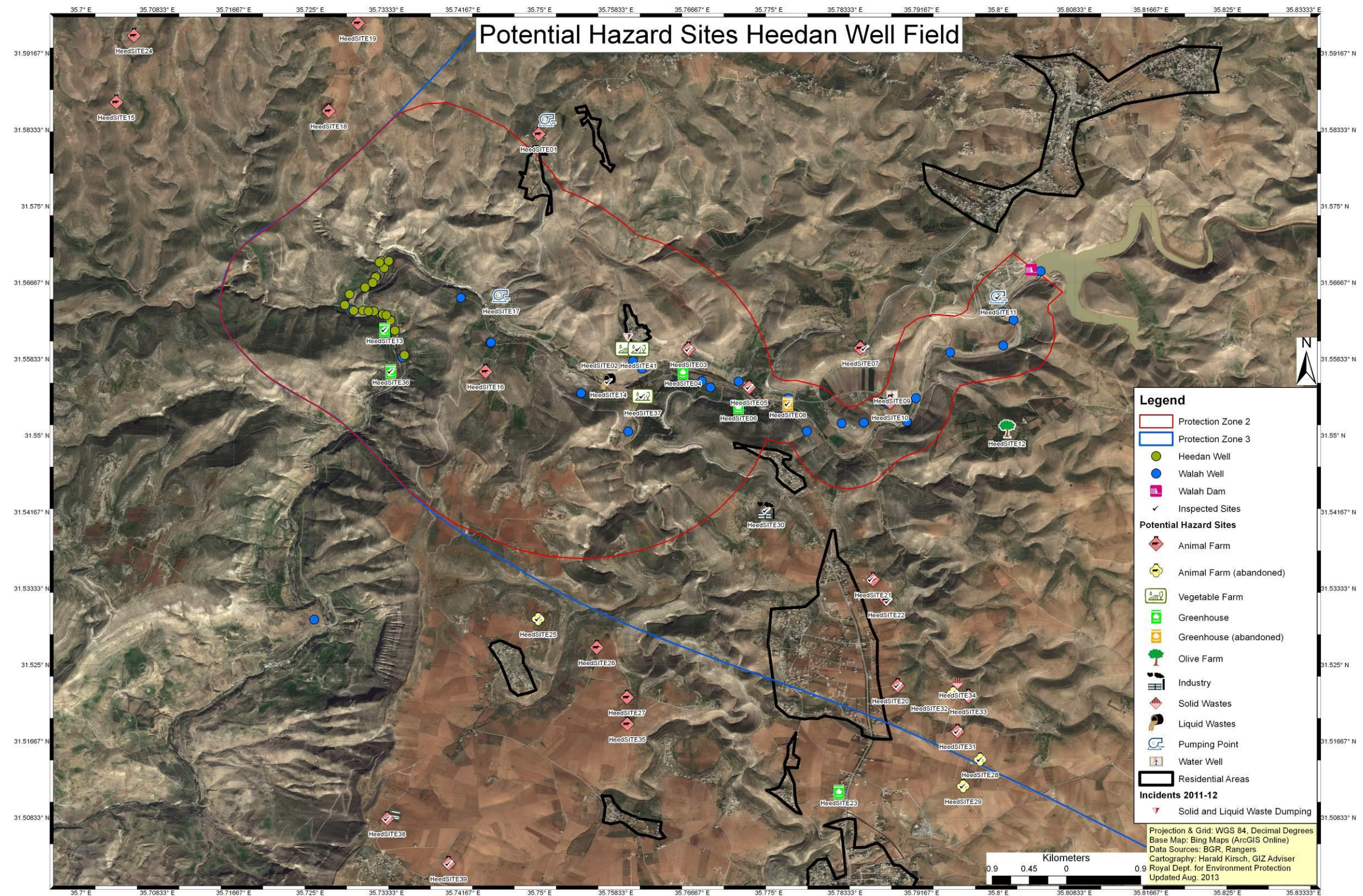


Figure 29: Potential Hazard Sites for Hidan Well Field

Table 2: Inspection sites Hidan well field (Coordinates WGS 84 Decimal Degrees)

Name	Latitude	Longitude	Description	Remarks	Inspection complete	Type
HeedSITE01	31.58288	35.74990	Chicken farm	Sinokrot Company, no violations, inspected by Technical Office & Madaba branch 22.10.13	yes	Egg production
HeedSITE02	31.55945	35.75938	Farm	Seems to belong to Heed Site41	yes	Vegetable Farm
HeedSITE03	31.55940	35.76622	Chicken Farm	Inspected 29.5.12 by BGR, GIZ, Rangers Technical Office; Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE04	31.55688	35.76563	Tree nursery	seen by Technical Office & Madaba branch 22.10.13	yes	Trees
HeedSITE05	31.55525	35.77284	Farm, goats, wheat storage	Visited 29.5.12 by BGR, GIZ, Rangers Technical Office; Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE06	31.55309	35.77168	Fruit orchard	Former chicken farm, Inspected by Technical Office & Madaba branch 22.10.13	yes	Lemons & Oranges
HeedSITE07	31.55952	35.78496	Chicken, sheep, goat Farm	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Animal Farm
HeedSITE08	31.55344	35.77707	Green house	Inspected by Madaba Branch 2.10.12	yes	Greenhouse (abandoned)
HeedSITE09	31.55441	35.78842	Water pond Well CD 1099	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Water Well
HeedSITE10	31.55362	35.78819	Farm, greenhouse, sheep	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Animal Farm
HeedSITE11	31.56510	35.80003	Water pond, pump for fire brigade	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Pumping Point

German-Jordanian Technical Cooperation – Water Aspects in Land-Use Planning
Delineation of Groundwater Protection Zones for Hidan Well field

Name	Latitude	Longitude	Description	Remarks	Inspection complete	Type
HeedSITE12	31.55073	35.80094	agriculture		no	Olive Farm
HeedSITE13	31.56152	35.73310	green house	Inspected by Madaba Branch 2.10.12	yes	Greenhouse
HeedSITE14	31.55586	35.75749	Illegal car wash site	Checked 29.5.12 by BGR, GIZ, Rangers Technical Office; Inspected by Madaba Branch 2.10.12	yes	Liquid Wastes
HeedSITE15	31.58635	35.70385	Cow farm?		no	Animal Farm
HeedSITE16	31.55698	35.74411	Sheep barn, Manure	Inspected by Technical Office & Madaba branch 22.10.13	yes	Animal Farm
HeedSITE17	31.56522	35.74581	Industry?		no	Industry
HeedSITE18	31.58538	35.72700	Cow or sheep farm		no	Animal Farm
HeedSITE19	31.59496	35.73018	chicken farm		no	Animal Farm
HeedSITE20	31.52272	35.78903	chicken farm, olive trees	Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE21	31.53428	35.78635	Horse stable & sheep farm	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Animal Farm
HeedSITE22	31.53212	35.78780	chicken farm, olive trees	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Animal Farm
HeedSITE23	31.51114	35.78264	green houses for planting		no	Greenhouse
HeedSITE24	31.59361	35.70578	Former farm or industry?		no	Animal Farm
HeedSITE25	31.52998	35.74984	chicken farm	Inspected by Madaba Branch 2.10.12	yes	Animal Farm (abandoned)
HeedSITE26	31.52689	35.75621	chicken farm		no	Animal Farm
HeedSITE27	31.52144	35.75951	chicken farm, olive trees		no	Animal Farm
HeedSITE28	31.51467	35.79801	chicken farm, olive trees	Inspected by Madaba Branch 2.10.12	yes	Animal Farm (abandoned)
HeedSITE29	31.51175	35.79617	chicken farm, olive trees	Inspected by Madaba Branch 2.10.12	yes	Animal Farm (abandoned)
HeedSITE30	31.54183	35.77469	Ministry of Public Works and Housing; Maintenance and construction facility	Inspected 16.9.12 by BGR, GIZ, Rangers Technical Office	yes	Industry

German-Jordanian Technical Cooperation – Water Aspects in Land-Use Planning
Delineation of Groundwater Protection Zones for Hidan Well field

Name	Latitude	Longitude	Description	Remarks	Inspection complete	Type
HeedSITE31	31.51774	35.79556	chicken farm, olive trees	Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE32	31.52192	35.79509	Animal Farm, suspected drain from manure dumps North and South of building	Inspected by Madaba Branch 2.10.12	yes	Animal Farm (abandoned)
HeedSITE33	31.52156	35.79674	chicken farm, olive trees	Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE34	31.52300	35.79556	Sheep barn, Manure?		no	Solid Wastes
HeedSITE35	31.51853	35.75956	Chicken farm, same compound as site 27?		no	Animal Farm
HeedSITE36	31.55699	35.73377	greenhouse	Inspected by Madaba Branch 2.10.12	yes	Greenhouse
HeedSITE37	31.55427	35.76123	vegetable farm	Inspected by Madaba Branch 2.10.12	yes	Vegetable Farm
HeedSITE38	31.50822	35.73337	chicken farm	Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE39	31.50333	35.74007	chicken farm	Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE40	31.49835	35.75624	chicken farm	Inspected by Madaba Branch 2.10.12	yes	Animal Farm
HeedSITE41	31.55943	35.76078	vegetable farm	Inspected by Madaba Branch 2.10.12	yes	Vegetable Farm

7. Recommendations

The productivity of Hidan well field is severely reduced due to the temporarily contamination of the pumped groundwater. Such events occur during every rainy season and are characterized by high fecal bacteriological pollution which leads to the shutdown of the well field. Shutting down the well field creates a tremendous shortcut in the water supply of Madaba. In order to improve the water supply by the well field, the following recommendations are given:

- The salt tracer test (section 4.3) confirmed a direct connection between surface water and the pumped groundwater from Hidan well field. Surface water during flood events is highly contaminated, but pollution sources of the surface water could not be narrowed down (section 4.4.1). Hence, measures for the protection of groundwater from infiltrating surface water should be prioritized. The construction of concrete structures to prevent the infiltration of contaminated surface water to the well field can be considered, but need a detailed analysis of preferential flow paths along the wadi.
- Protection zone 1 has to be equipped with fences and signposts. Only a few wells are sufficiently protected (CD3141, CD 3243, for detailed descriptions of the status of fences see Annex 1). Many wells are lacking of a fence and are accessible to local Bedouins with their sheep, leaving animal excrements inside protection zone 1 (Figure 30). Nevertheless, the installation of fences should be coordinated with the local farmers, who have been farming in Hidan before the wells were drilled. They are sometimes using water from the sampling hoses of the wells for irrigation. Access to well water has to be arranged for the local people. An uncoordinated erection of fences and an exclusion of local farmers will most certainly lead to the destruction of fences.



Figure 30: Grazing sheep inside protection zone 1

- Most of the well heads are not sufficiently sealed. Often, an open hole is left in the casing for the installation of the electric cables of the pump (Figure 31). Consequently, intentional (pouring or dropping of substances) or unintentional (mice, rats, etc. falling into the well head) contamination can occur directly at the pumped well. In some cases a cement base of the wells is also missing (see Annex 1).



Figure 31: Open cable installation at the well head

- During the site selection process for new wells, the sufficiency of distances to roads and buildings must be considered according to the guideline for drinking water protection.

- Illegal pumps are operated inside the well field by local farmers to pump water out of water pools in the wadi to their farms. The operation of the pumps and leaking fuel tanks can cause significant contamination with hydrocarbons (Figure 33). Awareness rising among the local farmers is a necessary precaution. Furthermore, instructions and regulations on the storage of hazardous substances such as oil tanks are needed.
- The abandoned wells are left open. They have to be sufficiently backfilled, sealed (e.g. with cement) and closed at the top to make sure that no surface water can enter directly to the groundwater (Figure 32).



Figure 32: Abandoned well next to a dirt road

- Agricultural activities inside protection zone 2 have to be analyzed based on their use of fertilizers and pesticides. If agricultural practices are not compliant with the water protection guideline they have to be changed in order to reduce the input of nitrate and bacteria from the application of unfermented animal manure. Only organic farming is allowed inside protection zone 2. Hence, the concept and benefits of it should be explained and demonstrated to the farmers.
- Villages in the vicinity of the project area should be connected to a sewer system. Often, septic tanks are not regularly emptied and therefore leak into the aquifer,

causing groundwater contamination. Until now it could not be identified whether bacteriological contamination in the well field is anthropogenic or from animals.

- Until now, protection zone 2 includes an area of 23.6 km², making it difficult to implement all related restrictions in the whole area. It is possible to narrow down the area of protection zone 2 with better information derived e.g. from further tracer tests. Hence, it is recommended to conduct additional tracer tests for a verification of the results and a better understanding of the hydrogeological situation around Hidan well field. A detailed structural map should also be prepared. Afterwards, the size of the protection zones should be reevaluated.
- In 2012, water from the Wala dam reservoir was infiltrated into the aquifer for the first time through the recharge wells. Bacteriological contamination occurred in Hidan well field at about the same time. Further tracer tests could also be helpful to clarify whether the injection of surface water via the injection wells has an influence on the water quality in Hidan well field, especially because the injection wells are located inside protection zone 2.



Figure 33: Illegal water pump with dangerous storage of diesel

Literature

- Abdulla, F. and T. Al-Assa'D (2006): Modeling of groundwater flow for Mujib aquifer, Jordan. *Journal of Earth System Science* 115, 289–297.
- Al-Hunjul, N. (1995): The Geology of Madaba Area: Map Sheet No. 3153 II, 1:50,000. The Hashemite Kingdom of Jordan, Ministry of Energy and Mineral Resources, Natural Resources Authority, Geology Directorate, Geological Mapping Division, Amman.
- Bajjali, W. and N. Abu-Jaber (2001): Climatological signals of the paleogroundwater in Jordan. *Journal of Hydrology* 243, 133 – 147.
- Borgstedt, A., A. Margane, et al. (2007). Delineation of groundwater protection zones for the Corridor wellfield. . Groundwater Resources Management. Technical cooperation. Project No: 2005.2110.4. Amman: 173.
- Coyne et Bellier, Ingema, Montgomery Watson & Arabtech Jardaneh(2003): Wala Dam Project – Completion Report. – Unpublished report prepared for EU Commission and Jordan Valley Authority; Paris, Rabat, Amman.
- Gassen, N. (2013): Delineation of Groundwater Protection Zones for AWSA Well Field. Technical Cooperation Project 'Water Aspects in Land Use Planning'. Technical Report No.2, prepared by BGR and MWI, 98p., Amman.
- Gassen, N. and Stoeckl, L. (2013): Conceptual Model for a Tracer Test in Wadi Hidan. Technical Cooperation Project 'Water Aspects in Land Use Planning'. Technical Report No.1, prepared by BGR and MWI, in co-operation with Julian Xanke (KIT), 37p., Amman, Hannover and Karlsruhe.
- Heise, J., Hiasat, T.(2011): Community-based awareness-raising activities on groundwater protection and conservation in Ain Rahoub/Al-Mughayyir. A baseline assessment. Special report No.2, prepared by BGR and MWI, 85p., Amman.
- Hoetzel, H., P. Moeller, and E. Rosenthal (2009): The Water of the Jordan Valley; Scarcity and Deterioration of Groundwater and Its Impact on the Regional Development. Springer London, Limited.
- Howard Humphreys & Partners, Studio Pietrangeli & Masar Engineering (1992): Dams on Wadi Wala and Wadi Mujib – Final Report – Volume I: Geology, Part IV - Site Investigation. – Unpublished reports prepared for EU Commission and Jordan Valley Authority; Leatherhead, Rome, Amman.

- Langguth, H. and R. Voigt (2004): Hydrogeologische Methoden; Mit 304 Abbildungen. Hochschultext / Universitext. Springer-Verlag GmbH.
- Margane, A., Hobler, M., Ouran, S. & Al Zuhdy, A. (1999): Groundwater Resources of Northern Jordan – Special Report No. 5: Hydrogeological Proposal for the Delineation of a Groundwater Protection Area for the Tabaqat Fahl (Pella) Spring. - Technical Cooperation Project 'Groundwater Resources of Northern Jordan', BGR & WAJ, BGR-archive no. 119256; Amman and Hannover.
- Margane, A. & Sunna, N. (2002): Proposal for a National Guideline for the Delineation of Groundwater Protection Zones. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 1, prepared by BGR & MWI, BGR archive no. 0125645, 161 p.; Amman.
- Margane, A., Borgstedt, A., Subah, A., Hajali, Z., Almomani, T. (2006): Delineation of Groundwater Protection Zones for the Rahoub Spring. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 7, prepared by BGR & MWI, BGR archive no. 0126944, 97 p.; Amman.
- Margane, A., Subah, A., Hajali, Z., Almomani, T., Koz, A. (2008): Delineation of Surface Water Protection Zones for the Mujib Dam. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 10, prepared by BGR & MWI, BGR archive no. 0128312, 132 p.; Amman.
- Margane, A., Borgstedt, A., Hamdan, I., Subah, A., Hajali, Z. (2009a): Delineation of Surface Water Protection Zones for the Wala Dam. Groundwater Resources Management. Technical cooperation. Project No: 2005.2110.4. Amman. Technical Report No 12: 126p.
- Margane, A., Subah, A., Hamdan, I., Hajali, Z., Almomani, T., Kilani, S., Hahne, K., Trappe, J., (2009b). Delineation of Groundwater Protection Zones for the Springs in Wadi Shuayb. –Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 14, prepared by BGR & MWI, BGR archive no.012xxxxx, 98 p.; Amman.
- Margane, A., Schelkes, K., Schroeder, W., Subah, A., Borgstedt, A., Schmall, A. (2009c). 50 Years of International Cooperation between BGR and Jordan. A Story of Success. Bundesanstalt fuer Geowissenschaften und Rohstoffe, Hannover
- Margane, A., Subah, A., Hamdan, I., Borgstedt, A., Almomani, T., Al-Hasani, I., Hajali, Z., Jaber, A., Smadi, H. & Mamoon, I. (2009d): Delineation of Groundwater Protection Zones for the Hallabat Wellfield. – Technical Cooperation Project 'Groundwater Resources Management', Technical Report No. 13, prepared by BGR & MWI, BGR archive no. 012xxxxx, 182 p.; Amman.
- Margane, A., Subah, A., Hamdan, I., Almomani, T., Hajali, Z., Ma'moun, I., Al-Hassan, I. & Smadi, H. (2010): Delineation of Groundwater Protection Zones for the Lajjun, Qatrana, Sultani and

Ghweir Wellfields. – Technical Cooperation Project ‘Groundwater Resources Management’, Technical Report No. 9, prepared by BGR & MWI, BGR archive no. 012xxxxx, 292 p.; Amman.

Masri, A. (2003): The Geology of Dhiban (Wadi al Mujib) Area - Map Sheet No. 3152-1. – NRA, Geol. Bull., 54, 92 p; Amman.

Shawabekeh, K. (1996): Geological Map of Main area, Map Sheet No. 3153-III, 1:50,000. The Hashemite Kingdom of Jordan, Ministry of Energy and Mineral Resources, Natural Resources Authority, Geology Directorate, Geological Mapping Division, Amman.

Steinel, A. (2012): Aspects for assessment and implementation of managed aquifer recharge (MAR) in (semi-)arid regions. Pre-feasibility study for infiltration of floodwater in the Amman-Zarqa and Azraq basins, Jordan. Technical Cooperation Project ‘Managed aquifer recharge’, BGR&MWI, BGR-Archive No.:ELVIS: B80134-08_03, Hannover

Subah, A., Hobler, A., Zuhdi, Z., Ouran, S., Khalifa, N., Rayyan, M., Atrash, M., Jaber, A., Hijazi, H., Al-Momani, M., & Momani, T. (2004): Hydrogeological Proposal for the Delineation of a Groundwater Protection Area for the Qunayyah Spring. - Technical Cooperation Project ‘Groundwater Resources Management’, BGR & MWI, BGR-archive no. 126726; Amman and Hannover.

Subah, A., Hobler, A., Hajali, Z., Khalifa, N., Momani, T., Atrash, M., Ouran, S., Jaber, A. & Tarawneh, R. (2006): Hydrogeological Proposal for the Delineation of a Groundwater Protection Area for the Wadi Al Arab Wellfield. - Technical Cooperation Project ‘Groundwater Resources Management’, BGR & MWI, BGR-archive no. 126796; Amman and Hannover.

Ta’any, R.A., Al Atrash, M. (2010): Effects of Wala Dam on the Groundwater of Wala Catchment Area. - Unpublished Report prepared at Al Balqa Applied University and Ministry of Water and Irrigation.

The World Bank (2005): Madaba, Economic Profile. Annex 3 of the Secondary Cities Revitalization Study, Third Tourism Development Project.

World Health Organization (2006): Protecting Groundwater for Health: Managing the Quality of Drinking-water Sources. Edited by O. Schmoll, G.Howard, J.Chilton and I.Chorus. ISBN 1843390795. Published by IWA Publishing. London. UK.

Annex 1: Well Sheets

ID: CD 3132	
Name: Heedan 2	
PBN: 1107865	PBE: 219802
Altitude (m .a.s.l): 339	Total Depth (m): 148
Aquifer: B2/A7	Yield: 184
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1	
Wellhead and Gates: Remarks	- The gate is open. - The status of the fence is good. - There is an opening on the well head to inter the electricity cable. - the concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign.  
Recommendations for PZ1:	- The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3133	
Name: Heedan 2	
PBN: 1108098	PBE: 219524
Altitude (m ASL): 420	Total Depth (m): 59
Aquifer: B2/A7	Yield: 28
Conductivity [m/d]:	TRANSMISIVITY (m ² /hr): 5
Remarks: Observation Well CD3133 is not sufficiently protected. The wellhead should have a proper concrete basement. The access to the observation well has to be managed. At the moment, the casing is not sealed, permitting direct access to the groundwater	
Wellhead and Gates:	

ID: CD 3136	
Name: Heedan 5	
PBN: 1108051	PBE: 219418
Altitude (m .a.s.l): 350	Total Depth (m): 137
Aquifer: B2/A7	Yield: 205
Conductivity [m/d]:	Transmissivity (m ² /hr): 15599
Protection Zone 1: Legend: Optimal PZ 1	
Wellhead and Gates: Remarks	- The gate is open. - The status of the fence is good. - There is an opening on the well head to inter the electricity cable. - The concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign.  
Recommendations for PZ1:	- The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3137	
Name: Heedan 6	
PBN: 1108107	PBE: 219230
Altitude (m .a.s.l): 353	Total Depth (m): 86
Aquifer: B2/A7	Yield: 205
Conductivity [m/d]:	Transmissivity (m ² /hr): 989
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- There is no gate - The status of the fence is bad - low Concrete base - There is an opening on the well head to inter the electricity cable. - There is no PZ 1 sign. 
Recommendations for PZ1:	- In order to implement PZ1, the fence should be fixed or replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3138	
Name: Heedan 7	
PBN: 1108159	PBE: 219280
Altitude (m .a.s.l): 360	Total Depth (m): 56
Aquifer: B2/A7	Yield: 325
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- The gate is open. - The status of the fence is good. - The concrete basin of the well is higher than the Ground level - There is no PZ 1 sign. 

ID: CD 3139	
Name: Heedan 8	
PBN: 1107934	PBE: 219703
Altitude (m .a.s.l): 354	Total Depth (m): 108
Aquifer: B2/A7	Yield: 77
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- The gate is open. - There is a gap on the fence. - There is an opening on the well head to inter the electricity cable. - There is no PZ 1 sign. 
Recommendations for PZ1:	- In order to implement PZ1, the fence should be fixed. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3141	
Name: Heedan 10	
PBN: 1108388	PBE: 219491
Altitude (m .a.s.l): 350	Total Depth (m): 81
Aquifer: B2/A7	Yield: 207
Conductivity [m/d]:	Transmissivity (m ² /hr): 960
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- The gate is closed by a piece of wire - The status of the fence is good. - low Concrete base - There is an opening on the well head to inter the electricity cable. - There is no PZ 1 sign. 
Recommendations for PZ1:	- The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3144	
Name: Heedan 13	
PBN: 1108628	PBE: 219682
Altitude (m .a.s.l): 355	Total Depth (m): 126
Aquifer: B2/A7	Yield: 220
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- The gate is open. - The status of the fence is bad - There is an opening on the well head to inter the electricity cable. - The concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign.  
Recommendations for PZ1:	- In order to implement PZ1, the fence should be totally replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3243	
Name: Heedan 15	
PBN: 1108603	PBE: 219633
Altitude (m .a.s.l): 365	Total Depth (m): 130
Aquifer: B2/A7	Yield: 231
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: remarks	The gate is open. The status of the fence is good. There is an opening on the well head to inter the electricity cable. the concrete basin of the well should be higher than the Ground level There is no PZ 1 sign.
	 
Recommendations for PZ1:	- The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3363	
Name: Heedan 12 A	
PBN: 1108459	PBE: 219532
Altitude (m .a.s.l): 360	Total Depth (m): 110
Aquifer: B2/A7	Yield: 200
Conductivity [m/d]:	Transmissivity (m ² /hr): 1920
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: remarks	There is no gate. no fence There is an opening on the well head to inter the electricity cable. The concrete basin of the well should be higher than the Ground level. There is no PZ 1 sign.  
Recommendations for PZ1:	- In order to implement PZ1, the fence should be totally replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

ID: CD 3368	
Name: Heedan 16 A	
PBN: 1108650	PBE: 219600
Altitude (m .a.s.l): 353	Total Depth (m): 185
Aquifer: B2/A7	Yield: 100
Conductivity [m/d]:	Transmissivity (m ² /hr): 427
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- There is no gate. - no fence - There is an opening on the well head to inter the electricity cable. - The concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign.  
Recommendations for PZ1:	- In order to implement PZ1, the fence should be totally replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

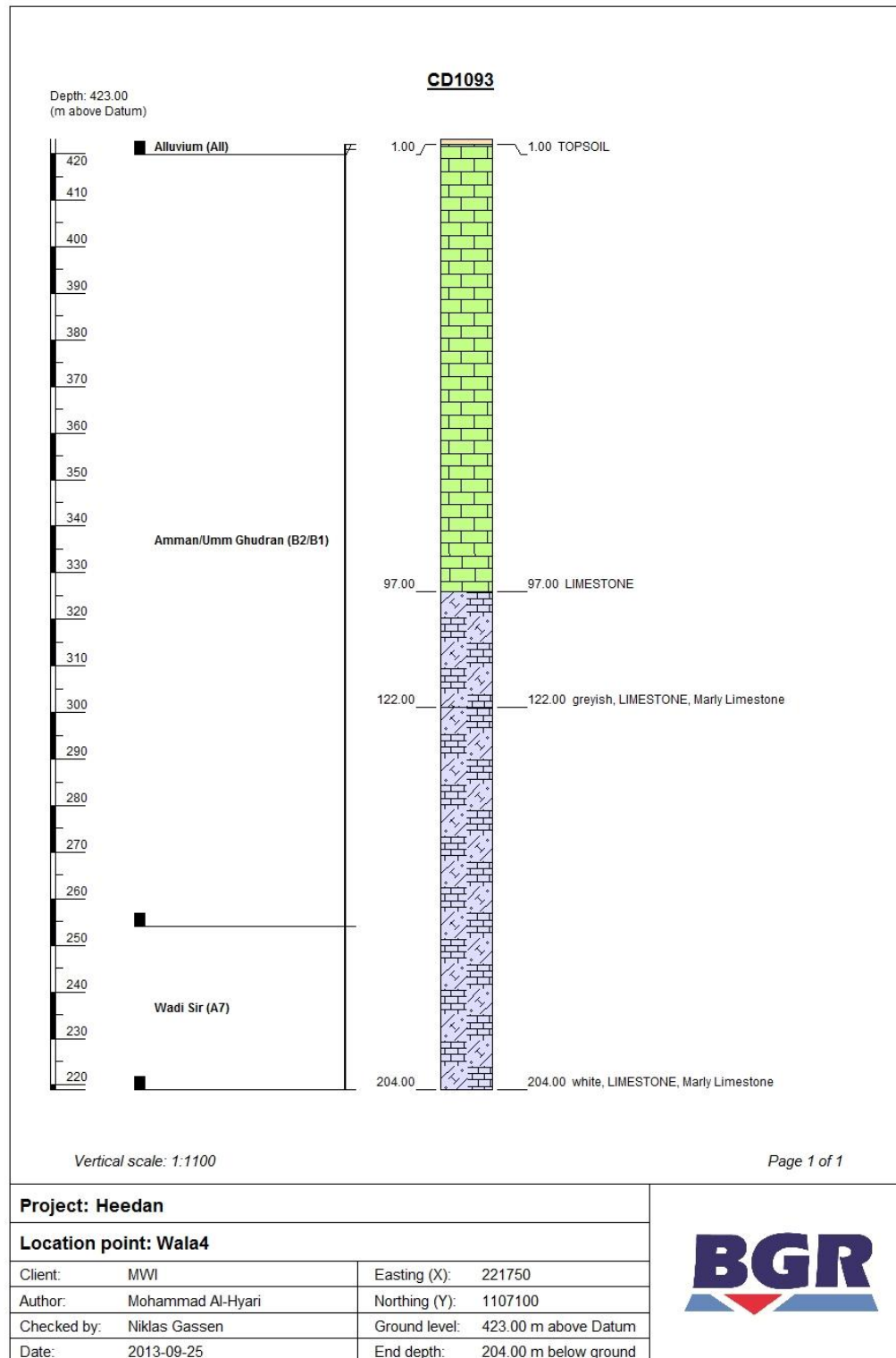
ID: CD 3474	
Name: Heedan 12 B	
PBN: 1108575	PBE: 219550
Altitude (m .a.s.l): 400	Total Depth (m): 158
Aquifer: B2/A7	Yield: 240
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- There is no gate. - No fence - There is an opening on the well head to inter the electricity cable. - The concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign. 
Recommendations for PZ1:	- In order to implement PZ1, the fence should be replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

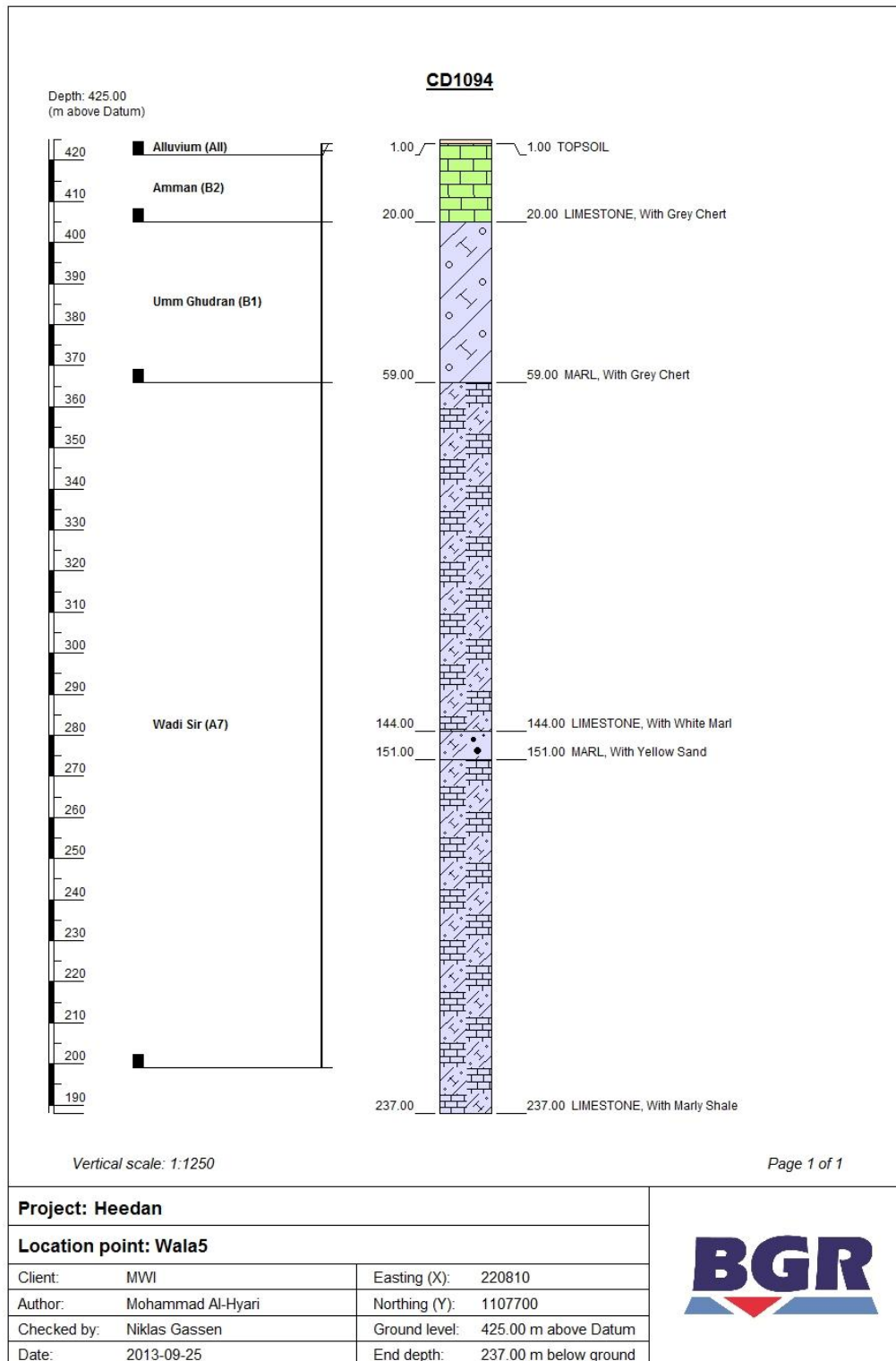
ID: CD 3474	
Name: Heedan 12 B	
PBN: 1108575	PBE: 219550
Altitude (m .a.s.l): 400	Total Depth (m): 158
Aquifer: B2/A7	Yield: 240
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend:  Optimal PZ 1	
Wellhead and Gates: Remarks	- There is no gate. - No fence - There is an opening on the well head to inter the electricity cable. - The concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign.  
Recommendations for PZ1:	- In order to implement PZ1, the fence should be replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

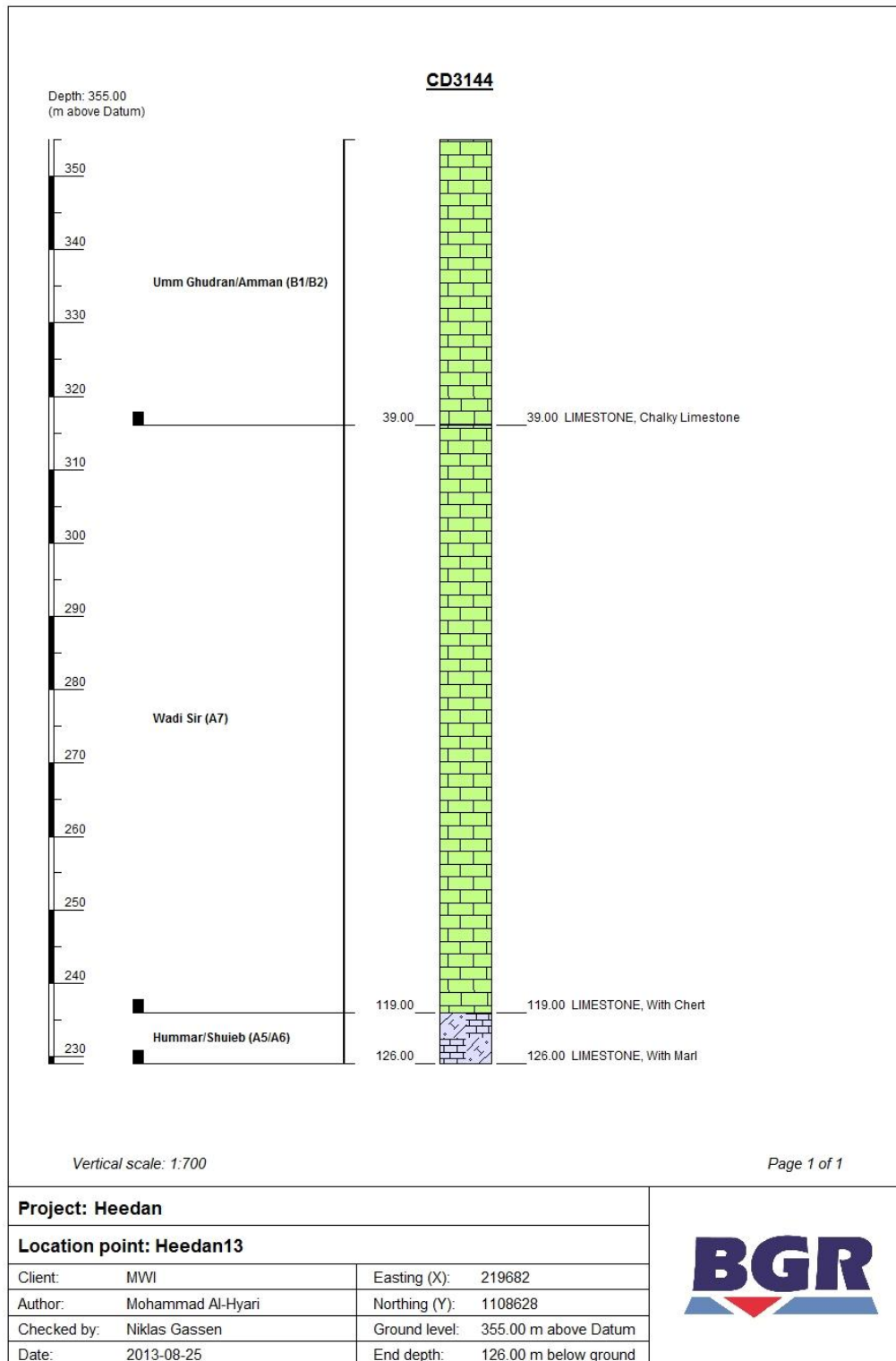
ID: CD 3475	
Name: Heedan 16 B	
PBN: 1108690	PBE: 219560
Altitude (m .a.s.l): 400	Total Depth (m): 185
Aquifer: B2/A7	Yield: 240
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- There is no gate. - No fence - There is an opening on the well head to inter the electricity cable. - The concrete basin of the well should be higher than the Ground level - There is no PZ 1 sign. 
Recommendations for PZ1:	- In order to implement PZ1, the fence should be replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

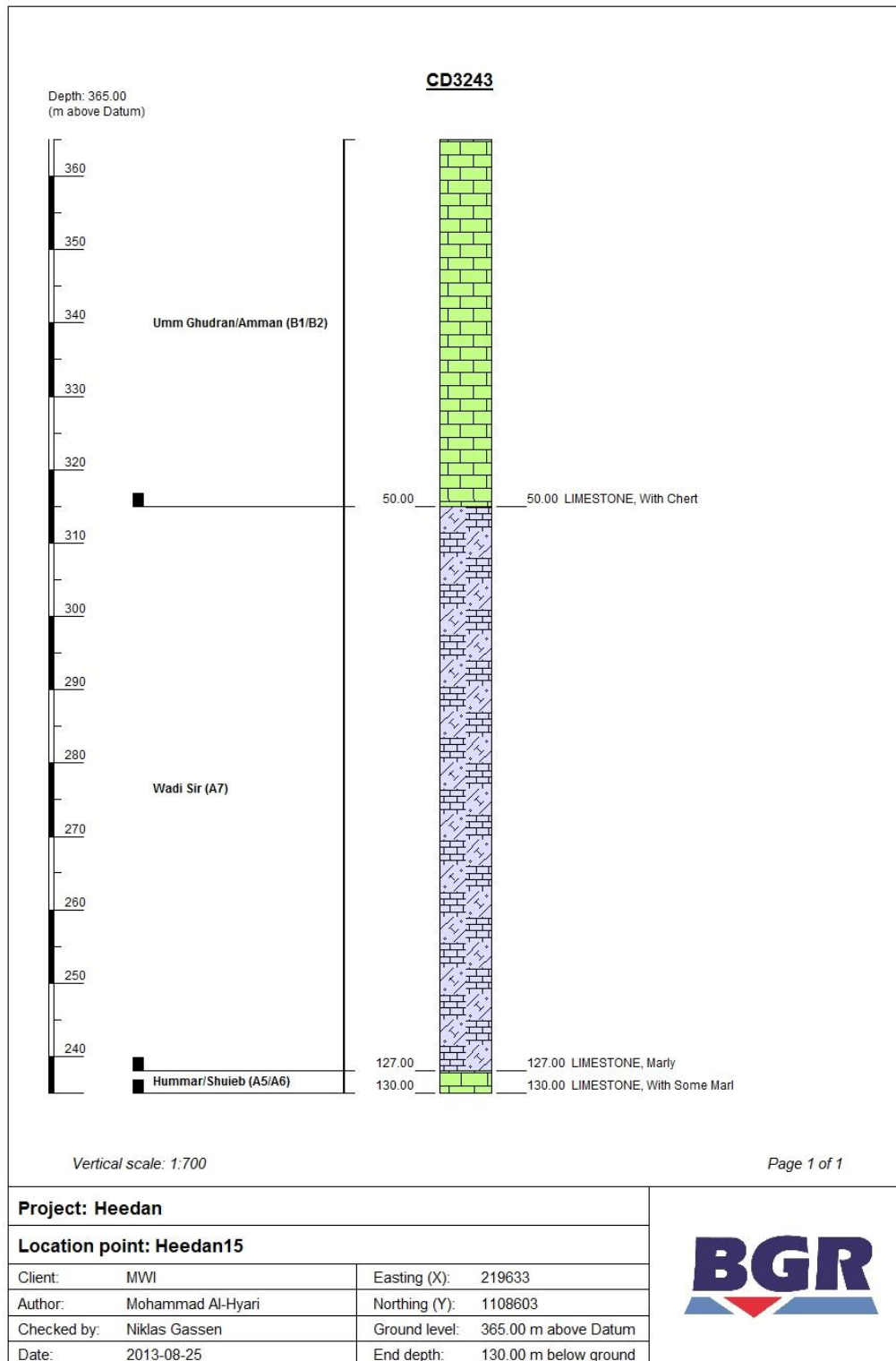
ID: CD 3581	
Name: Heedan 6 A	
PBN: 1108120	PBE: 219181
Altitude (m .a.s.l): 352	Total Depth (m): 185
Aquifer: B2/A7	Yield: 200
Conductivity [m/d]:	Transmissivity (m ² /hr):
Protection Zone 1: Legend: Optimal PZ 1 	
Wellhead and Gates: Remarks	- There is no gate - The status of the fence is bad - There is an opening on the well head to inter the electricity cable. - The electricity cable is unsecure - There is no PZ 1 sign.  
Recommendations for PZ1:	- In order to implement PZ1, the fence should be fixed or replaced. - The improper installation of the cables allow direct access to the casing. This should be properly installed.

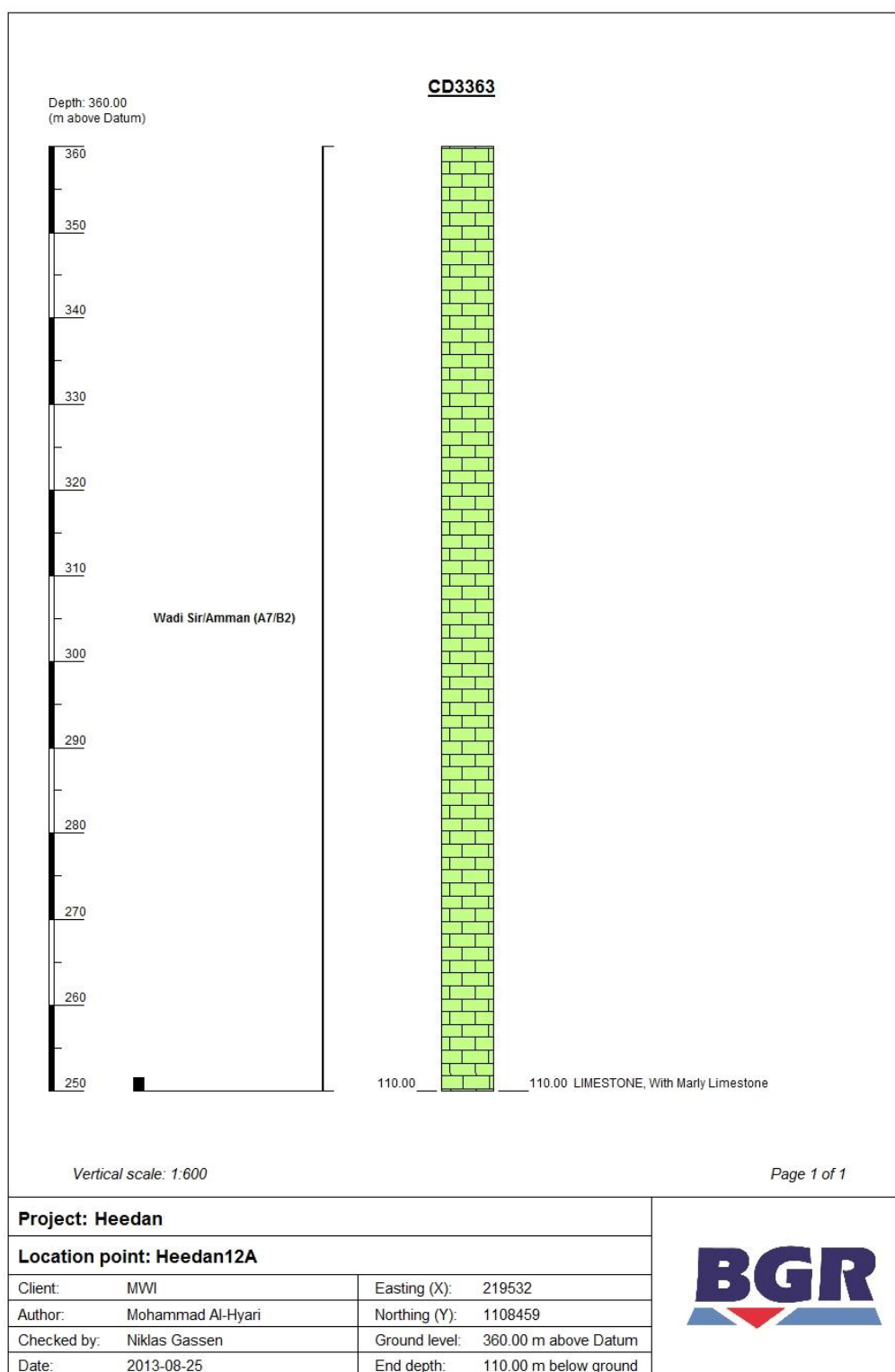
Annex 2: Well logs for Hidan wells

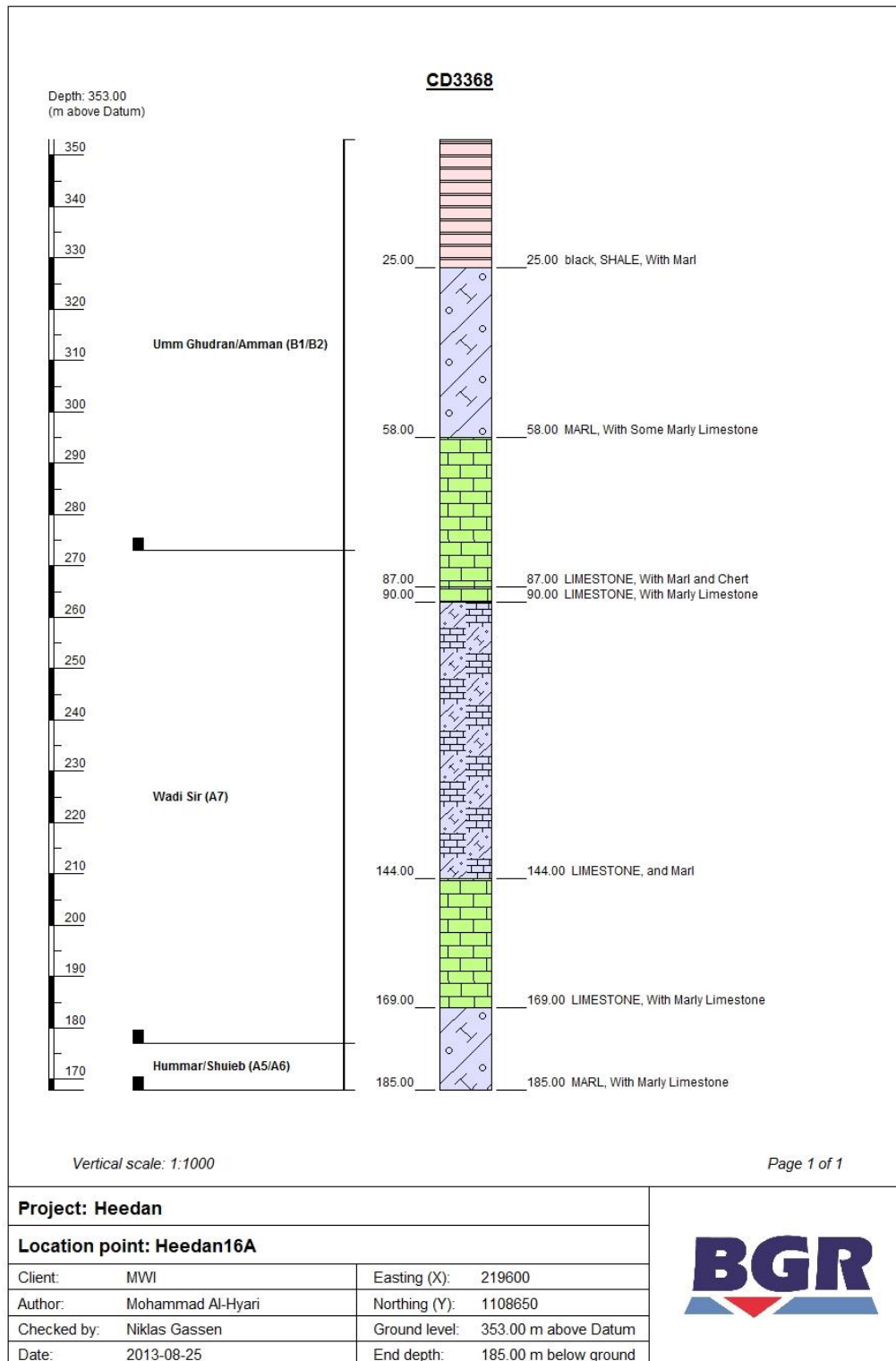


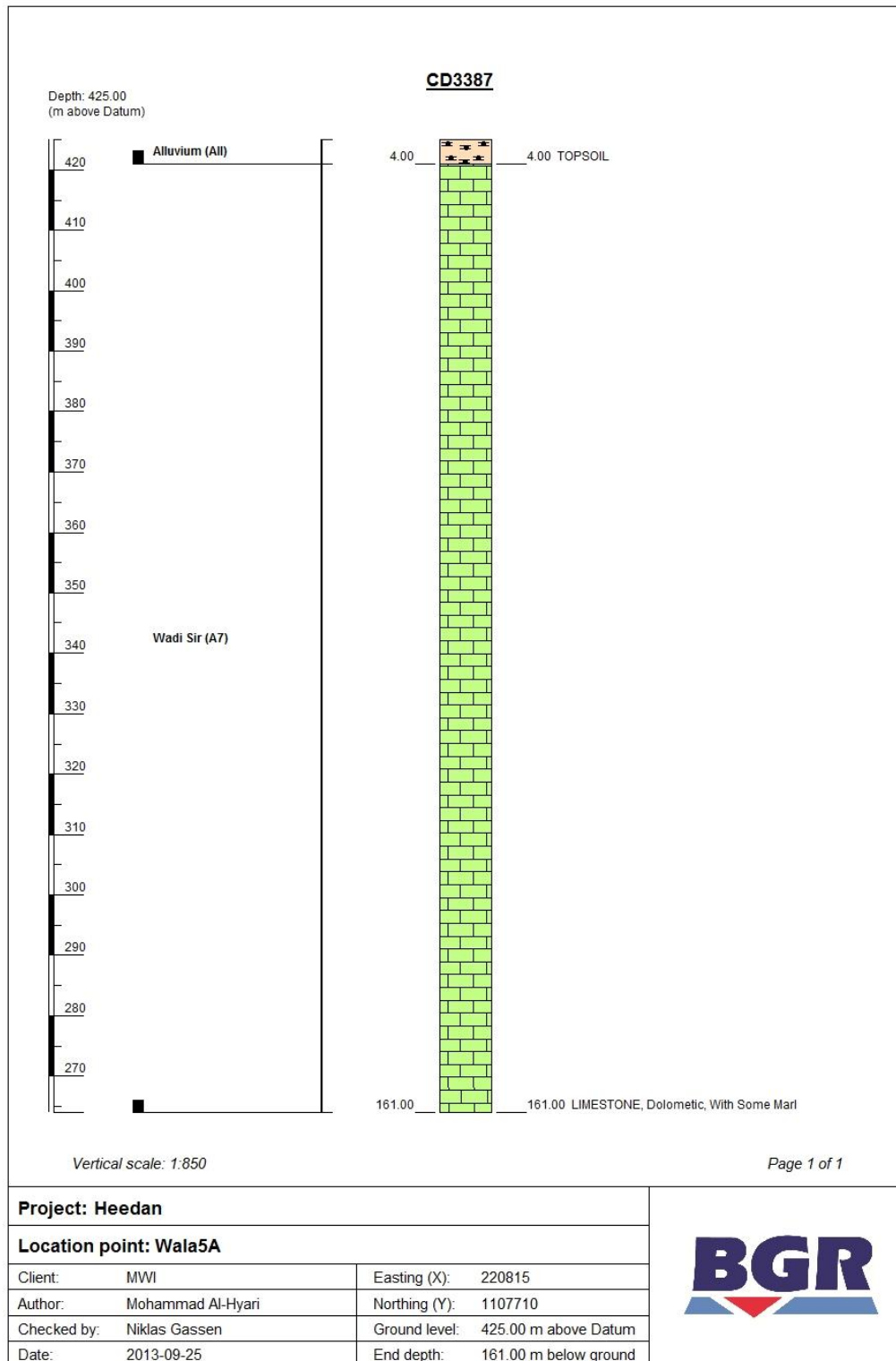


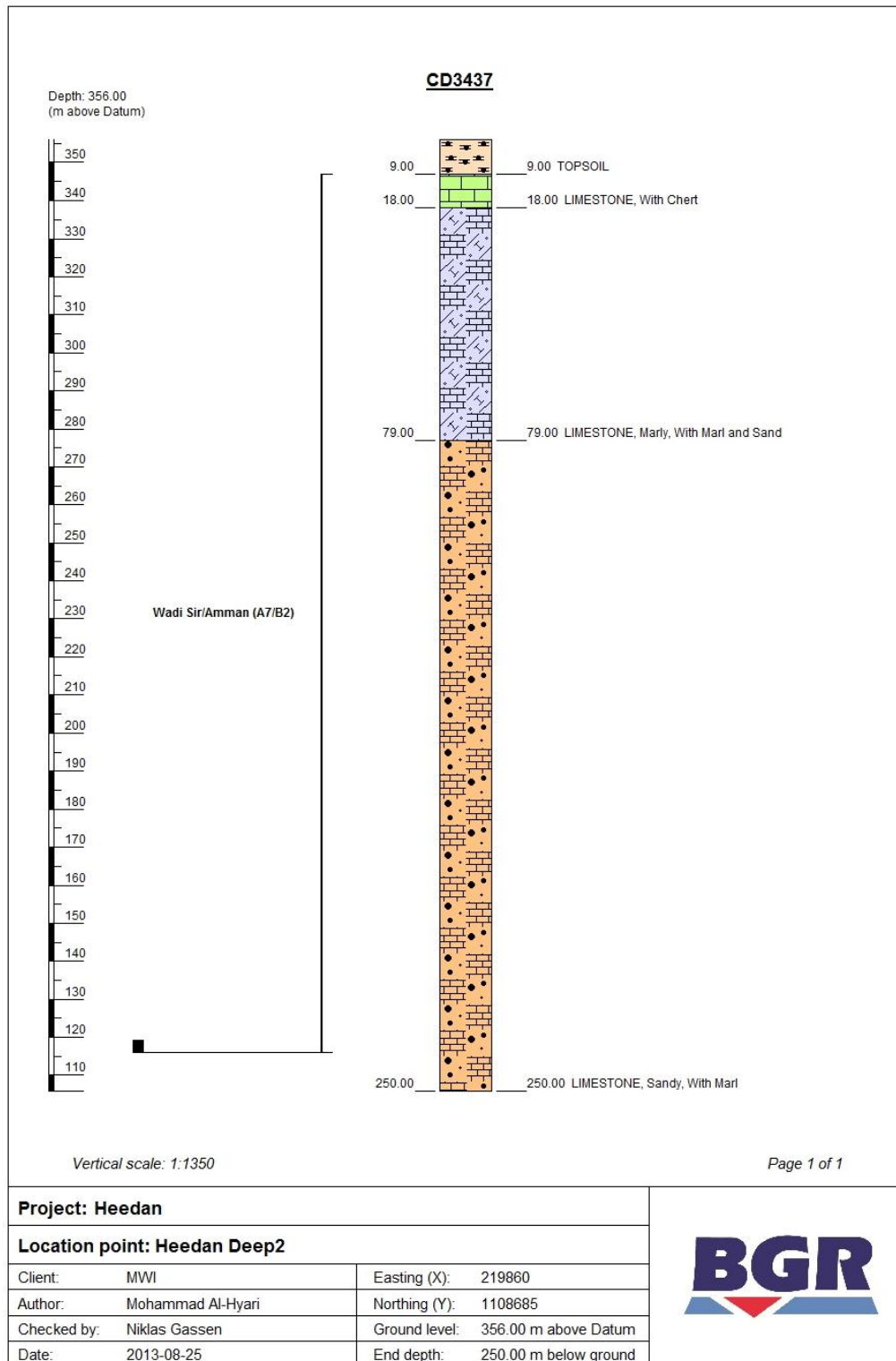












Annex 3: Quality data from flash floods

Table 3: Surface water quality analyses

Site	Date	pH	EC	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3	NO3	<i>E. coli</i>	Total coliform	Faecal coliform
Unit		[-]	[μS/cm]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	MPN/100 ml	MPN/100 ml	MPN/100 ml
Heedan 1	19.02.2012	7.28	776	80.56	26.39	49.68	3.91	80.23	93.12	0	262.91	9.31	23	23	23
	22.02.2012	7.86	944	82.56	31.5	72	3.52	94.79	113.3	0	308.66	8.04	790	3300	1300
Heedan 2	22.02.2012	8.2	960	89.98	32.4	75.2	3.52	97.27	116.6	0	328.79	7.42	2300	2300	2300
Heedan 3	19.02.2012	8.26	328	37.88	9.12	20.01	4.3	26.98	34.08	0	119.56	4.47	>1600	>1600	>1600
	22.02.2012	8.33	255	36.67	7.05	8.97	2.73	11.36	12	0.2	115.9	6.84	170	790	490
Heedan 4	19.02.2012	8.23	231	33.46	6.32	11.27	23.46	11.71	10.56	0	131.76	3.42	>1600	>1600	>1600
	22.02.2012	8.2	114	121	39.2	82.6	5.08	112.5	230.9	0	320.25	6.79	1700	24000	1700
Heedan 5	19.02.2012	8.29	337	39.08	9.12	18.63	2.4	26.27	32.64	0	1214.44	4.28	>1600	>1600	>1600
	22.02.2012	8.24	977	85.97	32.5	66.7	4.69	99.4	83.52	0	295.24	18.07	330	2300	330
Heedan 6	19.02.2012	8.28	335	38.88	9.24	19.55	2.2	26.98	32.64	0	126.88	4.1	>1600	>1600	>1600
	22.02.2012	8.36	973	88.18	34.3	68.5	4.69	121.4	102.7	0.39	267.79	23.16	790	4600	790
Heedan 7	22.02.2012	8.12	271	35.87	7.42	18.4	6.65	11.01	10.56	0	169.58	4.8	4900	>160000	7000

Annex 4: Photos



Figure 34: Surface water pool with inflow and no outflow, 150 m upstream of Hidan well field



Figure 35: Flexure upstream of Hidan well field

Annex 5: Water Resources Protection Guideline

- Unofficial translation -

Introduction

Water availability for various purposes is considered as one of the most important factors of development in any country in the world, and is of particular importance as it is closely linked to the quality of life in the areas of water scarcity, such as Jordan.

Jordan, like other countries in the region, affected by climate change phenomena that led to a change in the prevailing pattern, rainfall fluctuating average and time, succession of droughts seasons which become more severe than we knew for decades.

This style affects the environment in the Kingdom in general, including signs of desertification. It also has direct impact on the groundwater and surface water sources in particular; the kingdom depends mainly on groundwater resources to meet water needs for all sectors, especially household usages.

Jordan has started suffering a large deficit in its water resources since the last two decades. This suffering has increased in the past decade as a result of successive drought seasons witnessed by Jordan as well as the forced migrations which led to increase in the demand for water for different purposes of drinking, agriculture and industry so as to keep pace with progress and technology. This led to the depletion of many of surface water groundwater resources, drought of many springs, and change in the dynamic pattern associated with it. Problem of water in Jordan was not limited to scarcity, but also transcended to the deterioration in its quality and salinity as a result of depletion of groundwater on one hand, and the various humanitarian practices resulted from urbanization on the other hand.

Based on this, protection and conservation of water resources become an urgent and national need for optimal management of the already scarce resources and maximize benefit through the application of a national policy regarding the protection of surface and groundwater resources.

In this regard, the first step started through identification of the groundwater resources protection zones, and the application of rules and regulations in particular, as well as amendment of needed applicable laws so as to make it mandatory for the application.

These instructions submit limitation for areas and activities allowed or restricted or prohibited in each region and according to clear maps which will be adopted in the preparation of the kingdom master plans, based on the scientific considerations and the technical studies that are taken into account in the re-evaluation and modification

of sites of protection zones according to the surrounding local circumstances and the prevailing natural and environmental phenomena.

These instructions are not related to any legal or compensatory data. Also, it do not address the powers of other parties in the Kingdom concerned with issuing licenses. Various parties should refer to these instructions to license any facility or activity or project which may threaten the quality of water resources.

Requirements for protection zone delineation

Overview

Delineation of surface and groundwater resources protection zones requires reviewing the available information and studies to demonstrate their adequacy to assess the watersheds located within it. Also, water resources should be reviewed in terms of the geological and hydrological aspects, including the vulnerability maps and maps of protection zones. Information is updated when necessary to conduct the field survey.

Also, delineation of these areas requires considering criteria of selecting sites of determined activities planned by the Ministry of Environment, and licenses issued in this respect by Ministry of Municipal Affairs, Ministry of Agriculture, and Greater Amman Municipality. The following protection zones were adopted according to methodologies adopted all over the world. These protection zones are the first, the second, and the third protection zones for the surface and groundwater resources.

Basic data for evaluation purposes:

In order to conduct sound evaluation process, the following data and information relevant to water resources must be provided:

- General information on public and private drinking water resources under protection (name, operator, location, resource height, and the technical description).
- Basic information relevant to water of public and private wells; licenses of digging, extracting, and permission.
- Results of chemical, physical, and biological analysis conducted on water resources (raw water) for several year, either these analysis done by controlling parties or operating parties. These results indicate situation of recharge areas, water resources productivity, water quality, and contamination possibility.
- Hydrological and hydrogeological data and environmental isotopes relevant to water resource.

Instructions on Water Resources Protection

In order to protect and monitor water quality in water resources and based on the provisions of Articles (4) {a} and (44) of the groundwater monitoring by-law number (85) for the year 2002 and its amendments, the following instructions were issued:

These instructions are called "instructions on the protection of water resources for the year 2011"

Definition

The following words and phrases, wherever mentioned, shall have the following meanings unless the context indicates otherwise:

Ministry	Ministry of Water and Irrigation
Minister	Minister of Water and Irrigation
Secretary General	Secretary General of Ministry of Water and Irrigation Secretary General of Water Authority of Jordan Secretary General of Jordan Valley Authority
Water Authority Law	Water Authority applicable law no. (18) for the year 1988 and its amendments.
Jordan Valley Authority Law:	Jordan Valley Authority applicable law no. (18) for the year 1988 and its amendments.
Groundwater Control By-law and its amendments	By-law no.(85) for the year 2002
Groundwater	Water existing in subsoil and can be extracted through digging a well
Surface Water	All water bodies on surface; rivers or lakes or seas or permanent flow water or dams or ponds or springs water after flow
Spring	Water resource of ground origin. It flows to surface due to geological and hydrogeological factors; either continuous or intermittent

Aquifer	Layer of rock has the ability to store water ; this layer is solid cracked or fragmented and it have a permeable characteristic that allow movement and extracting of ground water
Groundwater recharge areas	Areas that fall under rain and snow accumulate on the surface or passing through the surface water resources and have permeable characteristics that allow water to seep into the ground to replenish groundwater
Main valley	Valley were flow of water lasts for six months or more
Well	Any hole or excavation occurred via machine or special tool used to access to groundwater aquifer to extract water by machine or automatically above surface.
Public well	Well owned by official parties or municipalities or companies manage water utility in governorates.
Private well	Well owned and exploited by non-formal parties and non-municipal ones.
Water contamination	Any change occur on the physical or chemical or microbiological or radium properties alone of in combination to limit the degree of suitability for the intended use.
Wastewater	Water resulted from household or industrial or agricultural utilizations.
Landfill	Site that includes the facilities and equipment for receiving waste with a view to disposal or treatment and storage.
Drinking water resources	Resources utilized or intended to be utilized for drinking purposes and household utilizations.
Watersheds	Is the area of land that falls under the rain or the water resources to supply the groundwater or surface water
Protection zones	Areas were various activities and practices are banned or restricted so as to protect the water resources from contamination and to limit negative impacts of these activities.
Karst layer	Is a limestone rock layer that contains the cavities and cracks, which are characterized by high permeability and

water movement is not homogeneous.

The time of the arrival of microbial contaminants	The time of the arrival of microbial contaminant from contamination resource to the water resource
Cesspool	Hole is created from impermeable concrete or any other material impermeable and insulated to prevent the entry of wastewater to the water layer according to the Jordanian specifications.
Public wastewater networks	All extensions, installations, facilities, and equipment for the transfer of wastewater from its production sites to the treatment plants
Cesspool	The hole specialized for the collection or disposal of wastewater and discharging it through the gaps and pores of the soil
Organic Agriculture	Agriculture that does not use any pesticides or chemical fertilizers
Population activities	Are the activities related to housing, tourism or trade and does not include development activity; artisanal or industrial or some activities such as fuel stations or washing cars or garages and olive presses

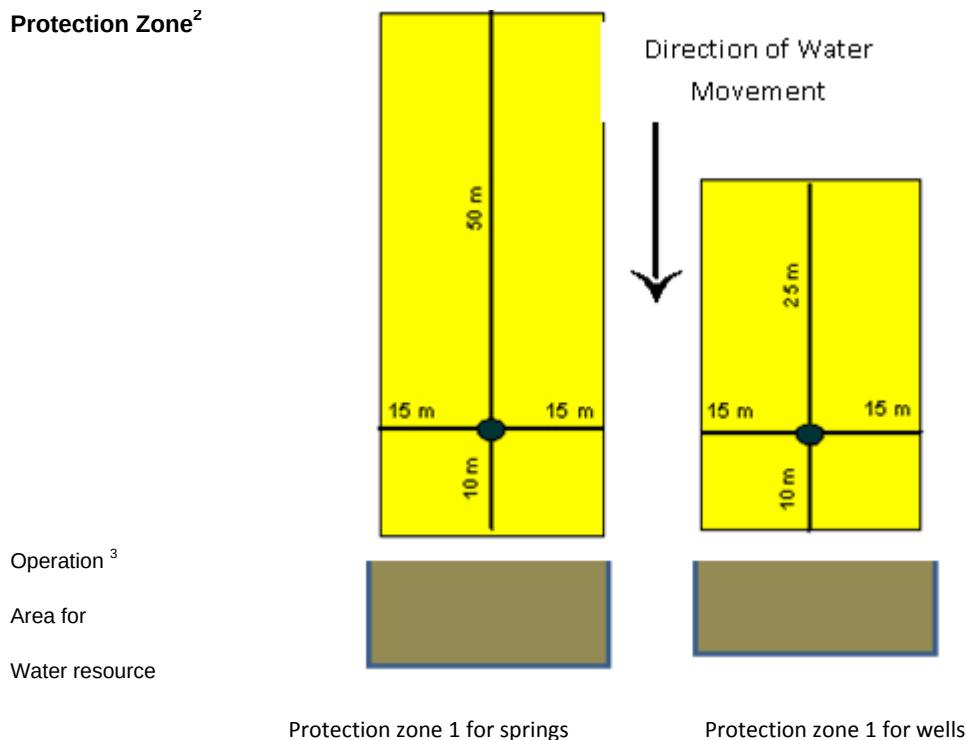
Groundwater Resources Protection Guidelines

Protection Zone:

■ Protection Zone I

- Zone I reaches at least 50 m and 25 m upstream of the spring or the well, respectively. The extension of the zone on both sides of the extraction point (spring/well) is around 15 m and 10 m in the downstream direction, as shown in Figures 1 and 2. Existing infrastructure and the current status of the area have to be taken into account.

Protection Zone²



- Each case is studied according to its nature so as to meet the sought purpose including lands allowed for acquisition and existing practices in the region (e.g: the surrounding area of some springs that exceeds (2) dunum and included within documents of lands and survey department, in this case, all acquired area is considered as protection zone I of the spring).
- ✓ Private wells and springs not utilized for drinking must comply with the limits of the protection zone I, to fix resulted distance of protection zone, to comply with terms of protection imposed on public wells as a condition for granting new

² Area of the water resource is the acquired area and/or fenced area surrounding the water resource

³ Any activity is forbidden in this area except for activities relating only to water resource operation provided that activity should be performed in a secure area below the water resource, taking into account the following regulations:

licenses⁴ and any type of licenses issued by the wells relevant authorities. The existing status should be taken into account when licensing wells, and each case should be studied alone.

- ✓ If there is cesspool, it should be given priority either to connect to the sewerage network in accordance with the regulations and instructions of sanitation or the adoption of technical procedures necessary for this cesspools according to the Jordanian specifications. Supervision should be intensified over these areas to ensure sound health and environmental conditions in this regard by the concerned parties.

▪ **Protection Zone II**

- ✓ Zone II is delineated referring to existing hydraulic information, technical studies and reports. Based on this information, MWI specialists will calculate the velocity of groundwater flow and define the boundary of the protection zone. The protection zone II comprises the area between the outer limit of Zone I and a virtual line from where groundwater flow will take 50 days until it reaches the spring or well. This distance between the spring/well and this boundary should not exceed 2 km in the upstream direction of the extraction point and 50 to 150 m in the downstream direction. Every case will be studied individually. In karst areas, groundwater vulnerability maps are used if available and the technical consultancy is considered
- ✓ The boundary of protection zone II is to be recalculated if more detailed information about the geology and hydrogeology becomes available, (e.g. aquifer description, hydraulic parameters, groundwater flow and velocity and other relevant information including hydro-isotope data, remote sensing data, tectonic data, geophysical data and mathematical groundwater models).
- ✓ Distance adopted as maximum for the second protection zone should be considered in case of availability of detailed studies with regard to the geological and hydrogeological situation, which represented in the properties of the layers, hydraulic elements, movement of groundwater and velocities, as well as applications of assistant science , including outlining the structural lines through remote sensing and applications of environmental isotopes, geophysical studies, and mathematical models of underground water reservoirs and others.

3 Granted licenses include: digging license, annual extracting license or annual license to sell valid or non-valid water

▪ **Protection Zone III**

The delineation of protection zone III comprises the entire groundwater recharge area for the well or spring. The procedure of defining the boundary of the groundwater catchment area (zone III) is based on hydrogeological considerations.

1.1 Activities allowed in Groundwater Water Protection Zones

- Activities allowed in Protection Zone I:
 - Operation of the well or water resource, provided that it should be constructed downstream of the extraction point, including the cesspools, fuel containers or chemicals storage facility.
 - ✓ First protection zone has to be implemented also for private wells. Private Wells are subject to the same protection conditions as governmental wells. This is an absolute condition for renewing the licenses of the wells (drilling license, annual abstraction license, or annual license for selling drinking water or other private licenses. The party responsible for the water resource should acquire the first protection zone where possible.
 - ✓ There should be adherence to the instructions on the signs inside the well protection zone. Irregularities should be inspected by concerned parties such as Ministry of Health, Ministry of Environment and other parties concerned with water resource protection in Ministry of Water and Irrigation, Water Authority of Jordan, and the Jordan Valley Authority.
 - ✓ Any trespassing against the first protection zone should be stopped; complete fencing of the area. The activities in this zone are limited to those related to the operation and management of the water resource. Environmental and constructional sound practices have to be undertaken.
 - ✓ Any installations necessary for operation and maintenance are to be designed in a way they cannot be hazardous to the groundwater.
 - ✓ Priority is given to the implementation of sewerage networks in areas of water resources where possible, or to construct cesspools according to the Jordanian specification in this regard.
- **Activities allowed in Protection Zone II:**
- Activities in Zone II are limited to residential activities and organic agriculture. Priority is to be given to the establishment of an appropriate sewerage network or a safe sub-surface disposal system (cesspools) in accordance

with the sewerage network by-law no. (66) of 1994 where possible, or to construct cesspools according to the Jordanian specification in this regard.

- Intensify control on these zones by ministry of Environment in coordination with other ministries and institutions according to its legal framework so as to ensure compliance with environmentally sound practices.
 - No licensing of new establishments, extensions or changes in use has to be given unless the responsible organization gives permission after referring to related studies and recommendations. If there are no such studies, new studies have to be conducted. Every case has to be treated individually and requires correction measures to be undertaken to prevent any negative impact on the water resources in this zone.
 - Agricultural development activities or existing industries which produce wastewater and may have an impact on the environment and on the water resources, are obliged to implement environmental sound practices according to the laws and by-laws applied in Jordan and comply with corrective measures decided by the responsible agencies⁵.
- **Activities allowed in Protection Zone III:**
All development, agricultural, industrial and social activities are allowed in this zone, under the condition that they comply with the laws and by-laws applied in the Hashemite Kingdom of Jordan and environmentally sound practices issued by Ministry of Environment.

4.1 Dams⁶

- **Protection Zone I:**
 - a- Protection zone I corresponds to the area surrounding the dam which is owned by Jordan Valley Authority for operational and implementation activities (registered on Jordan valley Authority maps).

⁵ Concerned parties include: ministry of interior, ministry of water and irrigation (WAJ, JVA), ministry of environment, ministry of municipalities, ministry of industry and trade, ministry of agriculture, Greater Amman Municipality.

⁶ Existing dams, utilized or expected to be utilized for purposes of drinking or industrial recharge: Mujib dam, Waleh dam, Wadi Arab dam, Wehda dam, Tannour dam, and shurhabiel (zuglab) dam.

- b- **Future Dams and Projects:** Protection zone I corresponds to the area surrounding the dam which is acquired by Jordan Valley Authority for operational and implementation activities. The fenced distance has to be not less than 100 m (or as the geomorphologic condition of the area requires) around the embankment of the dam assuming the highest water level according to the original design or to plans of future expansion.

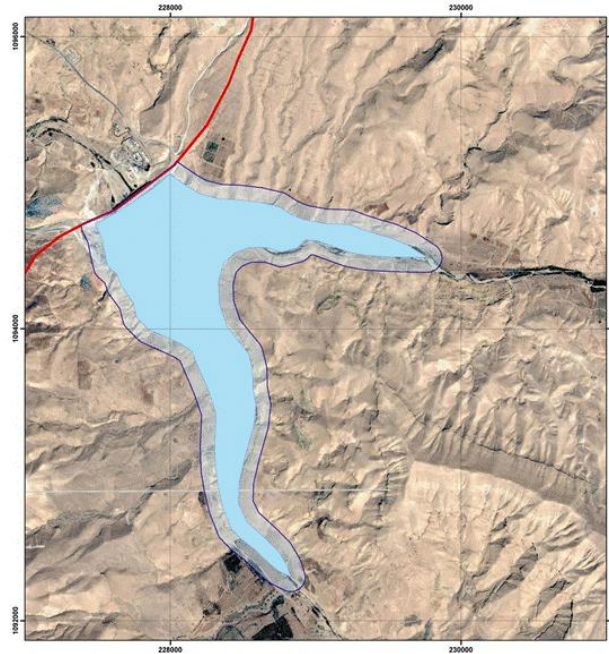


Figure 3: Protection Zone I (Example: Mujib Dam)

- **Protection Zone II**

Zone II begins at the boundary of zone I and is delineated case by case depending on the geologic and topographic situation (slope) of the area. The outer boundary of protection zone II should not be less than 2.5 km around the embankment of the dam or its edge.

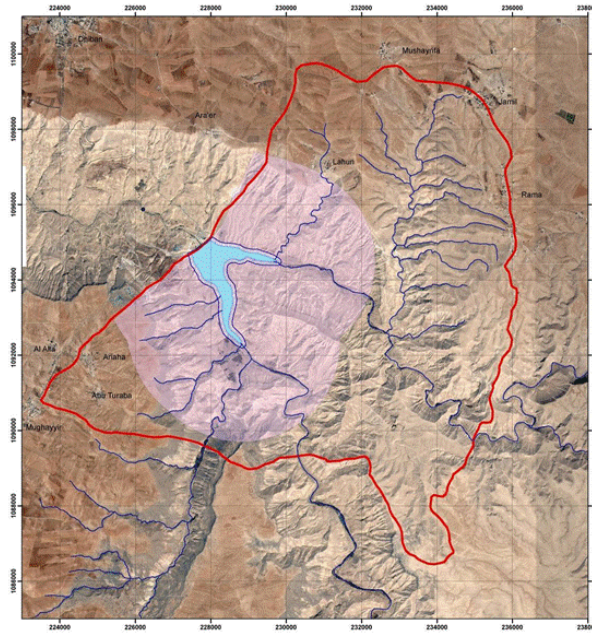


Figure 4: Protection Zone II (Example: Mujib Dam)

- **Protection Zone III:**

Zone III includes the entire catchment area which is estimated from the hydrogeological and hydrological condition of the area.

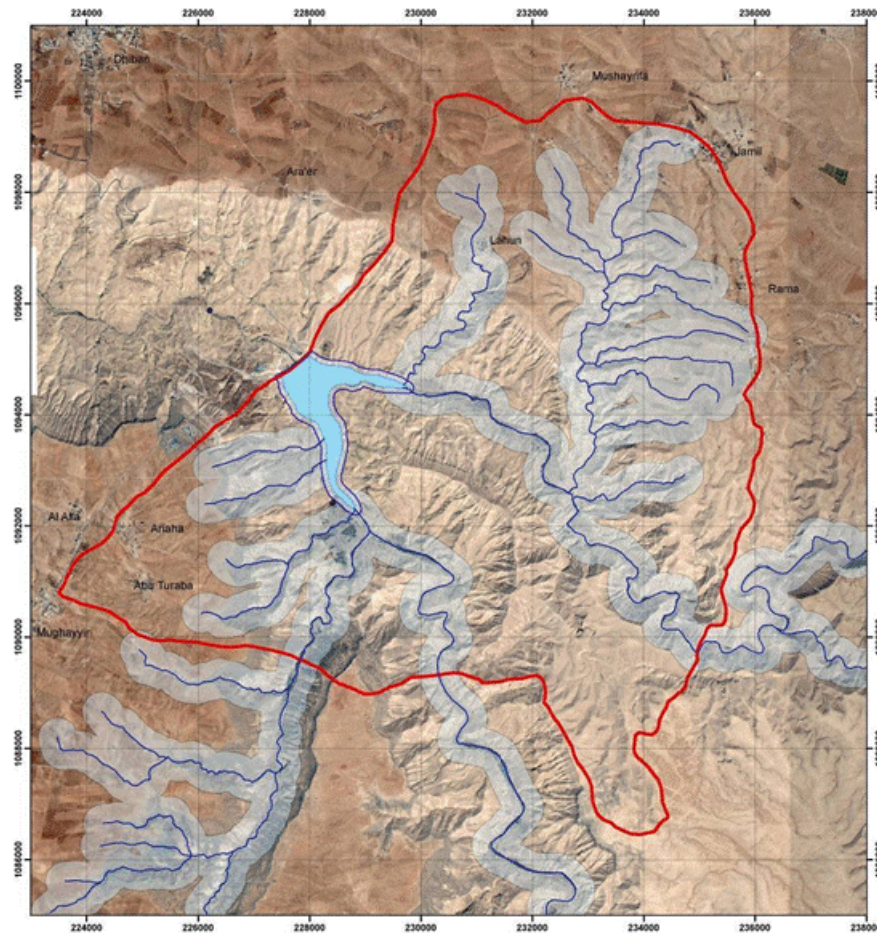


Figure 5: Protection Zone III (Example: Mujib Dam)

4.2. Wadis⁷

- **Protection Zone I:**

Zone I corresponds to the area of the wadi owned by the government and registered in the Land and Survey Department.

- **Protection Zone II**

Zone II starts at sides of wadis feeding the water body⁸ around 350 m each side and for a distance of 5 km above the water body. These dimensions could be revised based on the geologic and topographic situation of the area and inclination factor of the region. Also, engineering or procedural control that will be taken by parties concerned with region activities should be considered according to requirements of adopted licensing.

⁷ Valleys includes valleys feeding the dams and that released from dams and water bodies

⁸ Water resource include dam, spring, well

4.3. King Abdullah Canal (QAC):

Zone I corresponds to the area of KAC owned by the government. It comprises a total of 40 m on both sides of the canal according to the infrastructure in the area.

The canal has to be perfectly fenced and supervised along the canal extension.

• Activities allowed in Surface Water Protection Zones

Activities allowed in Protection Zone I

The activities in this zone are limited to those related to the operation and management of the water resource. Environmental and constructional sound practices have to be undertaken

Activities allowed in Protection Zone II

- The agricultural activities in this zone are limited to organic agriculture. This responsibility is undertaken by Ministry of Environment in accordance with applicable legal frames.
- When issuing licenses of any development activities, artisanal, investment or industrial; fuel stations, washing cars or garages or olive press, in addition to free zones and industrial zones, the issuing parties link issuing licenses to commitment not to produce and throw hazardous wastes.
- Priority is given to implement a sewerage networks in the inhabited protection zone II where water resources are available where possible, or priority is given to construct cesspools according to national codes in this regard.
- Intensify control on these zones by parties concerned with granting licenses, provided adherence to environmental sound practices issued by the Ministry of Environment.
- No licensing of new establishment, extensions or changes in use can be given unless the responsible organization gives permission after referring to related studies and recommendations to prevent any negative impact on the water resources in this zone.
- The required correction measures are to be undertaken by the owner of the establishment according to the recommendations prepared by the licensing committee.
- Existing development, industrial and agricultural activities, which produce wastes that may have negative impacts on the environment and water resources, are obliged to implement environmental sound practices and to carry out corrective measures decided by the responsible agencies⁹.

⁹ Concerned parties include: ministry of interior, ministry of water and irrigation (WAJ, JVA), ministry of environment, ministry of municipalities, ministry of industry and trade, ministry of agriculture, Greater Amman Municipality.

Activities allowed in the third protection zone:

All developmental activities are allowed in this zone, providing commitment to sound environment practices issued by Ministry of Environment.

1 Control and implementation

- ✓ Ministry of Water and Irrigation, Water Authority of Jordan, and Jordan Valley Authority implement requirements needed for the first protection zone including acquisition of lands surrounding the public water resource. Also, the aforementioned entities should address ministry of municipal affairs, Greater Amman Municipality, and Aqaba Special Economic Zone regarding the regulation of lands around the water resources so as to consider these instructions within organizational restructuring and detailed schemes relating to lands surrounding the water resources.
- ✓ Concerned parties in Ministry of Environment coordinate with the concerned official parties to control the second and third water resources protection zones, and should take necessary procedures according to the applicable laws.
- ✓ Ministry of Agriculture coordinates with the concerned official parties to control the agricultural activities and the necessary protection requirements especially within the second and third protection zones.
- ✓ All private wells owners should adhere to instructions of the public wells first protection zone.

Secretaries General of Ministry of Water and Irrigation, Water Authority of Jordan, and Jordan Valley Authority should circulate these instructions, and all concerned and competent departments should adhere to its contents, and to apply it as of its publication in the national gazette.

Issued on:/...../.....

Minister of Water and Irrigation

Eng. Mohammad Najjar

Annex 6: Inspection Form Sheets



Inspection form for WPZ 1 نموذج تفتيش على نطاق الحماية الأول للمصدر المائي



- Water resource description

وصف المصدر المائي			
Water resource Name إسم المصدر المائي:		Well	بئر
		Spring	عين ماء
Water resource ID الرمز الخاص (ID):		Dam	سد
		Canal	قناة
Well field Name حقل آبار:		Wadi	وادي

- Location:

الموقع:			
Governorate محافظة	District حي	City/Town/Village مدينة/قرية/بلدة	Area Name اسم المنطقة

- Site Coordinates in WGS 84 coordinate system:

نظام الإحداثيات العالمي 84 (خطوط طول وعرض):			
Latitude N (خطوط العرض)	Longitude E (خطوط الطول)	Elevation [m] الارتفاع عن سطح البحر	GPS Waypoint نقاط مميزة

- Observations of conditions of Zone 1:

ملاحظات ظروف منطقة الحماية 1:

- tick box yes / no (X) and add remarks and details about conditions if necessary
- إذا لا وضع (X) وأصف الملاحظات والعناوين حول الظروف إذا لزم الأمر / إذا نعم ضع إشارة في الخانة

Remarks, Details علامات/ عناوين	No لا	Yes نعم	Observation ملاحظات
			Is the source surrounded by a fence? هل المصدر المائي محاط بسياج؟
			Are there any gaps in the fence? هل يوجد فتحات في السياج؟
			Is there a gate? هل يوجد بوابة للمصدر المائي؟
			Are signposts fixed in the source gate and fence? هل لافتات منطقة الحماية الأولى مثبتة على بوابة وسياج المصدر المائي؟

Remarks, Details علامات/ عناوين	No لا	Yes نعم	Observation ملاحظات
			Are the sign posts are clearly visible هل لافتات منطقة الحماية الأولى مثبتة بشكل واضح للرؤية ويمكن رؤيتها عند وصول؟
			Are the sign posts are broken or dirty? هل لافتات منطقة الحماية الأولى المثبتة على المصدر غير نظيفة أو مكسورة؟
			Is there room for the guard inside Protection Zone 1? (If yes, describe the condition of the room) هل يوجد غرفة للحارس داخل منطقة الحماية الأولى؟ (إذا نعم، قم بوصف حال الغرفة)
			Is there a cesspool inside Protection Zone 1? (If yes, how far is it from the water source?) هل يوجد حفرة امتصاصية داخل منطقة الحماية الأولى؟ (إذا نعم،)
			Is there any pollution source inside Protection Zone 1 (inside the fence) like oil spills, sheep grazing, agricultural activities, etc? (If Yes, describe it) هل هناك مصادر للتلوث داخل منطقة الحماية الأولى (داخل السياج مثل بقع زيت، زراعات، رعي أغنام...؟ (في حالة وجود ملوثات ما هي؟)
			Is there a concrete base around the spring or well head? هل هناك يوجد قاعدة إسمنتية حول رأس البئر أو النبع؟
			Are there any cracks or holes in the concrete base or in the spring box allow the contaminants to reach the water? (If yes, how much its size?) هل يوجد فتحات أو شقوق في القاعدة الإسمنتية أو صندوق النبع تسمح بوصول الملوثات؟ (في حال وجودها، كم حجم هذه الشقوق؟)

- Other Notes: ملاحظات أخرى:

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German-Jordanian Technical Cooperation – Water Aspects in Land-Use Planning
Delineation of Groundwater Protection Zones for Hidan Well field



Facility Inspection Sheet WPZ 2
نموذج تفتيش على نطاق الحماية الثاني للمصدر المائي



1. Basic Information
1. معلومات أساسية

Governorate محافظة	District حي	City/Town/Village مدينة/قرية/بلدة	Area Name اسم المنطقة	Date of Inspection تاريخ الكشف

2. Facility Information
2. معلومات خاصة بالمنشأة

Beginning of Operation (month/year) تاريخ تشغيل المنشأة	Phone number هاتف المنشأة	Name of owner اسم صاحب المنشأة	License No. رقم رخصة المنشأة	Facility Name اسم المنشأة

Type of products نوع المنتجات	Type of Facility / operation نوع المنشأة

Other facility information (e.g. use of fertilizers and agrochemicals):
معلومات أخرى عن المنشأة (على سبيل المثال، تستخدم الاسمدة والمخصبات الزراعية)

3. Water Resources Information
3. معلومات عن مصادر المياه

What kinds of resources are used for the facility's water supply?
ماهي المصادر المستخدمة لتزويد المنشأة بالمياه؟

Remarks ملاحظات	Type of water supply نوع مزود المياه
	Spring عين ماء
	Pumping Well مضخة بئر
	Surface water (wadi, canal, lake) مياه سطحية (وادي، مبل، بحيرة)
	Tap water مياه حنفية

Did you have any problems with water supply in that past?
هل واجهت أي مشكلة في التزود بالمياه في الماضي؟

Details (what and when) عناوين (ماذا ومتى)	if yes please mark (X) إذا نعم ضع x	Type of problem نوع المشكلة
		Water quantity كمية المياه
		Water quality جودة المياه

4. Waste and waste water information
4. معلومات عن المخلفات و المياه العادمة

Is there any type of waste in the facility and how is it disposed?
إذا كان هناك أي نوع من المخلفات في المصنع وكيفية التخلص منها؟

Disposal / discharge methods طريقة التصريف/التخلص	if yes specify إذا نعم ضع x	Type of waste نوع المخلفات
		Solid waste مخلفات صلبة
		Waste water مياه عادمة

5. Facility GPS Coordinates Information
5. معلومات عن إحداثيات المنشأة

WGS 84 Decimal Degrees نظام الإحداثيات العشري

Latitude N (خطوط العرض)	Longitude E (خطوط الطول)	Elevation [m] الارتفاع عن سطح البحر	Site description details وصف للموقع	GPS Waypoint نقاط مميزة

6. Other environmental problems observed at facility or nearby:
6. أي مشاكل بيئية أخرى شوهدت في المصنع أو بالقرب منه

Name / Tel Number of respondent _____
الاسم / رقم هاتف معطي المعلومات

Name of inspector _____
اسم الشخص الذي قام بالكشف