CHANGES IN HYDRAULIC AND POLLUTION LOADS FOR THE SEWAGE STREAM OF WADI AL-SAMN (HEBRON DISTRICT)

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE DEGREE OF BACHELOR OF ENGINEERING IN CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

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In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of the department for the degree of Bachelor of Science in Engineering.

Project Supervisor **Department Chairman**

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إهداء

"وقل رب أدخلني مدخل صدق وأخرجني مخرج صدق واجعل لي من لدنك سلطانا نصيرا"
صدق الله العظيم

إلى أجمل الأمهات......

إلى من عشقت أن أكون ابنا لأجله.......

إلى من لا تكتمل الفرحة إلا بلقائهم.........

إلى قلب أدخل معنا جميلا في حياتي.....

إلى من أحببت مسؤوليتي بصداقته....

إلى اللذين يهرعون مع أول خيوط الفجر..

يهزون أرجوحة المجد.. لطفـــل كنعاني..

عشـق الوطــــــــن.. وأحـب حجارتـه ..

لطفولة تهتف.. لبيك فلســــــطين لبيك..

إلى حبات سنبلة.. تقاوم ضربة المنجل..

إلـى أيـد مقيدة.. برغـم قيودهـا تعمـل..

إلـــى الطفـــل الذي اغتيلت طفولتـــه..

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إلى الخالدين.. في ضمير شعبنا..

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ABSTRACT

CHANGES IN HYDRAULIC AND POLLUTION LOADS FOR THE SEWAGE STREAM OF WADI AL-SAMN (HEBRON DISTRICT)

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Current disposal options of municipal wastewater in some cities of the West Bank are the discharge into wadis directly from the sewer outfall. This is demonstrated frequently through the existing of many wastewater streams in the West Bank. Normally domestic and industrial wastewaters are received into municipal sewers.
The wastewater flow into wadis in such areas is existing over the year and in wintertime, chance is given to runoff water to be mixed with wastewater and thus loosing both waters without getting any beneficial use from them. On the contrary, pollution problems are becoming more complicated under wet flow conditions because the wadi flow or the wet section length is becoming longer.

The focus here is given to Hebron City wastewater stream (named wadi al-Samn, according to its name at the upstream), which originates in the Palestinian Authority areas, South of Hebron, passes Yatta, Beit-Emra, Karmah, Abu-al-Asja and Daherrya communities before it runs through the 1948-cease line fire to the east and then south of Beer al-Saba', and then enters Gaza, where it ends in the Mediterranean. The wadi total length is more than 120 km starting from the sewer outfall (upstream) at Hebron City and ending at the Mediterranean Sea (downstream), of which 47 km are inside the Palestinian Authority area including the West Bank and Gaza Strip.

The wadi path length at different sections is: 9 km for Hebron section, 11 km for Yatta section, 4 km for Beit Emra section and 14.5 km for Daherrya section. This means that the wadi extends for a distance of 38.5 km inside Hebron District borders while it extends for a length of 77 km inside the 1948-Palestine. Also the wadi part crossing Gaza Strip is at a length of 8.75 km which finally ends in the Med. Sea.

The influenced population from the wadi discharge is exceeding 50,000. While the influenced land by the wadi pollution is possibly extending at a distance of 0.5 km from each wadi side. This means that the affected land area could be about 40 km^2 inside the district. The effect on groundwater is expected and the wadi extends for a distance of 5 km on the Eastern basin and not less than 30 km on the Western basin. Pollution effects on agriculture, land (soil), ground and surface waters, wildlife and air pollution are expected to be severe.

Dry weather flow values indicates an average flow rate value around 3800m^3/d with velocity variation from 1.97 m/min to 7.36 m/min and with wadi wet cross sectional area variation from 0.31575 m^2 to 0.698 m^2. Wet weather flow values indicates flow rate value around 28000m^3/d and it represents storm conditions. This means that the wadi flow under wet conditions could be not less than 8 times its value under dry conditions.

At a certain segments of the wadi, a 38% COD reduction occurred for the wastewater while an increase of 36% occurred at other segments due to wastewater loads coming from tankers which originate from sepatge and stone-cutting industry. Then a decrease of 12% occurred at a following section and finally as the wastewater flows to at the wadi final part, an increase in COD value of 35% took place due to availability of sepatge and stone-cutting loads again.

Similar trend were observed for NH4 and TSS as the wastewater flows to the wadi downstream.

ABBREVIATIONS

The following abbreviations were used in this project:

B	Born
BOD	Biochemical Oxygen Demand
Ca^{++}	Calcium
Cl^{-}	Chloride
COD	Chemical Oxygen Demand
CO_3^{--}	Carbonate
DO	Dissolved Oxygen
EC	Electrical Conductivity
FAO	Food and Agriculture Organization
HCO_3^{-}	Bicarbonate
K	Potassium
Mg^{++}	Magnesium
Na+	Sodium
NO_2^{-}	Nitrites
NO_3^{-}	Nitrates
$NH4^{+}$	Ammonia
P	Phosphate
pH	Acidity / Basicity
SAR	Sodium Adsorption Ratio
SO_4^{-2}	Sulfate
SS	Suspended Solid
T	Temperature
TDS	Total Disolved Solids
TFCC	Total Feacal Coliform Count
TN	Total Nitrogen
TS	Total Solids
TSS	Total Suspended Solids
UASB	Upflow Araerobic Sludge Blanket
WHO	World Health Organization

CHAPTER ONE
INTRODUCTION

1.1 General Background

1.2 Problem Identification

1.3 Objectives of the Project

1.4 Study Area

1.5 Project Outline

1.6 Project Time Schedule

CHAPTER ONE

Introduction

1.1 General Background

The World's Health Organization up-to-date reports, says that water pollution and sanitation problems kills more people than AIDS does. Most of diseases affecting children in the third world come from water pollution and inadequate sanitation problems. The disposal of wastewater collected via sewers should be finally into treatment plants. However, this is not the situation in most of the developing countries. That’s to say, the collected sewage is frequently exported to the environmental elements untreated in many areas of the world. The receiving water bodies for such sewage loads are streams, rivers or wadis. Instead of fresh water streams many countries, such as Palestine, have wastewater streams which have severe effects on the environment.

Wastewater collected in cities is simply water mixed with a small fraction of solids or polluted liquids. If separate sewers are considered, then we talk about wastewater composed of fresh water mixed with human excreta besides some pollutants coming from the laundry and the kitchen. Also some industrial enterprises may dispose of their wastewater untreated into the sewers. In wastewater streams, chance is given to runoff water, under wet climate conditions, to be mixed with wastewater and flow together.

In the main cities of the West Bank, where sewers are existing, only some cities dispose of the wastewater into treatment plants while most of cities dispose sewage from their sewer outfalls untreated into wadis. Not less than 9 wastewater streams are currently existing in the whole West Bank.

This study focuses on analyzing the environmental impacts of one of the main wastewater streams of the West Bank. That's Wadi al-Samn which carries wastewater from Hebron City sewers' outfall to long distances in Palestinian land.

1.2 Problem Identification

The wastewater stream of wadi al-Samn is flowing and crossing many communities over Palestine. In fact, the wadi flows tens of kilometers over the area lands. It is expected that this sewage wadi affects the groundwater basins as well as public health and agriculture.

Upon careful review of the literature, we found that few studies are available on the target wadi and we can say that no study analyzes the wadi variations of pollution loads and flow rates with length progress.

1.3 Objectives of the Project

Upon studying wadi al-Samn here, we aim at the following:

- Making GIS mapping of the wadi flow path with affected communities shown. This mapping will cover the whole wadi path starting from Hebron City sewers' outfall and ending at the final point where the wastewater flow diminishes and finally ended.
- Creating GIS different layers for the wadi sections that crosses the Hebron District area.
- Preparing a map by GIS which shows the wadi path over the groundwater basins.
- Measuring the flow rate at the 6 different stations.
- Sampling the wastewater at these stations and measuring the flow.
- Analyzing the wastewater in the laboratory for parameters such as COD (Chemical Oxygen Demand) and Nitrogen.
- Analyzing in depth the pollution effects of the wadi and proposing solutions for the problem.

1.4 Study Area

The study area is wadi al-Samn flow path as a main focus with some focus on wastewater producers in Hebron City such as industries. Other wastewater producers, which dispose of their wastewater in the wadi, such as vacuum tankers and quarrying industry will be considered. Different villages, towns and cities where the wadi extends, inside the Hebron District borders, will be included as part of the study area. The wadi flows at the upstream from Hebron City at its southeastern part to reach the Meditation Sea in the west and at its final destination in the downstream.

Figure 1.1 shows the wadis drainage system in the Hebron District, wadi al-Samin flow path is shows in red color.

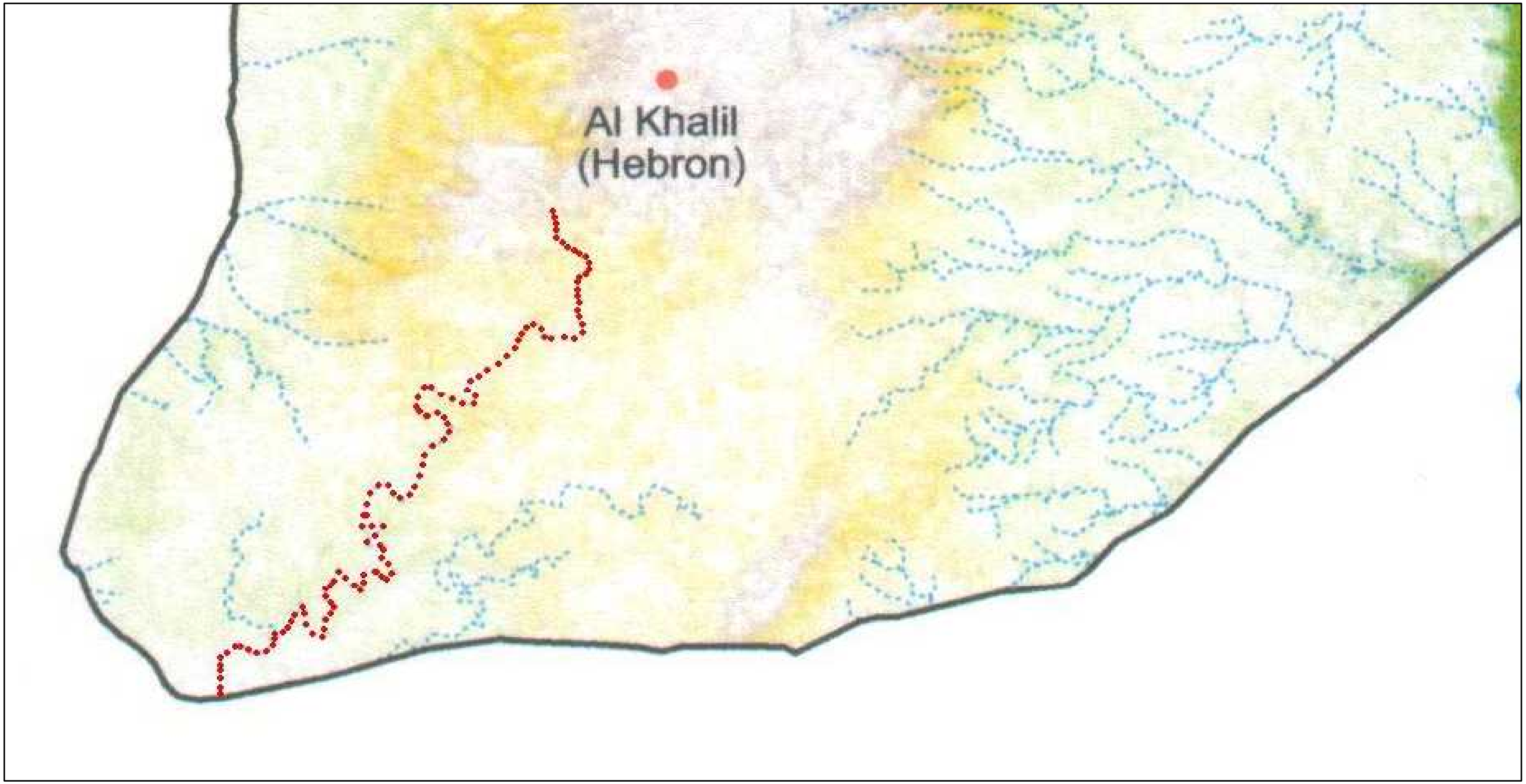

Fig. 1.1: Study Area Location Map (Wadi al-Samn path in Hebron district).

1.5 Project Outline

The study report has been prepared in accordance with the objectives and scope of work. The report consists of five chapters:

- The first chapter entitled” Introduction” talks about the untreated wastewater wadis, in addition to introducing the study area general description, objectives and problem identification.
- Chapter two entitled “Literature Review” talks about the previous studies and on wastewater in general. The characteristics and the amount of flow, and sewage and waste water treatment methods.
- Chapter three entitled “Study Area Description” is a description of the Hebron Province demography, population, topography and sanitary status in general with focus on Wadi al-Samn in particular.
- Chapter four entitled “Methodology” is talking about the methods of mapping and flow measurements in addition to sampling and laboratory analysis for the wastewater.
- Chapter five entitled “Maps of the Wadi Path” contains maps of the wadi path and discusses them .
- Chapter six entitled “Results and Discussion” discusses the Results of the study expressed as maps generated by the project team for the different wadi crossed areas.
- Chapter seven entitled “Conclusions and Recommendations” discusses the conclusions of the study and proposed recommendations.

1.6 Project Time Schedule

The different planned activities time frame is shown below.

Table 1.1: Schedule time for the project

Activity description	First Semester (2006)				Second Semester (2007)					
	Σεπ	Οχτ	Νοϖ	Δεχ	ϑαν	Φεβ	Μαρχη	Απριλ	Μαψ	ϑυνε
1-Conducting site visits for Wadi al-Samn										
2-Making available aerial photos or maps for the wadi										
3-Collecting literature and writing the literature part										
4- GIS Mapping for the Wadi										
5-Measuring the flow and taking sewage samples										
6. Analyzing sewage samples										
7- Writing the report										

CHAPTER TOW

LITERATURE REVIEW

CHAPTER TOW

Literature review

2.1 Intorduction

Wastewater it sometimes called used water which means that it is a tap water mixed with minor amounts of waste. Wastewater from household activities such as washing dishes, laundry or bath water is called gray water, while wastewater contaminated by sewage is known as black water. Mostly a combination of these two types flows into the public sewers. Although some kinds of water pollution can occur through natural processes, it is mostly a result of human activities. We use water daily in our homes and industries. The water resources we use are taken from lakes and rivers, and from underground (groundwater); and after we have used it, and contaminated it, most of it returns to the Hydrological Cycle and enters the environment.

Historically, wastewater has taken humanity quite a bit of time to come to grips with this problem. Water pollution also occurs when rain water runoff from urban, industrial areas, from agricultural land, mining operations makes its way back to receiving waters (river, lake or ocean) and into the ground.

2.2 Two major sources of wastewater are identified:

1- **Domestic wastewater** primarily from residential, commercial, institutional and public buildings. The amount of domestic wastewater is typically expressed in litter per day (LCD). Usually it is assumed to be a fraction (70-80%) of the specific domestic water consumption (ranging from 60 to over 350 Lcap.d) and varies over different countries depending of water resources availability and access systems available.

2- **Industrial wastewater** is a waer used in different industrial processes which varied in flow and pollutant mass loading and is affected by the types of the production process (batch, semi-continuous or continuous) and working hours. Municipalities not always have to accept industrial sewage in their sewerage stem. Restriction may be in order to:

1-Prevent the discharge of toxic and corrosive compounds that may damage sewer pipes or create stress to biological treatment processes.

2-Prevent incidental overloading of sewer system or treatment plant (Metcalf and Eddy, 1991).

2.3 Measuring the flow rate in open channels or streams

Open channel flows may be classified by either the time criterion or the space criterion. Based strictly on the time criterion, open channel flows may be classified into two categories: steady flows and unsteady flows. In a steady flow the discharge and water depth at any section in the reach do not change with time during the period of interest. But in unsteady flow the discharge and the water depth at any section in the reach change with time.

Based on the space criterion, an open channel flow is uniform flow if the discharge and the water depth remain the same in every section in the channel reach. Uniform flows in open channel are mostly steady. A varied flow in open channel is one in which the water depth and/or the discharge change along the length of the channel.

Methods for measuring the flow rate in open channels or streams

1- Float measurements

Mainly the Time movement of floats is a simple method of discharge measurement. Three equally spaced cross-sections are selected on a straight reach of the canal. The floats are released upstream of the upper measuring section in order to take up the stream velocity before reaching it. Their movement is timed by stop watch. The width of the stream is divided into equal segments and soundings are taken along the test reach to determine the average depth of each segment. The velocity of each segment is measured by repeated float tests. Segmental discharge is taken as average area multiplied by velocity, except for the edge segments for which discharge is taken as times velocity of adjoining segment multiplied by average area.

2- Parshall Flume.

2.4 Parameter commonly used for measuring wastewater

2.4.1 Characterization of Wastewater

Wastewater characterization is very important when designing awastewater treatment plants and assessing pollution loading rates. Extensive data is collected and used to model biological processes such as the case in activated sludge systems. In addition, characterization of the effluent is import to determine the reuse safe options.
Definition

Wastewater is generated from domestic and industrial sources. Industrial sources throughout the world are dumping 10,000 new organic compounds each year. These compounds need to be properly handled and removed if they cause health problems. Many industrial plants are required to pre-treat their wastewater before dumping it in the wastewater network.

2.4.2 Categories of characteristics

1-Physical Characteristics

The most important physical characteristic of wastewater is its total solids content. The different physical characteristics are discussed below.

- **Solids:** Wastewater contains a variety of solid materials varying from rags to colloidal material. In the characterization of wastewater, coarse solids are usually removed before the sample is analyzed for solids.
- **Total Solids: (TS)** are defined as the residue remaining after a wastewater sample has been evaporated and dried at a temperature of 103 to 105$_o$ C.
- **Total Suspended Solids (TSS**) are defined as the portion of TS retained on a specific size filter after drying at 105 degrees C.
- **Total Dissolved Solids (TDS)** can be defined as the solids that pass through a filter with nominal pore size of 2 microns or less.
- **Volatile and Fixed Solids**: are defined as those solids that can be volatilized and burned off when ignited in a muffle oven a t C $_o$ 50 500 ± . **They are assumed to be organic matter.**
- **Fixed solids** are defined as the residue that remains after a sample has been ignited in a muffle oven.
- **TS, TSS and TDS** are comprised of both fixed and volatile solids. The ratio of VS to FS (organic to non-organic matter) is used to characterize the wastewater in respect to amount of organic matter present in the wastewater.
- pH: The concentration range suitable for the existence of most biological life is typically 6 to 9. Wastewater with an extreme concentration of hydrogen ion is difficult to treat by biological means. PH can be calculated using the following equation:
  pH= -log10 [H]

2-Chemical Characteristics

- **Chlorides**

Chloride is a constituent of concern in wastewater because it affects the final reuse application of treated effluent. Conventional methods of wastewater treatment do not remove Chloride and hence if chloride is high in wastewater, the contributing sources need to be investigated and reduced for a beneficial use to be considered.

- **Alkalinity**

Alkalinity can be defined as the ability of wastewater to neutralize acids; it is a measure of buffering capacity against a *pH* drop. Alkalinity results from the presence of the following ions in wastewater:

- **Hydroxides ion:** OH^{-} **,Carbonates ion** CO **,Bicarbonates ion:** HCO^{-}

These ions can be present with elements **such as calcium, magnesium, sodium**, **potassium and ammonia**. **Calcium and magnesium carbonates** and **bicarbonate**s are the most common. It should be mentioned here that wastewater is normally alkaline.

- **Nitrogen :**Nutrients such as Nitrogen and phosphorus are essential elements for the growth of microorganisms, plants and animals. Nitrogen is the building block in the synthesis of protein and hence the quantity in wastewater is essential to be known to determine if the wastewater is treatable. Some times, if there is no enough nitrogen in the wastewater, quantities are added to make sure that biological processes can take place when treating wastewater.
- **Phosphorus: is** also considered as a nutrient that is essential for the growth of plants, algae and other biological organisms. Municipal wastewaters may contain 4 to 16 (mg/ltr)of phosphorus. This value can be a lot higher in communities where detergents of high phosphorus contents are used such as the case in Palestine.
- **Sulfur ion** is present in wastewater. It is required in the synthesis of proteins and is released in their degradation. Biologically, sulfate is reduced under anaerobic conditions to sulfide, which then combines with hydrogen to form hydrogen sulfide **(H_2S).**
- **Hydrogen sulfide gas** is usually entrapped in sewer pipes that are not running full which is usually the case. Then hydrogen sulfide gas can be oxidized biologically and produce sulfuric acid H_2SO_4 that is corrosive to concrete sewer pipes and it negatively affects the biological processes when sulfide concentration exceeds 200 mg/ltr. When hydrogen sulfide gas is mixed with other wastewater gases such as Methane, CH_4, and CO_2, then the combination is corrosive to metal pipes and can explode producing a huge force.

- **Metallic Constituents** Trace quantities of many metals are important constituents of mostwaters. Many of these metals are also classified as priority pollutants, pollutants that are can cause cancers. But most of these metals are necessary for the growth of biological life. The presence of any of theses metals in excessive quantities will interfere with many beneficial uses of the water because of their toxicity. Therefore, it is desirable to control the concentration of heavy metals when considering reuse options such as the case of controlling Boron concentration when the treated effluent is planned to be used for irrigation agricultural corps.
- **Organic Compounds** are usually composed of a combination of:

  a) Carbon

  b) Hydrogen

  c) Oxygen

  d) Nitrogen in some cases.
- **Biochemical Oxygen Demand(BOD)** The most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day BOD (BOD_5). Results of the BOD tests are used to:

  a. Determine the approximate quantity of oxygen that will be required to biologically stabilize **the organic matter present in wastewater**.

  b. Determine the size of waste treatment facilities.

  c. Measure the efficiency of some treatment process.

  d. Determine compliance with wastewater discharge permits.
- **Total Chemical Oxygen Demand (COD)** test is used to measure the oxygen equivalent of the organic material in wastewater that can be oxidized chemically using dichromate in an acid solution. The value of the COD is usually different than the value for BOD. Many organic substances which are difficult to oxidize biological can be oxidized chemically. COD test take about 2.5 hours compared to the 5-day BOD test.
- **Pathogenic Organisms** The source of pathogenic organisms found in wastewater can be excreted by human beings and animals who are infected or carriers of a particular infectious disease. There are four categories of pathogenic organisms found in

wastewater. These are: Bacteria, protozoa, helminthes and viruses (Standard Methods for the Examination of Water and Wastewater, 1998).

Table 2.1: Recommended microbiological quality guidelines for treated wastewater reuse in agriculture according to World Health Organization (WHO).
Source: …(1)

Category	***Reuse conditions***	***Exposed group***	***Intestinal nematodes [b] (Arithmetic mean no. of eggs per liter [c]***	***Fecal coliforms (Geometric mean no. per 100 ml [c]***	***Wastewater treatment expected to achieve the required microbiological quality***
A	Irrigation of crops likely to be eaten uncooked, sport field, public parks [d]	Workers, consumers, public	≤ 1	≤ 1000 [d]	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pastures and trees [e]	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 d or equivalent helminthes and fecal coliforms removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation tech., but not less than primary sedimentation

[a] In specific cases, local epidemiological, socio-cultural, and environmental factors should be taken into account, and the guidelines modified accordingly.
[b] Ascaris and *Trichuris* species and Hookworms.
[c] During the irrigation period.
[d] A more stringent guideline (≤ 200 FC/100 ml) is appropriate foe public lawns, such as hotel lawns, with which the public may come into direct contact.
[e] In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

Also Table 2.2 below shows Jordanian Standard for Treated Wastewater for many purposes such as: Irrigation vegetables, trees, Public Parks Fodder Crops ,fish farming And Ground-water Recharge. Focus in this study will be given to wadi disposal standards.

Table 2.2: Jordanian Standard for Treated Wastewater

Quality parameter mg/l except as otherwise indicated	Restricted Irrigation[(1)] (vegetables eaten cooked	Trees. Industrial & Cereal Crops	Discharge to streams/ Wadis	Ground-water Recharge	Fish Farming[(2)]	Public Parks Irrigation	Fodder Crops Irrigation
BOD	150	150	50	50	-	50	250
COD	500	500	200	200	-	200	700
Dissolved oxygen DO	>2	>2	>2	>2	>5	>2	>1
Total dissolved solids TDS	2000	2000	2000	1500	2000	2000	2000
Total Suspended Solids TSS	200	200	50	50	25	50	250
PH	6-9	6-9	6-9	6-9	6-9	6-9	6-9
Color (PCU) [(4)]	-	-	75	75	-	75	-
FOG	8	8	8	Non	8	8	12
Phenol	0.002	0.002	0.002	0.002	0.001	0.002	0.002
MBAS	50	50	25	15	0.2	15	50
Mo_3^{-}	50	50	25	25	-	25	50
NH_4^+ -N	-	-	15	15	0.5	50	-
T-N	100	100	50	50	-	100	-
PO_4^{3-} -P	-	-	15	15	-	15	-
Cr	350	350	350	350	-	350	350
SO_4^{2-}	1000	1000	1000	1000	-	1000	1000
CO_3^{2-}	6	6	6	6	-	6	6
HCO_3^-	520	520	520	520	-	520	520
Na^+	230	230	230	230	-	230	230
Mg^{++}	60	60	60	60	-	60	60
Ca^{++}	400	400	400	400	-	400	400
SAR	9	9	9	9	-	12	9
Residual Cl_2 [(5)]	0.5	-	-	-	-	0.5	-
TFCC (MPN/100Ml)[(6)]	1000	-	1000	1000	10000	200	-
Pathogens	-	-	-	-	100000[(9)]	Non	-
Amoeba & Gardia (Cyst/l)[(7)]	<1	-	-	-	-	Non	-
Nematodes (eggs/l)[(8)]	<1	-	<1	-	-	<1	<1

(-) Not Specified

(1) Figures related to heavy metals or rare elements are calculated based on reused water for irrigation of $1000m^2$ /dunum.yr in case more water was used for irrigation, the above limits are reduced accordingly.
(2) Figures depend on fish type, pH, TDS and temperature.
(3) BOD5 referred as filtered samples for natural treatment plants and unfiltered samples for mechanical treatment plants.
(4) Color unit is measured by Platinum Cobalt unit.
(5) Retention or contact time should not be less than 30 min.
(6) Most probable number per 100 ml.

Table 2.3: shows Characteristics of Raw Wastewater in the West Bank (WB) for several locations.

Table 2.3: Municipal Wastewater quality of the WB Districs

City/ Parameter	Ramallah	Al-Bireh	Jericho	Nablus	Jenin	Bethlehem	Hebron	Tulkarem	Mean value (WB)
BOD_5 (mg/l)	1150 [b]	619 [b]	976 [b]	1185 [c]	1100 [c]	660 [c]	1060 [b]	558 [b]	913.5
COD (mg/l)	3393.3 [a]	1289 [b]	1644 [b]	2115 [c]	1440 [c]	2724 [c]	2900 [b]	1200 [b]	2088.2
Kj-N (mg/l)	72.9 [a]	115 [b]	---	120 [c]	---	---	---	---	---
NH^+_4-N (mg/l)	44.9 [a]	77 [b]	---	104 [c]	---	---	220.7 [b]	---	---
NO^-_3-N (mg/l)	0.49 [a]	0.23 [b]	---	1.7 [c]	41 [c]	56.4 [c]	7.6 [c]	27.7 [c]	---
NO^-_2-N (mg/l)	0.04 [a]	0.03 [b]	---	---	---	---	---	---	---
$SO^{-2}4$ (mg/l)	299 [b]	61 [c]	---	137 [c]	---	---	---	---	---
PO^{-3}_4-P (mg/l)	8.3 [b]	4.3 [c]	---	7.5 [c]	15 [c]	14.9 [c]	43.6 [c]	18 [c]	---
P-total (mg/l)	---	---	---	---	---	141 [c]	---	---	---
Cl^- (mg/l)	741 [b]	273 [c]	---	1155 [c]	1400 [c]	1080 [c]	3540 [c]	801 [c]	1284.3
TSS (mg/l)	1000 [b]	400 [b]	620 [b]	1188 [c]	1088 [c]	688 [c]	1794 [c]	398 [c]	897
S^{-2}	1.1 [b]	---	---	---	---	---	---	---	---
pH	7.7 [a]	7.6 [b]	---	6.3 [c]	7.1 [c]	6.5 [c]	6.0 [c]	6.5 [c]	6.8
T (^oC)	17.2 [a]	15 [b]	---	---	---	---	---	---	---
DO (mg/l)	2.9 [a]	2 [b]	---	---	---	---	---	---	---
Fecal coliforms (# / 100 ml)	4.8×10^8 [b]	---	---	---	---	---	---	---	---

[a] The mean value of the analysis of 10 samples (awadallah, 2001)
[b] Data based on the analysis of 2 samples by the author.
[c] (Nashashibi and van Duijl, 1995).

2.5 Options for Wastewater Disposal

Wastewater is not allowed in the storm drain or street. However, the wastewater may be discharged to landscaping or the sanitary sewer, or it may be picked up and disposed of by a waste cesspit. Please note that if you are unsure of the types of pollutants in the wastewater, laboratory analysis may be required to establish the proper disposal method. Choose one of the three wastewater disposal options listed below based upon the following conditions:

Option 1: Discharge Wastewater to a Landscaped Area.

The wastewater must meet the following requirements if discharging to landscaping:

- The pH must be between 6.5 and 8.5. This can be checked quickly and easily through the use of pH paper test strips.
- The wastewater should not contain large volumes or concentrations of:

1- Toxic materials.
2-Degreasers.
3-Pollutants that may create a fire or explosion hazard (e.g., gasoline, diesel).
4-Solid or viscous pollutants in amounts sufficient to cause obstruction or blockage of flow.
5-Petroleum oil or other products of mineral oil origin.
6- Paint.

Prior to surface washing, you must exercise any reasonable means to eliminate large volumes or concentrations of the above listed pollutants. Common methods to eliminate standing pools of pollutants include the placement of absorbent to adsorb the pollutant, drysweeping the absorbent, and disposing of the absorbent properly.

- In addition, wastewater from cleaning foodrelated vehicles or areas, vehicle exteriors or engines, and buildings with leador mercurybased paint should not be discharged to landscaping. · Filter the wastewater if it contains debris, fibers, or other suspended solids.
- Ensure that the wastewater is fully contained within the landscaped area and will fully infiltrate into the ground prior to leaving the job site.

Option 2: Discharge Wastewater to the Sanitary Sewer.

The wastewater must comply with the following conditions if disposed of into the sanitary sewer system:

- The wastewater temperature must be less than 140°F (60°C).
- The pH must be between 6.0 and 12.0. This can be checked quickly and easily through the use of pH paper test strips. Adjust the wastewater to a pH that is between 6.0 and 12.0. Dilution is not an effective or acceptable pretreatment.
- The wastewater quality must comply with the local sanitary sewer district's discharge limits and requirements. The wastewater should not contain large volumes or concentrations of:
    - Pollutants that may create a fire or explosion hazard (e.g., gasoline, diesel).
    - Solid or viscous pollutants in amounts sufficient to cause obstruction or blockage of flow.
    - Petroleum oil, nonbiodegradable cutting oil, or other products of mineral oil origin.
    - Oil based paint.

- Prior to surface washing, you must exercise any reasonable means to eliminate large volumes or concentrations of the above listed pollutants. Common methods to eliminate standing pools of pollutants include the placement of absorbent to adsorb the pollutant, drysweeping the absorbent, and disposing of the absorbent properly.
- No wastewater shall be discharged into any publicly owned sewer manholes without the sewer agency's written authorization.
- Filter the wastewater if it contains debris, fibers, or other suspended solids.
- If chemicals (e.g., solvents or acids) are used during the cleaning process, additional precautions

may be needed. Contact your local sanitation district to learn if wastewater containing these chemicals requires pretreatment before discharge to the sanitary sewer or if it needs to be treated as hazardous waste.

- Ensure that the wastewater is released at a flow rate and/or concentration, which will not cause problems, pass through, or interference with the sewerage facilities. Generally, if you are using a privately owned cleanout, sink, toilet, or floor drain at a client's property, and the flow does not backup, the flow amount will not cause problems, pass through, or interference with the sewerage facilities.
- Privately owned cleanout (or sink, toilet or floor drain), oil/water separator, or below Ground clarifier at the client's property where the wash water is generated;
- Privately owned industrial sewer connection at the client's property where the wash water is generated; Waste hauler station at sanitary sewer facility; and Any other disposal points approved by the sanitary sewer facility.
- Maintain a logbook of all discharge.

Option 3: Micellaneous Disposal Options

Among them is the dispoal into wadis of untreated or treated sewage, disposal of treatd or untreatd effluents into rivers and disposal into sewage from where sewage is finally percolating underground strata of transferred to treatment plamts or rives/wadis. Emphasie should be given by local autrhorities for restrictions and monitoring in order to prevent any pollutant risks that may harm any environmental element (componenet).

2.6 Sanitary options for wastewater disposal

The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. The objectives involving the removal of suspended and floatable materials, destroy pathogenic micro-organisms and elemination of the most suspended and dissolved **biodegradable organic materials**. Aerobic and aerobic treatment technologies all rely on aerobic/anaerobic micro-organisms to break down the organic matter in the wastewater.

Many technologies utilize either an air pump or blower to provide oxygen to the micro-organisms, while some technologies are designed as “trickling filters”, where effluent is dosed onto an unsaturated media and the micro-organisms use the oxygen in the air which surrounds the media.

2.6.1 On-site sanitary options

The collecting will be occur by septic tank as flow (figure 2.3) :

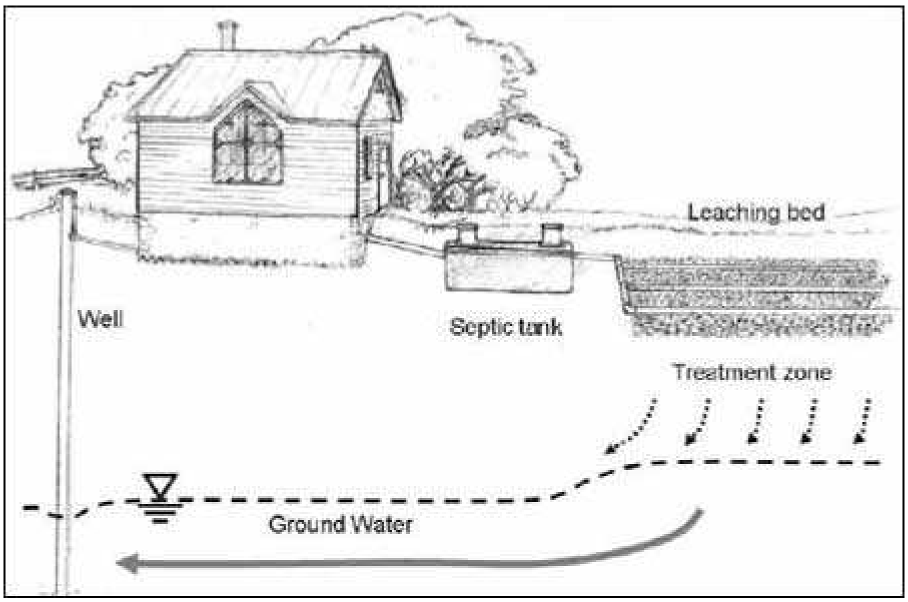

Figure 2.1: Wastewater Recycling from an Onsite System

The purpose of the septic tank is to separate liquid from solids and to provide some breakdown of organic matter in the wastewater. A septic tank is a buried, watertight container made from concrete, polyethylene or fiberglass. In the past, the tank was sometimes made of steel or wood (if you have a steel tank, it is likely rusted through and needs replacing. If you have a wooden one it is likely rotting and may need replacing.).

The size of the septic tank will depend upon the size of the house (number of bedrooms) and household water use, with minimum tank volumes ranging from 1,800 to 3,600 L depending on the province or territory. Older tanks may be smaller than those installed today and tanks may have one or two compartments, depending upon when and where they were installed.

As wastewater from the house enters the septic tank, its velocity slows allowing heavier solids to settle to the bottom and lighter materials to float to the surface (see Figure 2.4). The accumulation of settled solids at the bottom of the tank is called "sludge" while the lighter solids (greases and fats), which form a mass on the surface, is called "scum". Anaerobic bacteria, which are always present in wastewater, digest some of the organic solids in the tank. Clarified wastewater in the middle of the tank flows by displacement into the leaching bed for further treatment in the soil layer.

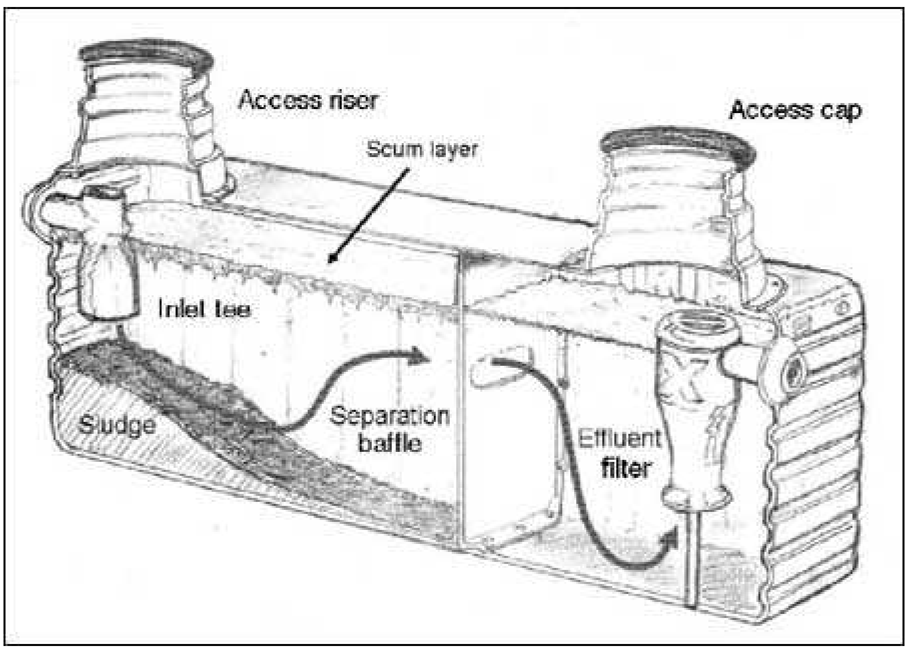

Figure 2.2: Common septic Tank with Access Risers and Effluent Filter

The partially treated wastewater from the septic tank flows into the leaching bed (see Figure 2.5). The leaching bed is typically a network of perforated plastic distribution pipes laid in gravel trenches over a layer of soil. In most provinces, the soil layer must be a minimum of 0.7 – 1.2 m above the high ground water table or a restrictive layer such as bedrock or clay and have a certain permeability (absorptive capacity). Older systems may have been constructed with clay tiles instead of plastic pipes, while new systems may use plastic chambers to replace the gravel trenches and perforated piping. The actual size, design and layout of the leaching bed is defined in Provincial/Territorial Code or Regulation and is based upon the volume of sewage generated, the absorptive capacity of the underlying soils, and the depth to the high groundwater table or limiting/ restrictive layer. Wastewater can flow by gravity from the septic tank to the distribution lines, or where required, can be collected in a pump chamber and pumped to a leaching bed at a higher elevation.

The leaching bed is a soil filter which uses natural processes to treat the wastewater from the septic tank. Contaminants in the wastewater include solid and dissolved organic matter (carbon compounds), nutrients (nitrogen and phosphorus) and harmful bacteria and viruses. A slime layer of bacteria, called a “biomat” layer, forms at the bottom and sidewalls of each distribution trench; and it is in this layer where much of the treatment occurs. Bacteria in the biomat layer and surrounding soils consume the organic matter in the wastewater as well as transform ammonia nitrogen, which is toxic to some aquatic species, to the less toxic form of nitrate-nitrogen. Harmful bacteria and viruses present in the wastewater are largely removed in the leaching bed through filtration, predation (eaten by other microbes) and environmental exposure. Some leaching bed soils will contain iron, aluminum or calcium which can adsorb phosphorus from the wastewater. The soil bacteria which perform the treatment require oxygen to function; therefore the leaching bed must be installed in soils that are not saturated by surface water run-off or a high groundwater table, and should not be paved or covered over with pavement, patios, sheds, and so on.

The leaching bed soil must be the right type to retain the wastewater long enough for treatment to occur, while at the same time allowing the wastewater to infiltrate into the ground.

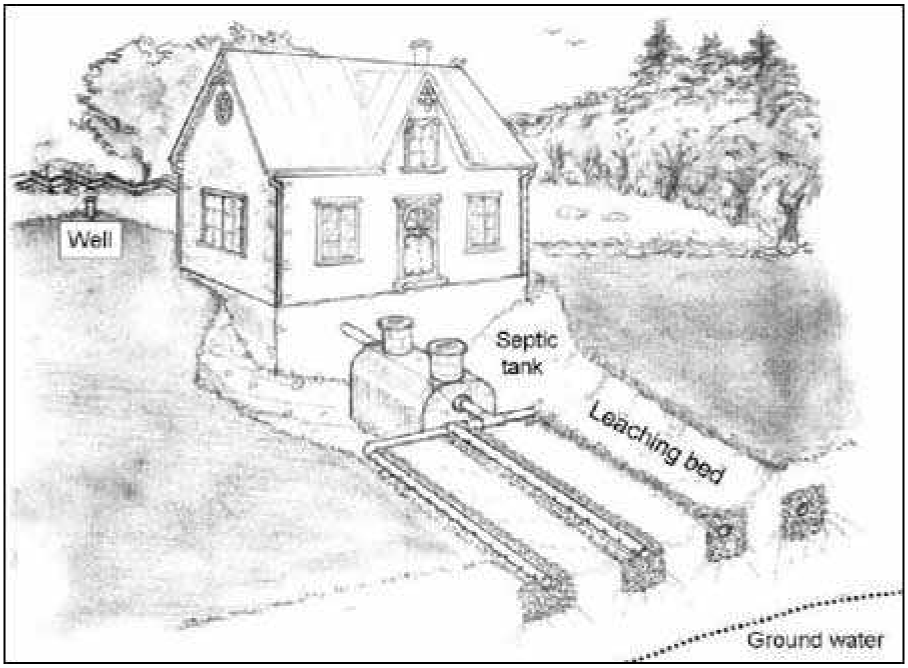

Figure 2.3: Conventional Septic System with leach field pipes

In cases where there is a sufficient separation from either the high groundwater table or bedrock, the network of drainage piping is installed directly in the native soil or in imported sand if the permeability of the native soil is not suitable. This is called a conventional system (see Figure 2.5). In cases where the high groundwater table or bedrock is close to the surface, the leaching bed must be raised so that there is sufficient unsaturated soil under the drainage piping. This is called a raised (bed) system or a mound system (see Figure2.6).

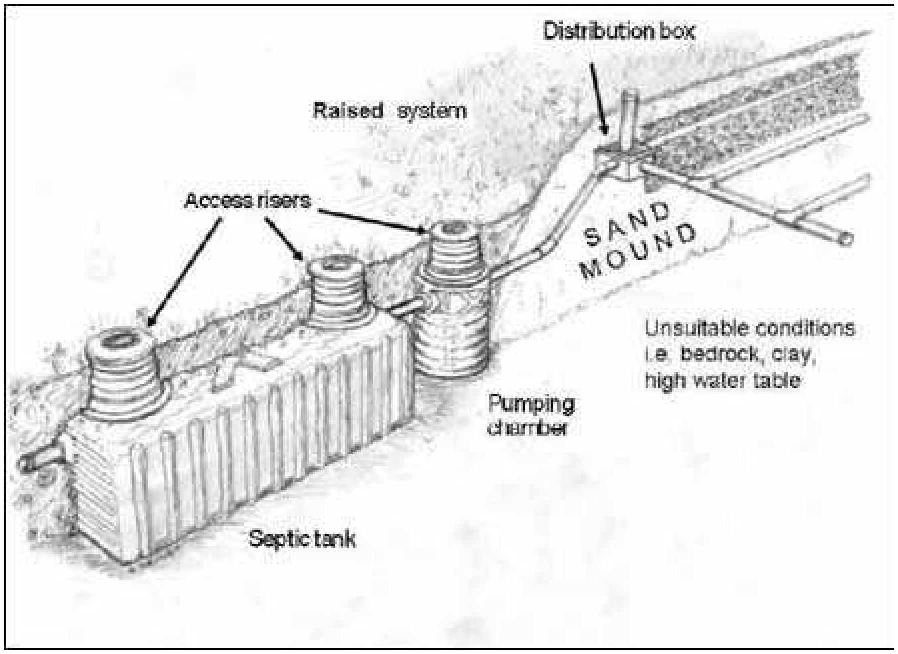

Figure 2.4: Raised Bed System Aerobic Treatment Technologies

much of organic matter from the wastewater, and a dispersal system, which is often a small leaching bed (see Figure 5).

2.6.2 Off-site sanitary options

In sewered areas many options for treatent could be used and the treatment level is limited by the receiveing water bodies or the target goal of treatment (i.e. reuse in agriculture, fish production..etc).

Wastewater Treatment Stages:

- Preliminary treatment, which removes coarse solids and other large materials.
- Primary treatment, which removes most of the solids from the sewage .
- Secondary treatment, which renders the outfall biologically safe.
- Tertiary treatment, which removes salts and chemicals.

Preliminary Treatment (pretreatment): is the very first stage, it is the removal of larger materials and grit that if not removed could hinder subsequent treatment processes. It is accomplished through the use of equipment such as bar screens and grit removal systems.

Primary Treatment: is an aim at producing minimum effluent quality. Primary treatment is usually comprised of preliminary treatment followed by primary clarifiers which remove approximately 50% suspended solids (SS) and 35-40% Biochemical Oxygen Demand (BOD).

This is accomplished by channeling flows through tanks with residence times of 2-4 hours, thus allowing suspended solids to settle. Post disinfection and a biosolids treatment process are sometimes included. Enhanced primary treatment can be performed by the addition of a coagulant such as ferric chloride along with a polymer, improving the degree of SS and BOD removal to 80% and 60%, respectively. The processes could include, sedimentation tank, skimming and chemically enhanced primary treatment.

Secondary Treatment: This stage of treatment enables the production of good effluent quality. In the secondary treatment process pollutants that pass through the primary sedimentation process are removed especially the organic matter. This stage of treatment removes most of the organic matter in the wastewater.

Extended aeration reactors, aerated lagoons, stabilization ponds, wetlands, trickling filter, rotating bio-discs and anaerobic reactors are a secondary treatment methods.

Tertiary Treatment: removes nutrients from the water, to restore it to a more natural state. The most damaging remaining minerals are usually nitrates and phosphates. These are especially damaging when the local economy depends on fishing by a large lake. Nitrates from even a small human population can cause eutrophication of a lake. The general process of eutrophication is algal blooming, followed by rotting, followed by oxygen depletion followed by the stinking death of the lake's aquatic life.

Biological Types of Wastewater Treatment (process technology)

The work of the bacteria is the cornerstone for most of the primary, secondary and even tertiary wastewater treatment methods. Bacterial activity could require dissolved oxygen as in the aerobic methods or work in the absence of dissolved oxygen as in the anaerobic methods. In some reactors the facultative bacterial cultures integrate the waste degradation. In all cases the bacterial population converts the wastewater organic matter and soluble material into other products such as gases.

Anaerobic treatment processes include anaerobic suspended growth reactors, up-flow or down-flow anaerobic attached growth reactors, fluidized-bed attached growth reactors, up flow anaerobic sludge blanket reactor (UASB), anaerobic lagoons, and anaerobic suspended growth reactors.

Anaerobic treatment converts the organic pollutants (Chemical Oxygen Demand COD, and Biochemical Oxygen Demand BOD) in wastewater into a small amount of sludge and a large amount of biogas (methane and carbon dioxide), while leaving some pollution unremoved. In contrast, aerobic processes produce a lot of excess sludge, and no biogas, while also leaving some pollution.

Aerobic processes use bacteria that need oxygen to live while anaerobic bacteria do not. In the absence of oxygen, many different groups of anaerobic bacteria work together to degrade complex organic pollutants into methane and carbon dioxide (biogas). The microbiology is more complex and delicate than in case of aerobic processes, were most bacteria work individually.

In the anaerobic process, the biological degradation of complex organic compounds takes place in several consecutive biochemical steps (chain reaction), each is performed by different groups of specialized bacteria. In practice, the acetogenic (acetate building) and methanogenesis phases are most often the rate limiting steps. On the other hand, the generation of methane gas can only happen as fast as methane bacteria receive their substrates. Methane bacteria only use acetic acid, hydrogen gas (H2) and carbon dioxide (CO2), or methanol as a substrate.

Aerobic biological wastewater treatment is based on the metabolic activities of microorganisms which utilize the organic components in the wastewater both as a respiratory substrate and as material for cell synthesis. The aerobic processes require aerobic conditions which can be realized by aeration. The speed of the aerobic oxidation reaction can be increased only by providing a high concentration of microorganisms.

Example of the biological anaerobic treatment:
The Upflow Anaerobic Sludge Blanket (UASB)

One of the most notable developments in anaerobic treatment process technology was the upflow anaerobic sludge blanket (UASB) reactor in the late l970s in the Netherlands by Lettinga and his coworkers. The principal types of anaerobic sludge blanket processes include the original UASB process and modification of the original design.
The distinctive element of the UASB concept is the sludge bed, formed by highly active and fast settling bacterial granules. This natural form of microorganism aggregation allows the retention of anaerobic biomass in the reactor, without the need of expensive or volume displacement packing materials like that in attached growth reactors. In certain cases, the sludge bed may be mainly flocculent, as in low loaded UASB reactors.
The wastewater is uniformly introduced by the distribution system on the bottom of the reactor and passes through the sludge blanket. During the upflow path, the polluting organic matter in the wastewater is taken by the microorganisms for their metabolic needs, resulting mainly in biogas, a mixture of methane (CH4) and carbon dioxide (CO2). This biogas is captured on top of the reactor by means of a collecting device called three phases separator that is also used for providing a settling zone on its upper part. The high density of the sludge prevents the washout of microorganisms by the up flow pattern. The treated effluent is finally drained at the top of the reactor.
By means of the three phase's separator, the biogas is evacuated to end-use or burning, the suspended solids are retained and sent back to the sludge zone, and the effluent is clarified. The compact design of this kind of reactors, in fact includes several stages in one tank.
The UASB is a high rate suspended growth type of reactor in which a pre-treated raw influent is introduced into the reactor from the bottom and distributed evenly. Flocs of

anaerobic bacteria will tend to settle against moderate flow velocities. The influent passes upward through, and helps to suspend, a blanket of anaerobic sludge. Particulate matter is trapped as it passes upward through the sludge blanket, where it is retained and digested. Digestion of the particulate matter retained in the sludge blanket and breakdown of soluble organic material generates gas and relatively small amounts of new sludge. The rising gas bubbles help to mix the substrate with the anaerobic biomass.

The biogas, the liquid fraction and the sludge are separated in the gas/liquid/solids (GLS) phase separator, consisting of the gas collector dome and a separate quiescent settling zone. The settling zone is relatively free of the mixing effect of the gas, allowing the solid particles to fall back into the reactor. The clarified effluent is collected in gutters at the top of the reactor and removed. The biogas has methane content typically around 75 percent and may be collected and used as a fuel or flared.

A properly designed UASB reactor eliminates the need for mechanical mixing and has few moving parts. If gravity distribution of the influent is possible, the treatment plant may need pumps only to remove excess sludge from the reactor periodically for transfer to drying beds.

The UASB reactor is the most widely and successfully used high-rate anaerobic systems for several type of wastewater. The great success of the UASB can be attributed to its capability to retain a high concentration of active suspended biomass with simple and low cost means. Moreover, the formation of granular sludge, which has a high methanoginic activity and is better settable than flocculent sludge, improves the maximum loading rate of the UASB system. Several versions of the upflow anaerobic sludge bed system were developed all on the same basis, like the expanded granular sludge bed (EGSB) reactor), the staged multi-phase anaerobic (SMPA) reactor, the high loaded UASB reactor and the upflow acidogenic substrate precipitation (UASP) reactor (Lettinga et al., 1980) .

Advantages of UASB system over Conventional treatment process:

1. A UASB treatment plant has fewer mechanical components, thus operation and maintenance are easy.
2. The energy requirements of a UASB reactor are very low. At the same time, it produces energy in the form of biogas, which is rich in methane and has a high energetic value. The biogas generated can be used for the production of electricity.
3. The reactor can be started up with ease even after the plant has remained shut for months. Therefore, the process is very good for treating wastewater from seasonal industries as well. A UASB system is less sensitive to interruptions in the waste water supply. After power breakdowns, the process starts immediately and no specific operation has to be executed. Thus the UASB system is more appropriate and cost-effective as compared to a conventional treatment system.
4. UASB system requires less space. The production of excess sludge in this system is very low. Further the sludge produced from the reactor is highly stable and has a good fertilizer value. (Metcalf and Eddy ,1991).

Chemical precipitation is another primary treatment option but is more costly. It involves the addition of lime, iron sulfate, and other coagulants to cause organic and inorganic solids to settle out of sewage and wastewater. It copes with the stringent water quality standards and toxic industrial pollutants entering sewage treatment plants.

Activate sludge treatment - which resulted in an effluent of 98% water and reduced bacteria by 90% - was also being used successfully in countries around the world. Not surprisingly, major technological improvements in the application of the activated sludge process coincided with the developments in biological nutrient reduction and physical-chemical separation resulted in higher quality effluents in the '80s and 90s.

Intermittent sand filtration (Biologically treating sewage) is good at the end of the treatment line, but required large tracts of land and specific soil compositions. Contact beds consisting of tanks filled with broken stones, slate or other coarse, inert substances were then developed, but proved difficult to operate. Trickling filter systems - which involved sprinkling untreated effluent over a bed of coarse rocks covered with biological growths.

2.7 Environmental impacts for wastewater disposal into wadis

The impact of disposing untreatd sewage into wadis are severe and can't be all mensioned here, however some important iompacts are:

-Polluting groundwater basins

-Degrading the ecosystems and damaging the environment in its comprehensive and global form

-Creating public health problems.

-Damaging the agricultural land.

-Threating and deteriorating the aesthice scenes of the community.

-Allowing illegal behaviour in sanitation to prevail.

-Pollution means now loosing money due to effects on natural resources such as soil and freshwater.

-Loosing the chance to get benefit from the storm water by using retaining it in dams or allowing it to recharge groundwater because it is mixed with sewage flows under wet weather conditions.

-Nontheless, in case we do not treate the sewage, we loose a marginal water source for agriculture (the treated wastewater).

CHAPTER THREE

METHODOLOGY

CHAPTER THREE
Methodology

3.1 Introduction

Initially, few or approximately no studies were available for Wadi al-Samn with little information given. To study the wadi we try to use the available tools, facilities and surveying work especially the available aerial photos. The wadi is passing many different towns and villages like (Yatta and al-Daherrya) with variable width of the section. Nonetheless, it even crosses the 1948 green-line.

3.2 Identifying sites for sampling and flow rate measurements

For this purpose, we will carry out field visits for different segments of the wadi and select the best points at different localities where our fieldwork is feasible and road access is available thus we can measure flow rate easily and take samples. These points will be known later as stations.

Firstly, our judgment for selecting the sites takes into consideration the covering of different localities as possible, representing the flow rate changes and representing different nodes at the wadi path.

To identify the position for each point we will use GPS (Global positioning system) for field data to identify the locations of the proposed stations and insert these points' coordinates into GIS (Geographical information system) on different base maps (depending on the availability of theses maps for us) such as:

- Digitized aerial photo for Hebron district.
- Digitized aerial photo for different towns and villages in the district.
- Digitized aerial photo for the wadi path itself.

- Topographic maps

Different layers of the GIS could be produced for the wadi, but the availability of aerial photos is a limiting factor. In fact, from the initial stages of the project, we started to contact different people and organizations to make available any mapping work fro the wadi. Unfortunately, this is unavailable at PPU database.

3.3 Flow rate measurement

To measure the flow rate (Q) we will use methods reported here in chapter 2 (the section about flow rate) of this study .
Measuring the flow rate at the different 6 selected stations will enable us to analyze the variation in discharge contributors (such as vacuum-tankers) and any other factors that may affect the wadi discharge.
The table format for the data could be as follows

Table 3.1: Data and measurement form

Station #	Horizontal distance from the outfall (m)	Q (m^3/min)
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Then graphical presentation for the data through placing the distance (m) from the sewer outfall on the X-axis and placing the Q value variation on the Y-axis will enable us to see changes and give interpretation of the data.
Other useful uses of Q value measurement will be through linking the data with any measures wastewater parameter such as the COD, ammonia.. etc.
Flow measurements for wastewater streams is similar to measure flow in open irrigation channels. More details will be given here.

Units of Measuring Water Flow

There are many ways to express water volume and flow. The volume of water applied is usually expressed in acre-inches or acre-feet for row crops or gallons per tree in orchards. Flow rate terminology is even more varied. Flow rate is expressed as cfs (cubic feet per second), gpm (gallons per minute) and in some areas, miner's-inches. Below is a description of each.

-*Cubic feet per second* (cfs): One cubic foot per second is equivalent to a stream of water in a ditch 1-foot wide and 1-foot deep flowing at a velocity of 1 foot per second. It is also equal to 450 gallons per minute, or 40 miner's-inches. Gallons per minute (gpm): Gallons per minute is a measurement of the amount of water being pumped, or flowing within a ditch or coming out of a pipeline in one minute.

Miner's inches: Miner's-inches was a term founded in the old mining days. It is just another way of expressing flow. Some areas in the World still use this measurement unit. Caution needs to be taken because there are Pressure or Head (H): People often use the phrase "head of water." A foot of head usually implies that the water level is one foot above some measuring point.

However, head can also mean pressure. For example, as the level of water rises in a barrel, the pressure at the bottom of the barrel increases. One foot of water exerts 0.43 pounds per square inch (psi) at the bottom of the barrel. Approximately 2.31 feet of water equals 1 psi. Thus, if a tank of water were to be raised 23.1 feet (2.31 x 10) in the air with a hose connected to it, the pressure in the hose at the ground would be about 10 psi.

-*Area*: The cross sectional area of a ditch is often required to calculate flow. Some ditches are trapezoids and others or more like ellipses. To find the area of a trapezoid (Fig. 3.1.a), measure the width of the bottom (b) and the width of the ditch at the water surface (s) and add them together. Divide that number by 2 and then multiply by the height (h) of the water. If the ditch is more elliptical in shape (Fig. 3.1.1b), take the depth of the water (h), multiply it by the width of the ditch at the surface (s), divide by 4 and then multiply by PI (3.14).

To calculate the cross-sectional area of a pipe, the formula is PI x r2, where PI is 3.14 and "r" is the radius of the pipe. NOTE: All measurements should be in feet.

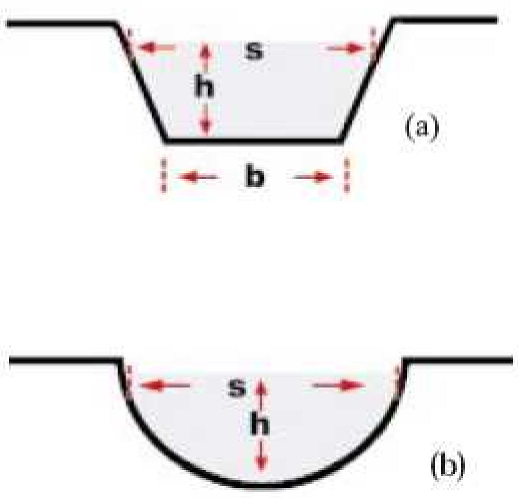


Figure 3.1: Cross-sectional dimensions for trapezoidal (a) and elliptical (b) ditches.

-Measuring Water Flow in Ditches

The Float Method: This method is useful to get a rough estimate of flow. First, choose a 100-foot (30.48 meter) section of ditch that is fairly uniform in depth and width. Mark the zero point and the 100 ft point with a flag or stick.

The 100 ft mark should be downstream from the zero point. For most people, one good, long stride equals three feet. If there is no tape measure available, step off about 33 paces. Next, calculate the ditch cross sectional area (see "Area" above for details). Use an average of several measurements along the ditch. Now, take a float (tennis balls, apples, oranges, etc.) and place it a few feet up stream from the zero point, in the center of ditch. Once the float hits the zero point, mark the time (probably to the nearest second). Then, mark the time the float passes the 100 ft mark. Record the time. Do this several times. Try to place the float in the center of the ditch flow so that it won't bounce off the sides or get caught up in any weeds. After 5-10 tries, average the recorded times.

The flow rate is determined by calculating the velocity of the water and multiplying it by the cross sectional area of the ditch. First, take the length of the ditch (100 ft) and divide it by the time (in seconds). This will give the surface velocity (speed) in feet per second. However, water at the surface flows faster than water in the center of the flow and it is the average flow or center flow that is needed. Therefore, a conversion factor must be used to determine the mean channel velocity. The factor by which the surface velocity should be multiplied by is a function of the depth of the water in the ditch. Table3.2 gives the coefficients to be used. Find the depth measured on the left and the corresponding coefficient on the right. Then multiply the surface float velocity by the coefficient to obtain the mean channel velocity.

Finally, take the cross sectional area of the ditch (ft2) and multiply it by the corrected velocity (ft/sec) and this will compute the flow rate in cubic feet per second (cfs). To convert to gallons per minute, multiply the cfs by 450. Tracer Method: This method is very similar to the float method but with one exception, a colored dye or salt is used instead of a float. Estimates of the ditch area are still required. Pour the dye upstream of the zero point, and record how long it takes the dye to travel from the zero point to the 100 ft mark. Then the calculations are exactly the same as the float method. This method often works well if the float keeps getting caught on the sides of the ditch. However, in many cases the dye is difficult to see because of the color of the water itself. Test the dye first to make sure it can be seen. The correction factors used with the float method (Table 3.2) are not required for the tracer method.

Velocity Head Rod: The velocity head rod is used to measure the velocity of water in a ditch and is relatively inexpensive and fairly accurate. The rod is in actuality a ruler used to measure the depth of the water.

Table 3.2: Coefficients to correct surface float velocities
to mean channel velocities…(7).

Average Depth (ft)	Coefficient
1	0.66
2	0.68
3	0.70
4	0.72
5	0.74
6	0.76
9	0.77
12	0.78
15	0.79
20	0.80

The water height is first measured with the sharp edge of the ruler parallel with the flow and the again with the ruler turned 90 degrees. The difference in the height of water is the head differential and using Table 3.3, an estimate of the velocity (feet per second) can be made. From there, follow the same formula as with the float or tracer method, i.e., multi-ply the velocity by the cross sectional area of the ditch to get cubic feet per second. The velocity head rod method works only for velocities greater than 1.5 ft/sec and less than about 10 ft/sec. *we will also convert units to metric system.*

<u>The procedure is:</u>

• Place the rod with the sharp edge upstream. Record the depth of the water (normal depth).

• Place the rod sideways. This will cause some turbulence and the water level will “jump” causing the water level to rise. Record the level again (turbulent depth).

• Subtract the normal depth from the turbulent depth and this will be the jump height.

• Find the corresponding velocity from Table 3.3.

• Multiply the velocity by the cross sectional area of the ditch to get the flow rate (cfs).

Table 3.3: Conversion chart for velocity head rod measurements from inches to ft/sec.

Jump (inches)	1/2	1	2	3	4	5	6	7	8	9	10	11	12	15	18
Velocity (ft/sec)	1.6	2.3	3.3	4.0	4.6	5.2	5.7	6.1	6.5	6.9	7.3	7.7	8.0	9.0	9.8

3.4 Sampling and Analytical Methods

3.4.1 Sampling

Sampling will include the 6 proposed stations and will be carried out twice. We will include one type of sampling methods (grab samples).

- Grab samples

These samples will be a pick up type, if analysis started within 2 h of collection, cold storage is unnecessary and if not started within 2 h of sample collection the sample should be kept at 4°C. In fact, our analysis will start within 6 h of collection; this is because the sampling site is faraway from the laboratory, sample should be stored at or below 4°C and we should report the time and temperature of storage with the results. Analysis should never at more than 24 h of grab sample collection. When samples are to be used for regulatory purposes we make every effort to deliver samples for analysis within 6 h of collection. A 2-liter sample is sufficient for our laboratory work.

Grab samples will be collected from the several stations at the wadi path covering different localities.

3.4.2 Analysis and measurements

The analyses of the samples will be conducted at the Palestinian Hydrology Group (PHG) laboratory.

In situ measurements of the flow will be done; the physical parameters such as pH, temperature, and dissolved oxygen will be measured.

Parameters such as sulfate and chloride will be measured for samples. Sulfate changes will enable us to quantify the effect of air pollution due to the transformation of sulfate into sulfides (malodorous compound). While chloride follow up measurement at different wadi stations will enable us to conduct evaporation analysis through making a mass balance (equation 3.1) and thus losses due to infiltration could be quantified. Ammonia nitrogen and chemical oxygen demand (COD) measurement will be done as well as total dissolved solid (TDS), total solid (TS), electrical conductivity (EC) ..etc.

$(C*Q)_n = (C*Q)_m + \text{evaporation}$ ………. (3.1)

Where:

C: is the concentration (mg/l) while n and m are representing two successive different points at the wadi hydraulic gradient.

3.4.2.1 Chemical Analysis (according to Standard Methods for the Examination of Water and Wastewater, 1998).

- ***Chemical oxygen demand (COD)***

Measurements will be done by using the reflux method (acid destruction at 150°C for 120 minutes). From the diluted sample (10 ml will be diluted to 50 ml), 2.5 ml will be filled in the COD-tube.

The absorbance will be measured by spectrophotometer at 600nm wavelength. Calibration equation will be prepared and later on used in the calculations.

- ***Ammonia nitrogen (*** $NH^{+}{}_4 - N(mg/l)$ ***)***

After direct Nesslerization and the distillation step, 1 ml distillate will be diluted to 50 ml using demonized water, and then continued as Standard Methods for Examination of Water and Wastewater. By direct Nesslerization followed by spectrophotometer measurement according to the Standard Methods (visible spectrum range) and placing the data on calibration excel equation, ammonia could be calculated .

- ***Sulfate (*** $SO_4^{-2}(mg/l)$ ***)***

Sulfate will be measured by turbiditimetric methods using barium chloride, then absorbance of the formed crystal will be measured at 420 nm. A calibration equation will be prepared and data be calculated by excel equation.

Chloride (*Cl- (mg/l)****)***

This will be done by titration with silver nitrate after adding the dichromate indicator, then calculating the concentration by using the equation:
$(MV)_1=(MV)_2$, where M and V are representing molar and volume values before and after adding the titrant.

3.4.2.2 Physical Analysis

For the parameters: Turbidity, pH, Temperature, Dissolved Oxygen (DO), Total Dissolved Solid (TDS), Salinity and Electrical Conductivity (EC) electronic ready-made meters will be used.

3.4.2.3 Sediments Depth

By means of lowering a 90^{o} steel bar inside the wadi segment bottom, the sediment depth will be measured. To determine the exact depth, a towel (or a bandage tap) will be placed at the lower steel bar part and a scaled meter will be used to measure the sediment marked part..

3.5 Data Interpretation

The measured Q values besides the measured chemical parameters will be converted into hydraulic and pollutants loads and variation along the wadi section will be followed-up. Besides that, and as we mentioned before, the changes in the wadi path length at different stations and for some parameters (chloride as example) will help assessing the infiltration and the flow rate variation with some assumptions for any missed data. Statistical analysis for the data will be done. An example of the data presentation will be such as the table format below.

Table 3.4: Data format for field and laboratory work handling

Station #	1	2	3	4	5	6
Horizontal distance from the outfall (km)						
Q (m^3/min)						
COD (mg/l)						
COD Load (ton/d)						
Ammonia (mg/l)						
Ammonia Load (ton/d)						
Chloride (mg/l)						
Chloride load (ton/d)						
….etc						

In addition, graphical presentation for the data will be used. The GIS will be used to draw changes in flow and pollutants variations at different stations.

CHAPTER FOUR
STUDY AREA DESCRIPTION

CHAPTER FOUR
Study Area Description

4.1 Background about Hebron City and District

The Hebron governorate has 160 communities scattered over 1043 square kilometer and a population of approximately half million. The area is comprised of 15 municipalities, two refugee camps (AL-Fawwar and AL-Arroub),and numerous village. Figure 4.1 shows the different communities of the district.

Rainfall in the Hebron occurs between early November and end of March. The rainfall varies according to a steep elevation gradient from about 450 mm per year at the south end of Hebron City to about 250 mm per year in Yatta between which the distance is less than 10 km. Growth of plants takes place during the summer months for rainfed agricultural season that is practiced in the Hebron.

Within the Hebron governorate, there are no operational wastewater treatment facilities and Hebron city is the only municipality that has a sewer collection system. The system is limited and provided coverage to approximately 85 percent of the homes in the Hebron municipality.

As with most arid region, wadis like wadi al-Samn , are subject to periodic flooding in the winter. But this wadi now flows year-round, with a mixture of raw sewage from Hebron’s 180,000 residents and Kiryat Arba’s 7500 residents. Based on wastewater characterization tests conducted in 1999/2000 by Hebron Municipality, the flow rate was estimated at about 6000 m^3/day. The wastewater is generated from a domestic and industrial sources, 98% of Hebron City’s industries are connected to the wastewater collection network, and most of this is untreated, though some preliminary treatment in

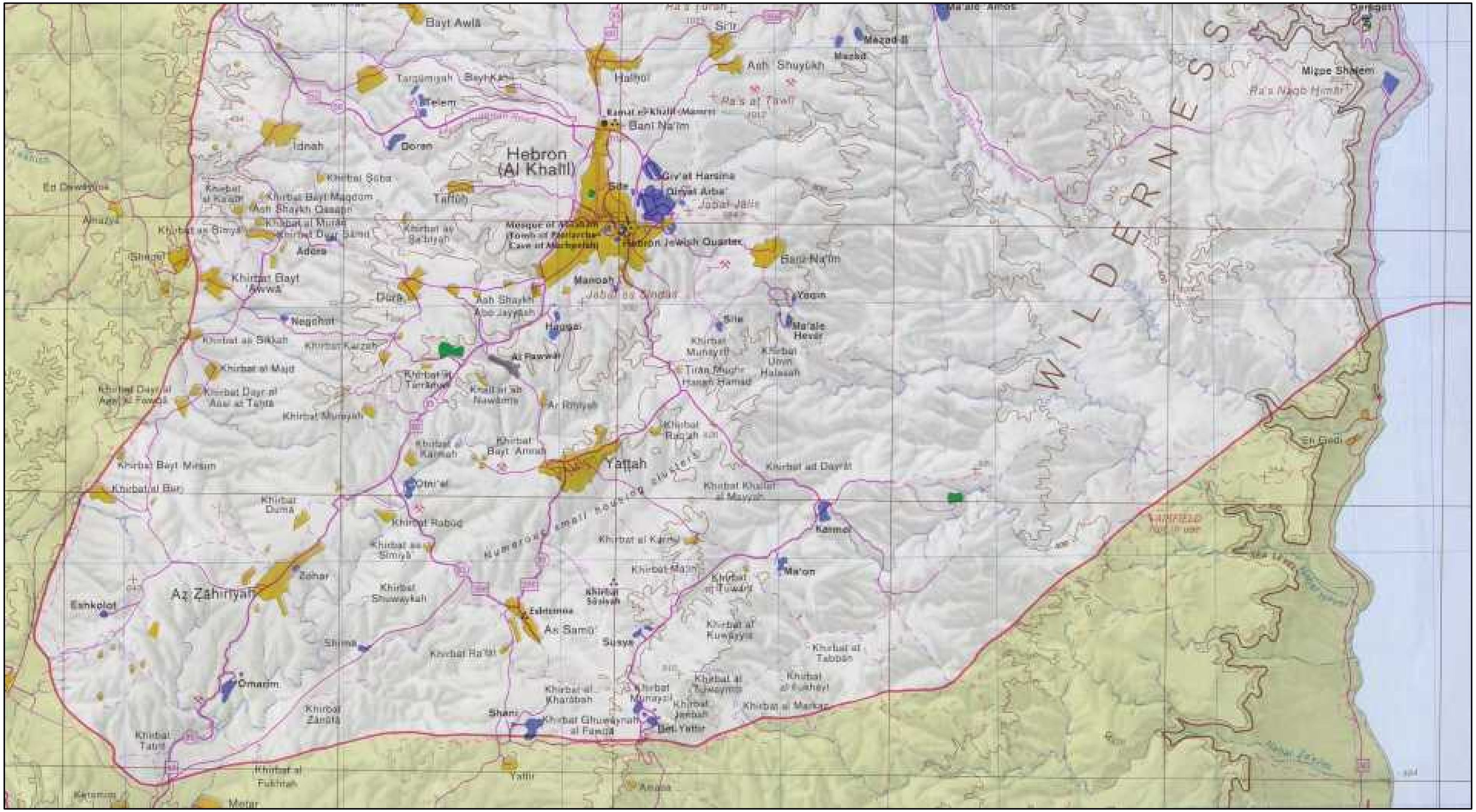


Figure 4.1: Hebron District Map

some industries should be practiced. Prominent industries include stone cutting and finishing industry, tanneries, electroplating, garages, dairy factories, slaughter houses, and car washing facilities. Because of these sources, the flow rates, acidity, and other water parameters vary greatly over the course of the day.

The collection system in Hebron City comprises some 145 km of trunk, collector and local sewers, 4 pumping stations, and 10 km of pressure mains.

A pond treatment plant was constructed in the 1980s, and is currently out of operation. Hebron is also a highly industrialized city, industrial pretreatment before discharge to the sewer system is negligible.

Hebron's first wastewater collection system was started in the 1930s and comprised the construction of the combined trunk sewer that transported rain and sewage from the old part of the city to the wadi. During the last 10 years, the collection system has been expanded through funded construction contracts and is now serving various areas of the Hebron Municipality, mainly the western and eastern parts. A detailed description of the wastewater collection system may he found in various studies prepared by the Hebron Municipality.

The collection system of Hebron City consists of over 120 km of lateral sewers and more than 25 km of trunk sewers, virtually all flowing by gravity to the discharge point at Wadi al-Samn. The exceptions are in the northern and western parts of the city, where the wastewater is pumped over an intervening hill to the main sewer trunk lines and the trunk lines currently discharge to Wadi al- Samn.

Although only an estimated 85 percent of the population is connected to the collection system, a significant percent of the Hebron Municipality is in a position to he served by the collection system by virtue of the presence of sanitary sewers in the streets. Many potential contributors have not yet been connected.

In order to plan improvements to or expand the wastewater system, it is essential that the existing facilities be assessed to determine the following:

- Size, level, and performance
- Structural condition and residential life
- Service condition, including siltation, internal surface encrustation, and blockages

- Adequacy, service ability, and performance of mechanical and electrical equipment

4.2 Sewage Disposal Facilities

Around 85% of Hebron City is connected to the sewage disposal network. The fraction depends on cesspits for sewage disposal. There is other sewage collection network in the camps only but not in most of the villages in the district. The village inhabitants depend on cesspits for sewage disposal.

Few municipalities in the West Bank have installed wastewater collection systems, with only about 70% coverage within these municipalities. Only minor parts of the rural areas is yet covered with collection or treatment facilities. Septic tanks and cesspits are infrequently emptied and septage disposal is hazardous.

And also few wastewater treatment plants (Jenin, Ramallah, Al-Berih, and Tulkarm) exist in the some cities of West Bank. Investigation has shown that wastewater treatment plants in the West Bank do not produce safe effluent except for the newly established AlBerih plant. Such plants are producing a partially treated effluent and their performance is inadequate The existing treatment plants were designed upon assumptions of characteristics of wastewater and flow of American and European countries which is not representative of our wastewater characteristics. The efficiency of the existing treatment plants is low. They are old and the capacities are not sufficient to handle current wastewater flows. The plants were never properly operated and maintained, and equipment was rarely maintained. Most sewage is discharged untreated into wadis resulting in environmental contamination and creation of a health threat. Untreated and unsafe treated wastewater was illegally used by some farmers in the West Bank to grow different marketable crops (mostly vegetables) without taking into consideration the major health effects. Al-Bireh City wastewater treatment plant is the only exception since it is newly implemented by the German fund and it is well-functioning.

4.3 Wadi al-Samn Pathway

The focus here is given to Hebron City wastewater stream (named wadi al-Samn, according to its name at the upstream), which originates in the Palestinian Authority areas, South of Hebron (Al-Khalil in Arabic), passes Yatta, Beit-Emra, Karmah, Abu-al-Asja and Daherrya communities before it runs through Israel to the east and then south of Beer al-Saba', and then enters Gaza, where then ends in the Mediterranean (Figure 4.2). *We prepared the following measurements based on the original map, (hard copy) of Figure 4.2, and the data are as follows:*

- The wadi path length starting from Hebron and ending in Yatta = 9 km
- The wadi path length starting from Yatta and ending in al-Daherrya = 15 km
- The wadi path length starting from al-Daherrya and ending at the Hebron District border= 14.5 km
- The wadi path length starting from the District border and ending in al-Saba'City = 20.25 km
- The wadi path length starting from the al-Saba' City and crossing the Gaza Strip borders = 56.75 km
- The wadi path length starting from the Gaza Strip borders and ending in the Mediterranean = 8.75 km

The data above indicates the following main points:

- The wadi extends for a distance of 38.5 km inside the Hebron District
- The wadi extends for a length of 77 km inside the 1948-Palestine
- The wadi part crossing Gaza Strip is at a length of 8.75 km

Finally we can say that the wadi total length is 124.25 km starting from the sewer outfall (upstream) at Hebron City and ending at the Mediterranean Sea (downstream), of which 47.25 km are inside the Palestinian Authority area.

The wadi segments are known with different common names (historical) as it flows from the upstream to the downstream and these are summarized as follows:

- Wadi al-Samin in the areas adjacent to Hebron City
- Wadi al-Nar in areas adjacent to Yatta and al-Daherrya
- Wadi Khalil in areas emerging from al-Daherrya and extending to Beir Al-Saba'
- Wadi al-Shallaleh in areas extending from Beir al-Saba' and reaching Gaza Strip borders
- Wadi Gaza inside Gaza Strip

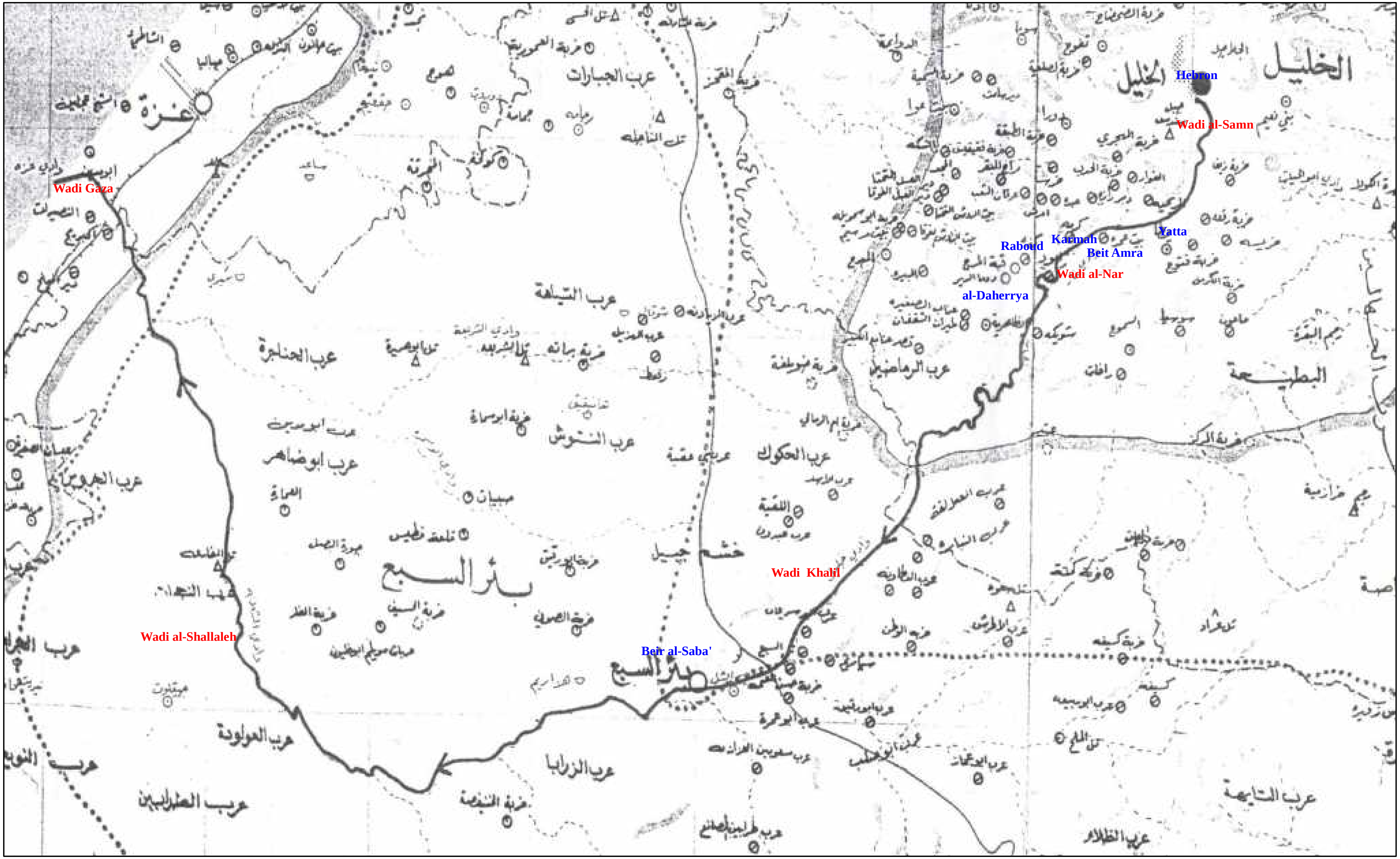


Figure 4.2: The Wadi Pathway starting from the sewer outfall and ending in the Mediterranean

4.4 Water Supply and Demand

Hebron Municipality consumes not less than 90 m^3/hr from the Palestinian Water Authority wells (administered by the municipality) which is equivalent to 2160 m^3/day, and Mekorot supplies the municipality with approximately 7000 m^3/day at the best conditions, and may be decreases to during the summer months. The average water supply is not less than 10,000 m^3/day, distributed to the population of Hebron City. The daily per capita supply rate varies from 20 l/c/day during the summer months to 60 l/c/day during the best conditions of supply, (including water losses). The daily consumption is considerably low compared with the Israeli per capita consumption that is currently estimated at about 150- 250 l /c /day. The villages of the district which are supplied by Mekorot have a shortage in water supply around the year and have almost little water supply during summer months.

Water provided by Mekorot is conveyed from Herodion wells into the supplied areas through a 16-inch diameter pipeline while the municipality wells are from Toqu'e and Sa'ir wells. Hebron Municipality buys water from Mekorot at a price of 2.66 NIS/m^3 and sells it for consumers at a tariff of 4.5 NIS. Table 4.1 shows some historical records, according to Hebron Municipality, about water consumption and leakage.

Table 4.1 unaccounted for water and per capita consumption for Hebron (1996/1999)

Water supply **Year m^3/year billed**	**Unaccounted for water**	**Housing connections**	**population**	**Consumption l/c/day**
1996 4,112,724 1,960,536	52%	10,961	82,207	65
1997 3,665,210 2,447,758	33%	11,373	85,297	79
1998 3,422,587 2,351,922	31%	11,833	88,747	73
1999 3,746,878 2,713,317	28%	12,367	92,752	80

Source:…(3)

Assuming availability of adequate water supply for the Hebron City, the total water consumption could be at 9000 m^3/d for the year 2006 according to our estimation using 50 l/c/d of water consumption.

4.4.1 Water Distribution Network

Although 90 percent of the population in the Hebron Governorate has access to piped water, there are many problems with water quality and continuity of supply. During the summer, people in the villages or camps, and even Hebron City suffer from water shortages. Future plans to rehabilitate the networks and to increase supply rates are prepared by municipalities and village councils. Most of the Hebron Governorate population is using cisterns as an alternative source for domestic and agricultural purposes.

The current network was constructed in the early 1996s. The network consists of steel pipelines ranging from 50 mm to 400-mm diameter. Approximately 33 percent of the water is lost due to leakage, illegal connections to the pipeline, and the inaccuracy of water meters.

Currently, two groundwater wells were drilled at al-Ein village (Bani-Naim neighborhood) with mainlines and pumping stations to serve the southern part of the District, but due to political problems with the USAID the project is not operating.

4.4.2 Water Per Capita Consumption and Demand

Previous projects and reports estimated the per capita water demand as shown in Table 4.2. It is expected that the water supply service will be improved and the per capita consumption will increase. The long-term outlook for per capita water demand growth appears to be moderate. Political uncertainties and/or high costs involved in some of the supplemental supply projects, coupled with growing populations and industrial needs, are thought to require a continued national policy emphasizing the wise and legal use of water.

Table 4.2 per capita water consumption (l/c/day)

Data Source	2000	2005	2010	2015	2020	2025
Palestine national water plan.	55	107	142	-	173	-
Water sector strategic planning study.	89	115	128	165	179	-
Hebron water master plan.	94	112	128	145	165	-

Source: …(3)

4.5 Wastewater Production

Wastewater consists primarily of used water from domestic, commercial, and residential uses. To estimate the per capita wastewater flows from water supply data, it is necessary to assess the differences between the amount of water supplied and the amount of water eventually discharged to the sewer.

In many parts of Hebron, large disparities exist between per capita demand and water quantities that are actually used by consumers. In addition, a considerable portion of the water used does not reach the sewer system due to product water consumed by industries; water used for gardening and irrigation; and leakage from water mains and service pipes (unaccounted for losses).

As there are no reliable means to accurately measure the water consumed within the study area, the per capita wastewater flows are estimated values. Wastewater generated has been taken as 80 percent of the water consumed all over the study area. Although this figure is considered high in hot areas like the Hebron Governorate, many people have their own cisterns, which make the quantities of wastewater larger than the metered water consumption from the public supply.

4.5.1 Wastewater Flow Variations

Wastewater flows vary slightly throughout the year due to the influence of seasonal changes. Factors to be considered in this regard include:

- Variations in population contributing to the wastewater system but this could be of minor effect.

- Variations in the production of wastewater.
- Wet weather infiltration/inflow effects.

4.5.1.1 Variations in Quantity and Quality of Wastewater

Some industrial operations, such as food processing, entail seasonal activity, which could be a factor to consider in the agricultural production areas. Although in most areas of the Hebron Governorate seasonal activity is not considered to be significant, the data collected during 1999 and 2000 indicate higher levels of chemical oxygen demand (COD), ammonia, TSS (total suspended solids), and total phosphate during the summer months (June through September), suggesting that perhaps there are some seasonal industrial loads variations in Hebron City.

Mild seasonal variations in the production of wastewater are related to personal hygiene and laundering of clothes. During hot summer weather, people bathe or shower more frequently than during the winter months. The extra flows during summer may be significant, but reduced infiltration or possibly infiltration of wastewater from the sanitary sewer network, particularly during the dry months (this can't be quantified at present), could cancel out those increased wastewater flows.

According to the data from the Hebron City outfall collected during 1999 , the diurnal variation in wastewater strength is great, especially for TSS, Table 4.3 (The data represents concentrations in the 4-hour composite samples collected in April 14-15, 1999 with a total of 8 samples). In the early morning hours, TSS levels are below 1000 mg/L, but the levels exceed 10,000 mg/L during the working day. After work hours and into the evening, TSS levels decrease. The TSS appears to be coming from the industrial areas to the south and is most likely attributable to the stone cutting operations.

Table 4.3:TSS Daily Variation at Hebron sewer outfall

Time	TSS (mg/l)
3:00 PM	833.4
8:00PM	19.080
11:00AM	4140
2:00 AM	27,520
8:00AM	32,340
11:00 AM	1,755

Source: …(8)

4.5.1.2 Industrial Wastewater

Hebron City has many industries of various sizes. The main sewer system serving Hebron City was constructed to transport industrial wastes as well as municipal flows. At present the industrial flows are minimal (approximately 10 percent of the total future estimated flows), hut the associated organic load contributions are major, especially from the tanneries and food processing industries.

TSS concentration levels in the combined industrial/domestic wastewater in the Hebron service area are nearly two orders of magnitude higher than that of typical domestic sewage. This is certainly due to the discharge to the sewer of wastewater from stone cutting operations, as evidenced by the following:

- The TSS comes from the industrial area
- The TSS is generated during work hours
- The TSS is not volatile and is therefore inorgani**c.**
- The TSS is not in the form of settleable solids; rather fine particles or colloids **.**
- The inspection of manholes serving the stone cutters shows a huge build-up of material

Before any new proposed sewage treatment plant, the stone cutting wastewater must be either pre-treated to levels close to domestic strength (< 500 mg/l TSS) or not discharged to the sanitary sewer at all. Excessive solids will disrupt and/or overload the treatment system and currently these solids flows with the wastewater inside wadi al-Samn.The opportunity exists to treat this wastewater onsite and reuse the wastewater in the sawing and cutting operation. The solids must be disposed of separately and not discharged to the sewer.

4.5.1.3 Summary of Wastewater Flows

From previous discussion, water consumption is not an accurate reflection of wastewater discharge, since it is subject to socio—economic and climatic conditions. Hebron Governorate is a mixture of both urban and rural areas. It includes Hebron City, which is a predominantly urban development with a fairly dense population and where land devoted to gardens and grassy areas requiring irrigation is small. ‘the next largest cities in the study area are Yatta, Dura, and Al- Daherrya, which are a mixture of urban and rural areas and where the difference between water consumption and wastewater production tends to he relatively small. As a result, an average reduction of 20 percent has been applied to the per capita water consumption adopted to give the wastewater discharge. The current and projected per capita wastewater flows are shown in Table 4.4.

Table 4.4: Projected water consumption and wastewater discharges for Hebron.

year	Average water consumption l/c/d	Wastewater discharge l/c/d
٢٠٠٠	٩٠	٧٢
٢٠٠٥	١١٥	٩٢
٢٠١٠	١٢٨	١٠٢
٢٠١٥	١٦٥	١٣٢
٢٠٢٠	١٧٩	١٤٣
٢٠٢٥	١٧٩	١٤٣

Source: …(8)

4.5.1.4 Wastewater Organic Strength-Hebron City

The organic strength of a wastewater flow is commonly measured in terms of its BOD and/or COD levels. Tests for these two parameters are used as an indicator of the sewage strength, i.e. the amount of organic pollution present in the wastewater.

The strength of sewage is classified within ranges of BOD and COD as indicated below:

Table 4.5: Strength of sewage

TYPE	BOD mg/l	COD mg/l
weak	<110	<250
medium	220	500
strong	400	1,000
Very strong	>400	>1,000

Source:…(4)

The records of laboratory tests performed at the Hebron City outfall were reviewed for the period from April 1999 to March 2000. The analysis, which is presented in Table 4.6, makes certain simplifying assumptions and approximations with respect to these sources of wastewater and must be considered as illustrative due to the nature of the data. To gauge the quality of the sewage, samples of the outfall were collected at 2-hour intervals and proportioned to the flow to get a 24—hour composite sample.
Values presented appear to he generally consistent. BOD5, COD loading, and TSS of the raw sewage and effluent values give results that classify the wastewater as a strong sewage while reflecting the population connected to he sewer system, including industrial loads.

Table 4.6: Parameter Outfall Characteristics and Per Capita Loading, Period April 99 - October 99

Parameter	Unit	Min	Max	Average	Waste loading factor g/capita/day
Flow	m^3/d	5,086	9.007	6,742	
Total BOD	mg/l	365	1,991	1,025	60.0
Soluble COD	mg/l	177	1,500	447	26.0
COD	mg/l	978	6,282	3,050	179.0
SS	mg/l	9	155	48	2.8

Parameter	**Unit**	**Min**	**Max**	**Average**	**Waste loading factor g/capita/day**
TSS	mg/l	2,470	98,486	25,131	1471.0
VTSS	mg/l	530	2,280	1,350	79.0
TDS	mg/l	1,030	16.039	2,714	159.0
NH3	mg/l	50.4	181.7	119.5	7.0
NO3-NO2	mg/l	0.032	0.97	0.32	0.02
TKN	mg/l	116	555.5	254.8	15.0
T-PO4	mg/l	2.77	949.2	129.3	8.0
O-PO4	mg/l	0.67	33	16.5	1.0
CL	mg/l	207	2,246.8	599.4	35.0
SO4	mg/l	58.7	822.7	220	13.0
T-Alkalinity	mg/l	640	1,333.3	807	47.0
pH	mg/l	2.4	187	23.55	1.4
Oil &Grease	mg/l	0.8	347	95.3	6.0
Cadmium*	µg/l			<0.2	
Chromium*	µg/l			<2.0	
Lead*	µg/l			<2.0	
Nickel	µg/l			<10.0	
Zinc*	µg/l			151	0.010
Mercury*	µg/l			<20.0	
Cyanide, total	µg/l			75	0.005

Parameters measured once, not included in the monitoring program*

Source:…(8)

Hebron Governorate wastewater is a mixture of both urban and rural treatment loads. For overall average organic loading, including the industrial load in the case of Hebron City, 60 g/c/d of BOD 5 has been assumed. For Hebron City, present and future loading scenarios, 40 percent of the total BOD is assumed to come from industry and 60 percent from domestic sources. It is assumed that the per capita BOD load will remain the same despite varying unit wastewater production, so the raw wastewater will become slightly more diluted with time.

4.5.1.5 Other Contributors to Hebron Sewage Flows

It noteworthy to mention that other contributors for wadi al-Samin sewage flow, which carries sewage from Hebron sewers' outfall, are firstly al-Fawwar stream of wastewater which meets wadi al-Samin flow near Beit Emra, secondly sepatge from vacuum tankers is disposed of at different random points of the wastewater stream flow (wadi al-Samin). In fact al-Fawwar is sewered area with complete coverage and data about it is given in table 4.7. The wadi flow at al-Fawwar wastewater stream is estimated at 700 m^3/d.

Table 4.7: Results of the Analysis of Raw Wastewater Samples.

#	Parameters	Unit	Average Value	Typical Value
1	Temperature (T)	ºC	15.7	-
2	pH value (pH)	-	7.99	6.5-7.5
3	Electric Conductivity (EC)	μs/cm	1883	-
4	Turbidity	NTU	1506.5	-
5	Total Solid (TS)	mg/l	2551	375-1800
6	Total Suspended Solid (TSS)	mg/l	1649	120-360
7	Total Dissolved Solid (TDS)	mg/l	902	250-800
8	Chemical Oxygen Demand (COD)	mg/l	1009.5	200-780
9	Biochemical Oxygen Demand (BOD)	mg/l	400	100-400
10	Dissolved Oxygen (DO)	mg/l	4.23	-
11	Salinity (S)	mg/l	0.99	-
12	Total Coliform (TC)	-	$2.5x10^4$	$4.1x10^4$-$2.1\ x10^8$

Source: …(1)

Data about sepatge (wastewater from cesspits) from tankers is given in table 4.8 below. Cesspits are a common alternative for wastewater disposal in the absence of sewage system. Cesspits are usually designed to serve a single household or a multiple apartment building. The volume of the cesspit depends on the availability of land space and the economic status of the owners. They range from 5 to 25 cubic meter. Cesspits are usually emptied by vacuum tankers owned and operated by either the municipalities, UNRWA, or the private sector. Contents are disposed of at any available location, in many cases, in the wadis. This sewage type is apparently disposed of without consideration to the natural habitat, soil fertility, groundwater, or built-up areas.

Table 4.8: Septage characteristics

Parameter	Range	Mean	No. of samples
pH	6.7-7	6.8 ± 0.1	10
COD (mg/l)	1616.7-8633.3	4145.8 ± 3120.5	10
NH_4^+-N (mg/l)	48.85-635.4	190.5 ± 200.6	10
Organic-N (mg/l)	14.7-134.2	59.1 ± 43.7	10
NO_3^--N (mg/l)	0.01-0.12	0.06 ± 0.08	10
NO_2^--N (mg/l)	0.01-0.03	0.02 ± 0.01	10

Source: …(6)

4.6 Aquifer Vulnerability to Pollution

The Hebron Groundwater Management Model/WRP2 project (West Bank Integrated Water Resources Program Phase III, Task 8 ,2001), indicated that there is potential for groundwater quality degradation in the Hebron Governorate, because the Governorate constitutes the recharge area for the Upper and Lower Aquifers. Both aquifers are exposed' in the highlands, which are relatively with high amounts of rainfall. Several potential sources of groundwater pollution are located in this sensitive recharge area, including wastewater the pollution loads which are moving through wadi al-Samn wastewater Stream which crosses the district from the north-eastern to the south-western. It is highly recommended that water quality monitoring in both the Upper and Lower Aquifers should he conducted because both aquifers are vulnerable to pollution. According to us, sampling of the groundwater wells that are located on or near wadi al-Samn pathway could help in evaluating the pollution effects coming from this wastewater stream and thus it gives an indication of the groundwater aquifer pollution.

4.7 Wastewater Treatment

The ideal solution for pollution coming through wadi al-Samn is to accelerate the process of constructing Hebron wastewater treatment plant which will replace the current harmful disposal of wastewater in the environment.

The main objective of wastewater treatment is to protect the environment from:

- high amounts of solids;
- excessive organic matter;
- low oxygen level in the disposed wastewater;
- high concentration of nutrients (N and P);
- toxic amounts of hazardous compounds; and
- contamination with pathogenic organisms.

This is done in order to:

- prevent the environmental nuisance.
- prevent the transmission of water borne diseases.
- utilize the effluent as a highly economic water resource for meeting the ever-
- growing water demand; and establish or maintain a healthy aquatic habitat for flora and fauna.

Environmental-Related Problems

The major environmental-related problems found during the field survey in the district. are as follows.

- Frequent flooding of cesspits throughout the district, and wastewater flow in wadi .Al-Samn, which crosses many villages in the district. There are major environmental and health problems, which can potentially lead to transmission of infectious diseases, in addition to foul odors and habitat for mosquitoes.
- Absence of a storm water drainage system causes overloading of the existing sewage

network, in Hebron City, which results in blockage and flooding.

- Contamination of groundwater aquifers and springs as a result of wastewater.
- percolation to groundwater from cesspits and wastewater flow in the wadis is possible.
- Irrigation with raw wastewater is another problem found primarily in wadi al-Samn area (Figure 4.3). This practice has great potential for problems because the irrigated crops including tomatoes, cauliflower, squash, eggplants, grapes, and other field crops, are often eaten fresh.

Figure 4.3: Cultivated areas irrigated with raw wastewater, wadi al-Samn

The challenge of an adequate wastewater collection and disposal system requires immediate attention from the authorities and official institutions. Public awareness and education about the need to properly manage wastewater must be increased, especially among farmers and consumers. The potential danger of improper sewage disposal to human health and welfare should be stressed. Authorities must enforce regulations that require proper wastewater disposal by individuals, the commercial sector and industrial facilities, to prevent pollution.

CHAPTER FIVE

MAPS OF THE WADI PATH

CHAPTER FIVE

Maps of the Wadi Path

During the Introduction part of our project, we focus on the mapping by using GIS. The available aerial photos were used to create 6 different maps (show on next pages map (1-6)). Map 1 are showing the total wadi path while map 2 show path for wadi al-Nar through the Basin Groundwater .But maps (3-6) are showing four consecutive section of the wadi inside Hebron District.

Map number 1 shows the overall wadi path, starting from the south-eastern part of Hebron city at its upstream and ending at the City at its estuary in the down stream. The wadi passes parts Hebron City land then crosses yatta and Beit Amera (flowing south-west ward). After that it crosses Karmah, Rabbad and al-daherya areas. All of this flowing occurs in the Hebron District borders. The total length of the wadi that is inside the District borders and according to our mapping is (38.5 km). This is shown on map1 in the red color for the wadi.

The same map (#1) shows that the wadi continues to flow in a south-western mode to an additional distance of (20.25 km). Then there is an inflection point at the wadi path (due to change in topography) that makes the flow direction to be north – western for a length of 56.75 km before it enters Gaza Strip.

Then it crosses Gaza Strip to the Mediterranean at a length of 87.5 km.
The total wadi path length is 123 Km starting from Hebron in the east and ending in Gaza in the west.

We can say that the wadi flow with wastewater in the dry season is possibly ending at the Hebron District borders .But under wet weather conditions, storm water runs in the wadi and is mixed with sewage and flow to reach the Mediterranean Sea. This means it affects soil, groundwater, population and environmental in general in all areas located at the (123 km) distance of its pathway.

Map 2 focuses an the groundwater basins in relation to wadi path in Hebron District. It is shown that 5 km of the wadi are located on the Eastern Groundwater Basin while about 32.5 km of the wadi are located on the western ground water Basin that is inside Hebron District while longer distance of the wadi path is on the western Basin part that is outside the Palestinian Authority area.

This implies that the wadi flow path is affecting not less than 2 groundwater basins which are inside the Palestinian controlled areas.
According to our expectations, groundwater wells such al-Reheya wells and al-Fawwer wells are vulnerable to pollution from this wadi sewage flow.

Map 3 shows that the wadi flows 9 km inside Hebron City administrative areas.
This area is mainly agricultural with same dwelling areas scattered over there.
Map 4 shows that the wadi flow path in yatta area is about 11km .A many areas affected here is available stone-fruit planted area. Also in yatta and in areas like al-heileh, population live near stagnant pools of sewage which disturbs their life and health .In yatta also, a segment of the wadi is known as wadi al-Sadeh and there the wadi cross section varies from (50-250) m of wet section full of sewage from the wadi mixed with slurry material (mainly calcium carbonate) from stone cutting industry waste. This could affect soil alkalinity and we see many olive and almond trees inside wastewater pools of the wadi.

Map 5 shows the wadi section of Biet-Amera (which comes after yatta) which is at a length of 4 km. This segment crosses Biet-Amera residential as wells agricultural areas and creating sever pollution problems. Here owners of vacuum tankers dispose of the septage at different points of this wadi section and the pollution problem is magnified.
Map 6 shows al-daheyria section which is the final part n the wadi path existing inside Hebron District and it is the longest one. This segment length is 14.5 Km and crosses the communities of Karmah ,abu-alasja and al-daherya. It damages the agricultural arable land there and cutting off the road access to many land owners.

In summary, we can say that the current wastewater stream of the Hebron District which extends for a distance of about 38.5 km inside the District is causing severe environmental impacts are:

1- Polluting groundwater basin (the Eastern and the western).
2- Damaging the land and so makes restrictions in land use .people consider that part of their lands located close to the wadi path as lost part.
3- Affecting agricultural production by either causing die-off of crops or trees because of its toxic pollution loads. On it may cause some illegal use use of wastewater for irrigation and all of this affects public health , public acceptance for the wadi agriculture production and marketing of vegetables and crops for the area farmers.
4- Creating nuisance in the farm of odors and mosquitoes for population living in the wadi neighborhood.
5- Affecting other environmental elements such creating polluted soils and air.
6- Affecting animal grazing, raring .this vegetables impacts animals production for the local farmers living in the wadi path neighborhood. Because animals could eat polluted grass and drink from the wadi flowing wastewater. This also affects public health because pollutants accumulated in animal tissues and milk find there way to humans through the food chain.
7- Damaging the biodiversity and wildlife in areas surrounding the wadi.
8- Loosing huge quantities of a water source (wastewater) that upon treating it we are making available huge quantities of treated wastewater that can be reused in irrigation. For example treated quantities can be used to irrigate not less than 4000 donum of agricultural land. This production means money and economical growth besides jobs for huge number of people.
9- If we talk about the economical impacts we can say that this sewage stream is creating losses in financial resources for the country. This is clear in it impacts a reducing and detriment-rating agricultural production as well as the environmental besides loosing the wastewater without being able to treat and reuse it.

Nonetheless in the second semester our analysis for this wadi impacts will be clearer when we make our qualitative and quantitative measurement as mentioned in the methodology part of this study.

- Table (5.1) shows the affected population from the wadi wastewater flow

Table 5.1: population statistics about influenced communities

Community Name	**Population 2005**
Arabiye	1709
Al –Rihya	3593
Karmah	1404
Hebron	171221
Yatta	44122
Al-Daherrya	29466
Biet Amera	1752
Sum	253267

Identify for this points:

The number of this point is six points.

Identify for this points:

- The first point is the beginning of (wadi al-samn) in Fahaes and this picture describe the place

Fig 5.7: beginning flow in Hebron City

- The second point is the Abu Al-Orqan and this picture describe the place

Fig 5.8: the path of wadi al-Samn in Abu Al-Orqan

- The third point is in the al -Rihya and this picture describe the place.

Fig 5.9: the path of wadi al-Samn in al –Rihya

- The fourth point is in the al-Karmah and this picture describe the place.

Fig 5.10: the path of wadi al-Samn in al-Karmah

- The fifth point is in the wadi al-Ghozlan and this picture describe the place**.**

Fig 5.11: the beginning path of wadi al-Nar in al-Ghozlan

- The sixth point is in al-Daherrya and this picture describe the place**.**

Fig 5.12: the path of wadi al-Nar in al-Daherrya

CHAPTER SIX

RESULTS AND DISUSSIONS

CHAPTER SIX
Results and Discussions

6.1 Variation of the wadi flow and wastewater characteristics

6.1.1 Introduction

For the purpose of flow measurement and investigation of the wadi's wastewater characteristics, six stations were identified on the wadi path to carry out the fieldwork. These stations were selected based on the following criteria:

1. Since we are planning to measure the velocity by the float method, we selected wadi sections which are with minimum slope and are with homogeneous section width as possible. The first station at the upstream should be at the sewer outfall where the wastewater starts to be exposed in the wadi and flows in the wadi channel. Therefore, the first station which is appropriate for flow measurement was selected at a distance of 1837 m from the sewer outfall. It should be mentioned here that the sewer outfall is located at 2 km distance from the wadi upstream. This indicates that the first station selected is at 3.837 km from the wadi upstream start point. To make it easier, we mapped all of our work in the next sections by assigning a reference point which is that point mentioned above and located at 1837 m from the sewer outfall and this point is defined on our GIS mapping as reference point. The other five stations were selected in wadi segments following the first station at the wadi downstream as shown in figure (6.1).

For the six stations (name later on as *a, b, c, d, e* and *f*), a measurement for the stream wet channel section area was done as well as measuring the stream velocity in multiple trials. The velocity measurement was done by allowing the float (a tennis ball with r=2cm) to run for distance 20-50 m with timing. The results are shown in the table (6.1).

2. Also these stations are the pints from which we collected our samples of wastewater for laboratory analysis.

Table 6.1: The coordinates of the stations

Station ID	Station name	X-coordinate	Y-coordinate
a	Hebron	160459.30	99212.97
b	Al –Rihya	157226.01	96455.98
c	Karma	152976.87	94297.01
d	Abu-Ghozlan	151771.41	93705.26
e	Abu Al-Orqan	150733.12	95003.29
f	Al-Daherrya	148792.28	90752.89

6.1.2 Variation of the wadi flow

Table 6.2 shows the measurements done for the wadi discharge. Firstly, the wet section was measured by measuring the depth of water vertically at different depths, then we calculated the wet section area. Secondly, the float running velocity was measured by making 5-6 trials and making timing for each. A correction of the velocity was done using the correction factors we reported in table 3.2 in chapter 3.

Generally, the data set of table 6.2 shows that the wadi wet sectional area varies from 0.31575 to 0.76 m^2 while the wadi flow varies from 0.72 to 23.45 m^3/min.
In summary, we distinguished the following variation for the wadi discharge values:

- Dry weather flow values represented by the values measured at stations *a*, *b*, *c, d* and *e*. For these stations the average flow rate value was 2.6374 m^3/min with velocity variation from 1.97 m/min to 7.36 m/min with wet cross sectional area variation from 0.31575 m^2 to 0.698 m^2. We emphasize here that for these five stations, measurements were carried out during non-rainy weeks (at least no rains for one week before measurement and at time of measurement the weather is dry).

- Wet weather flow values: which is done at station *f*, the measurement was conducted for flow at time of medium rains preceding the measurement with light rains at day of measurement. The value measurement for this station was 19.488 m^3/min and it represents storm conditions. This means that the wadi flow under wet conditions could be not less than 8 times its value under dry conditions.

Table 6.2: Measurements for the wadi discharge

Station	Trial #	Distance (m)	Time elapsed (minute)	Velocity (m/min)	Correction of Velocity (m/min)	Wet section Area (m^2)	Q (m^3/min)
a	1	20	6.8	2.9	2.0	0.698	1.370
	2		6.9	2.9	2.0		1.397
	3		6.5	3.1	2.0		1.384
	4		7.2	2.8	1.9		1.360
	5		6.8	2.9	1.9		1.329
	6		6.0	3.3	2.0		1.382
	average						*1.37*
b	1	20	6.3	3.2	2.16	0.76	1.64
	2		6.4	3.1	2.13		1.62
	3		6.0	3.3	2.27		1.72
	4		6.5	3.1	2.09		1.59
	5		6.9	2.9	1.97		1.50
	6		6.0	3.3	2.27		1.72
	average						*1.63*
c	1	50	4.0	12.50	8.43	0.655	5.52
	2		4.5	11.11	7.49		4.91
	3		4.6	10.87	7.33		4.80
	4		4.9	10.20	6.88		4.50

Station	Trial #	Distance (m)	Time elapsed (minute)	Velocity (m/min)	Correction of Velocity (m/min)	Wet section Area (m^2)	Q (m^3/min)
	5		4.8	10.42	7.02		4.60
	6		4.6	10.87	7.33		4.80
	average						*4.86*
d	1	50	4.5	11.11	7.36	0.59	4.34
	2		4.6	10.87	7.20		4.25
	3		4.0	12.50	8.28		4.88
	4		4.9	10.20	6.76		3.99
	5		4.6	10.87	7.20		4.25
	average						*4.5*
e	1	50	3.95	12.66	2.56	0.31575	0.81
	2		4.0	12.50	2.59		0.82
	3		3.5	14.29	2.27		0.72
	4		4.2	11.90	2.72		0.86
	5		4. 1	12.20	2.65		0.84
	6		3.6	13.89	2.33		0.74
	average						*0.79*
f	1	40	0.58	68.97	46.44	0.505	23.45
	2		0.6	66.67	44.89		22.67
	3		1.0	40.00	26.93		13.60
	4		0.7	57.14	38.48		19.43
	5		0.9	44.44	29.93		15.11
	6		0.6	66.67	44.89		22.67

Station	Trial #	Distance (m)	Time elapsed (minute)	Velocity (m/min)	Correction of Velocity (m/min)	Wet section Area (m^2)	Q (m^3/min)
	average						19.49
Total average					**10.16**	**3.52**	***5.44***

Graphical data for the variation of velocity versus wadi path length (distance) is shown in figure (6.2). In addition, a GIS map is shown for the flow in figure (6.3).

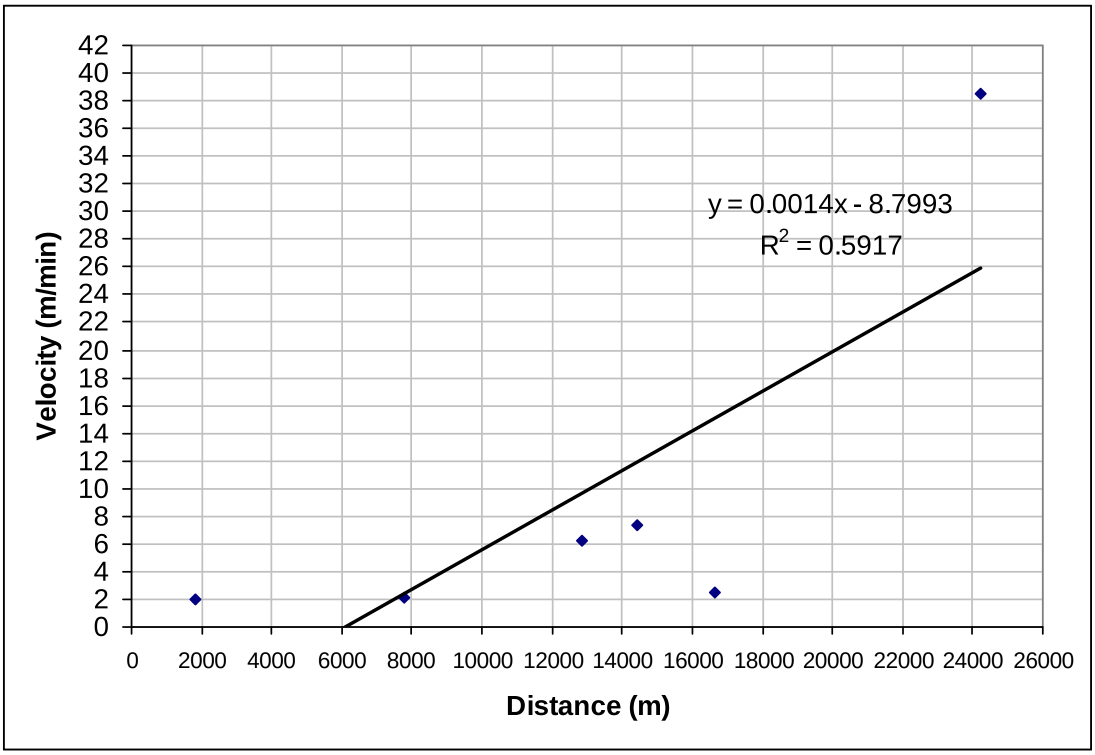


Figure (6.2): variation of velocity versus wadi path length (Distance)

To make a better understanding of the flow data we mention the following important notes:

- Q value at station *a* reflects the wastewater coming from Hebron city (domestic [equivalent to 180000 capita]+ industrial) in addition to Qiryat Arbaá colony which has a population size of 7500.
- Q value at station c incorporates additional flow coming from the sewered area of al-Fawwar (estimated at 700 m^3/d)
- The wadi sections receive unpredictable flows via tankers both from sepatge tankers and stone-cutting industry.

The wadi slope affects the velocity of the wastewater, although we applied correction for the velocity. For this purpose, we introduce the wadi topographic maps and the wadi profile (Figure (6.4) and Figure (6.5)). Figure (6.4) shows that the correlation between the distance (wadi path length) and the elevation is high (R^2>0.9). This in turn affects the velocity when the water moves downward.

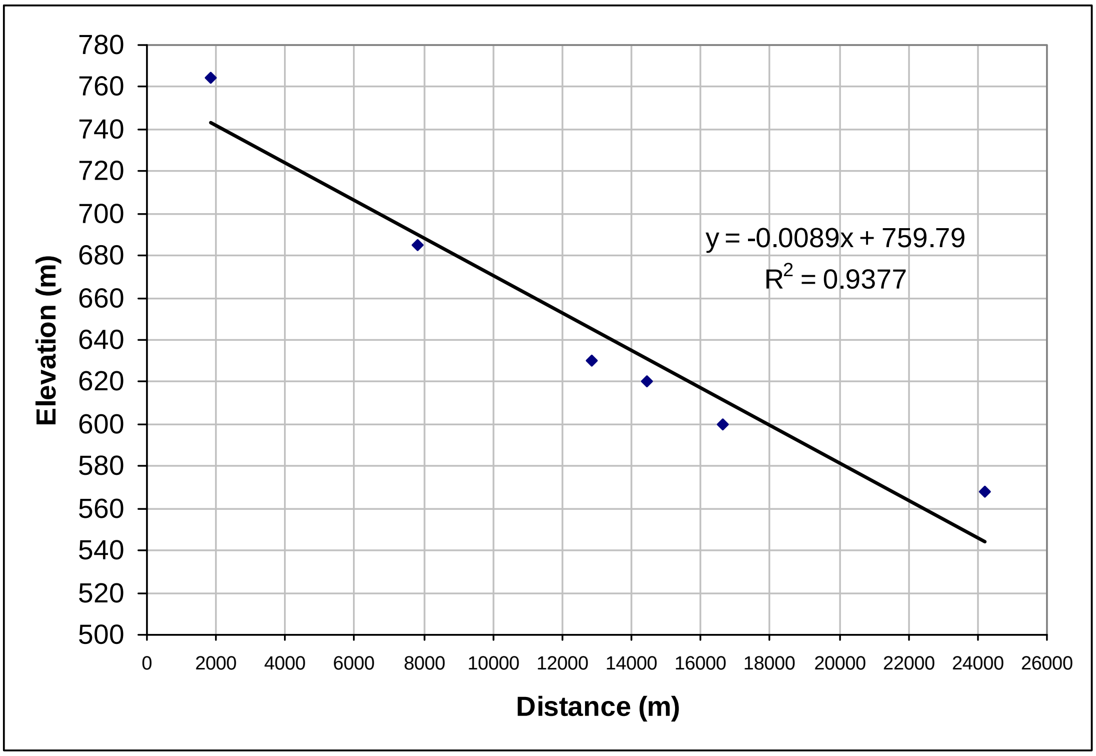


Figure (6.4): Elevation versus wadi path length (Distance)

6.1. 3 Variation of the wadi wastewater characteristics

Our wastewater sampling type is grab samples, which reflects the wastewater characteristics at the time of sampling. Therefore, loads coming from different wastewater sources could make different characteristics.

6.2 General Overview

In general, the wadi wastewater characteristics at different stations are shown in table 6.3.

Table 6.3

The table indicates a COD value of 2095 mg/l, TSS of 4683 mg/l, NH4 of 82 mg/l, Cl of 445 mg/l, TDS of 1334 mg/l, and TS of 2607 mg/l and pH of 7.7, on average and as indication of the whole wadi conditions.

Also, the wastewater characteristics at station *a* is a representative for the raw sewage characteristics of Hebron city and it is distinguished by high chloride content (1437 mg/l) which reflects an industrial shock load. While the COD was 2538 mg/l and TSS was 3850, all of which are reflecting high strength wastewater (i.e concentrated).

The most important factor is that, the wadi is the main available body for receiving the emptied sepatge load.

6.2.1 Data interpretation

In the following, we are discussing each parameter variation along the wadi:

6.2.1.1 COD variation

A reduction of 38% for the COD value occurred as the wastewater traveled from station *a* to station *b* due to natural channel treatment. As the wastewater passes station *c* (coming from station *b*) to reach *d* an increase of 36% increase occurred due to wastewater loads coming from tankers which originate from sepatge and stone-cutting industry. Also the wastewater stream of al-Fawwar is combining the main wadi flow between these stations. As the wastewater passes station *d* to station *e*, a decrease of 12% occurred for the COD which indicates natural channel treatment and absence of sepatge loads or its availability in minor volumes. Finally as the wastewater flows to station *f*, an increase in COD value of 35% took place due to availability of sepatge and stone-cutting loads again. Figures 6.6 and 6.7 shows the spatial variation of COD.

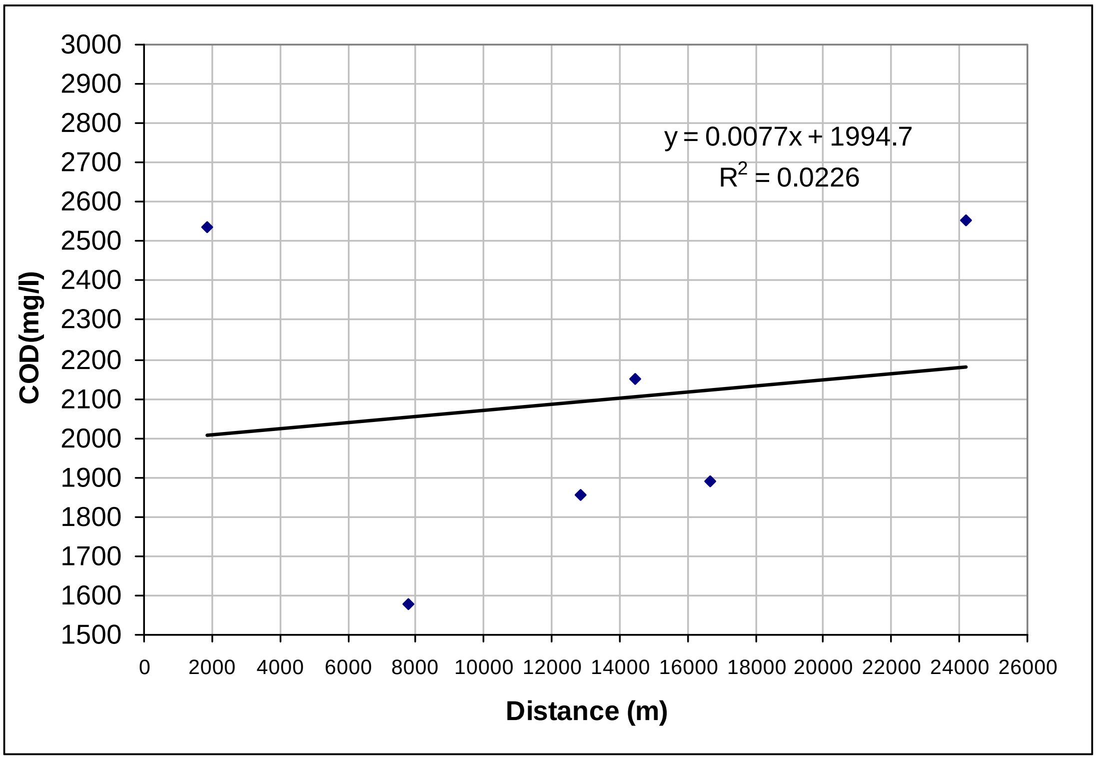


Figure (6.6): COD versus wadi path length (Distance)

6.2.1.2 TSS variation

The TSS value was decreased by 60.5% as the wastewater flows from stations *a* to *c*. This is due to natural channel treatment, however still sepatge loads are available in this wadi segment. Then as the wastewater traveled from stations *c* to *d*, an increase of 425% in the TSS value took place and is mainly attributed to sepatge loads however; stone-cutting industry wastewater is also available as a secondary source. Then a 47% TSS reduction took place as the wastewater passes from stations *d* to *e*. Then increase in TSS as the wastewater travels to the last station (*f*) of 125% occurred and is mainly due to sepatage loads. Figures (6.8) and (6.9) shows the spatial variations of the TSS.

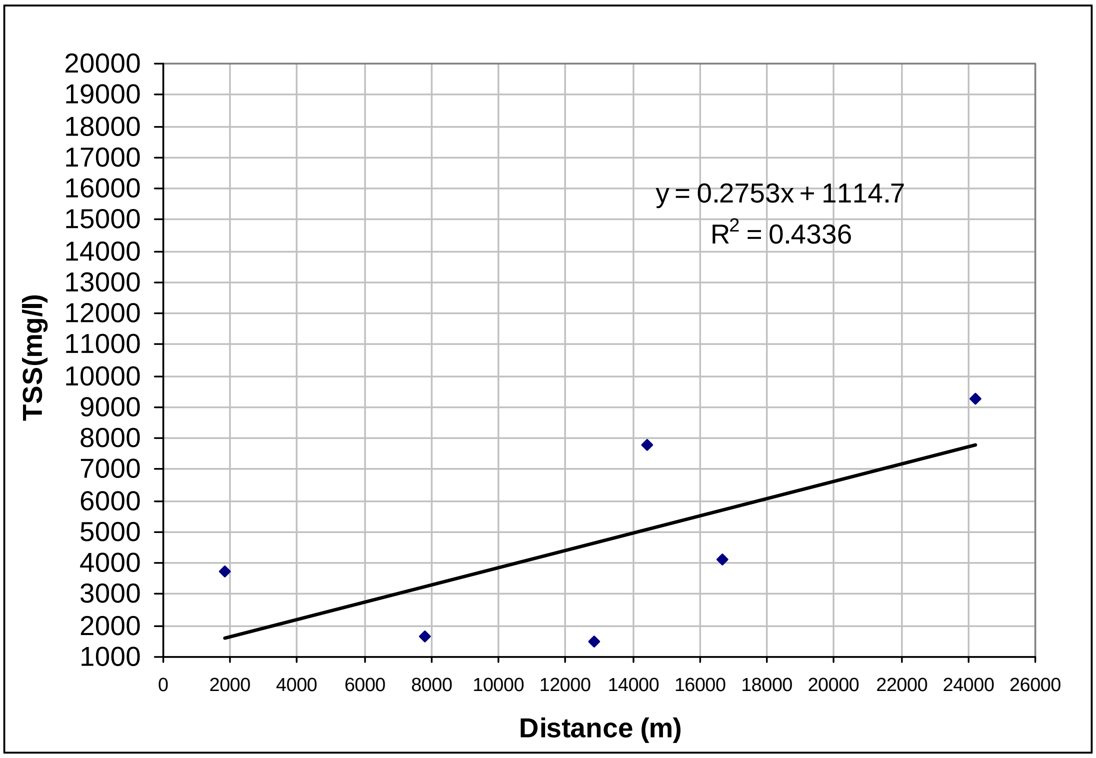


Figure (6.8): TSS versus wadi path length (Distance)

6.2.1.3 NH4 variation

For this parameter variation trend is more or less similar to the COD trend. As the wastewater travels from station *a* to *c*, *a* 38% reduction of NH4 took place and this implies that, the stone cutting industry loads rather than the sepatge loads is affecting the wastewater ammonium content. Also this wadi segment (stations *a*-*c*) if affected by increase in pH which allows ammonia volatilization. The wadi segment between stations *c*-*d* shows increase of ammonium due to sepatge loads whiles the wadi section between stations *d*-*e* shows decrease and finally section *e*-*f* shows increase due to sepatge loads availability. Figures (6.10) and (6.11) shows the spatial variations of the NH4.

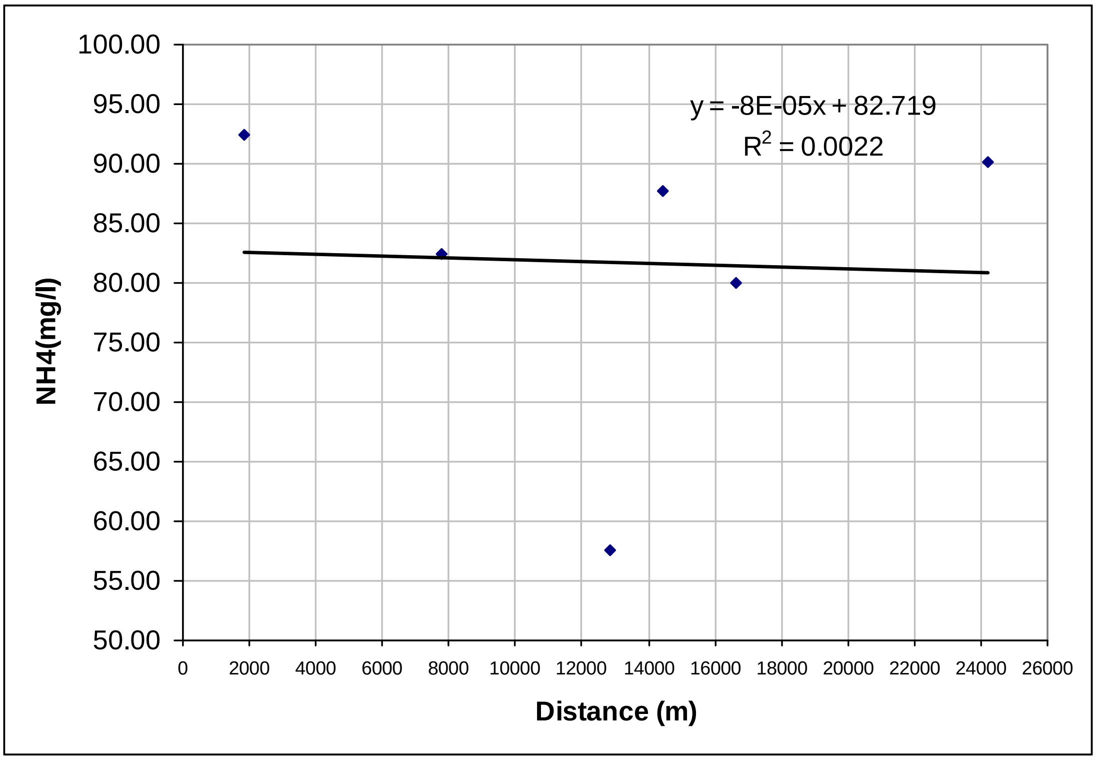


Figure (6.10): NH4 versus wadi path length (Distance)

6.2.1.4 Salinity parameters variation

Changes in different salinity forms expressed in the forms of TDS or EC or Cl or Salinity, take the same trend (Figure 6.12). There is a decrease in chloride value as the wastewater travels from stations a to c while it goes up at station d and decreases again as passes to stations e and f. The GIS maps for different salinity parameters are shown in figures (6.13) to (6.16).

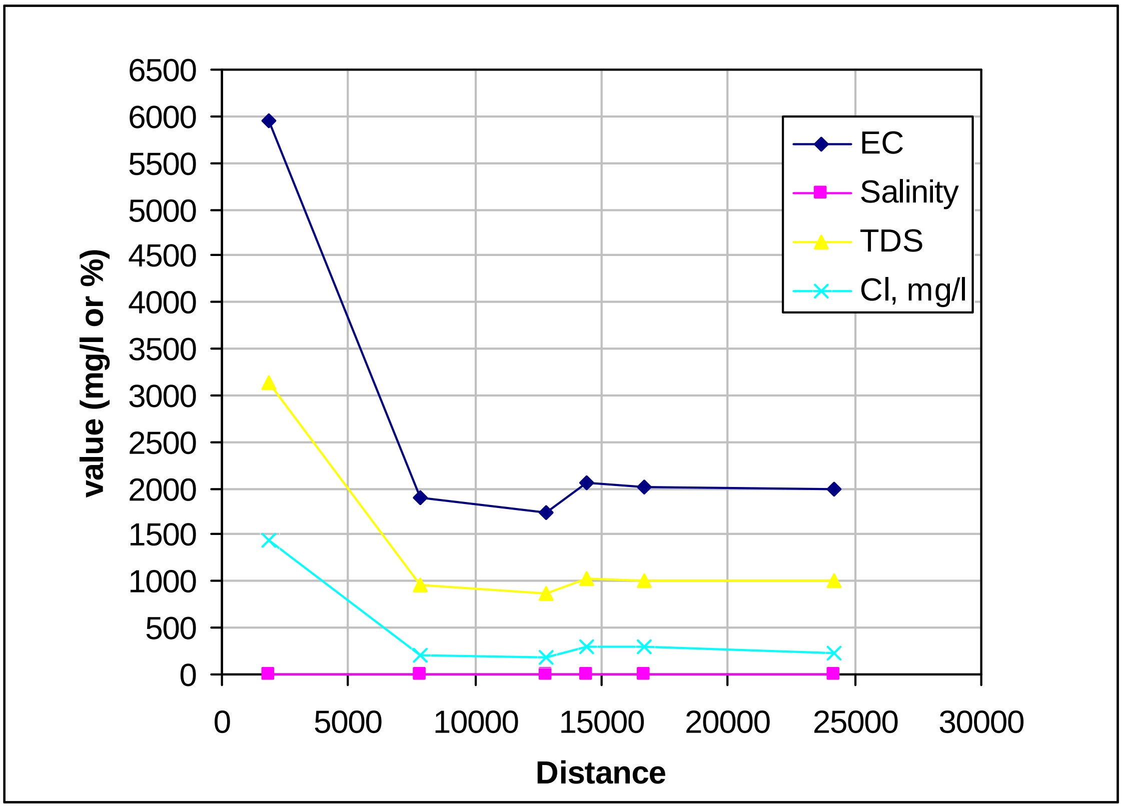
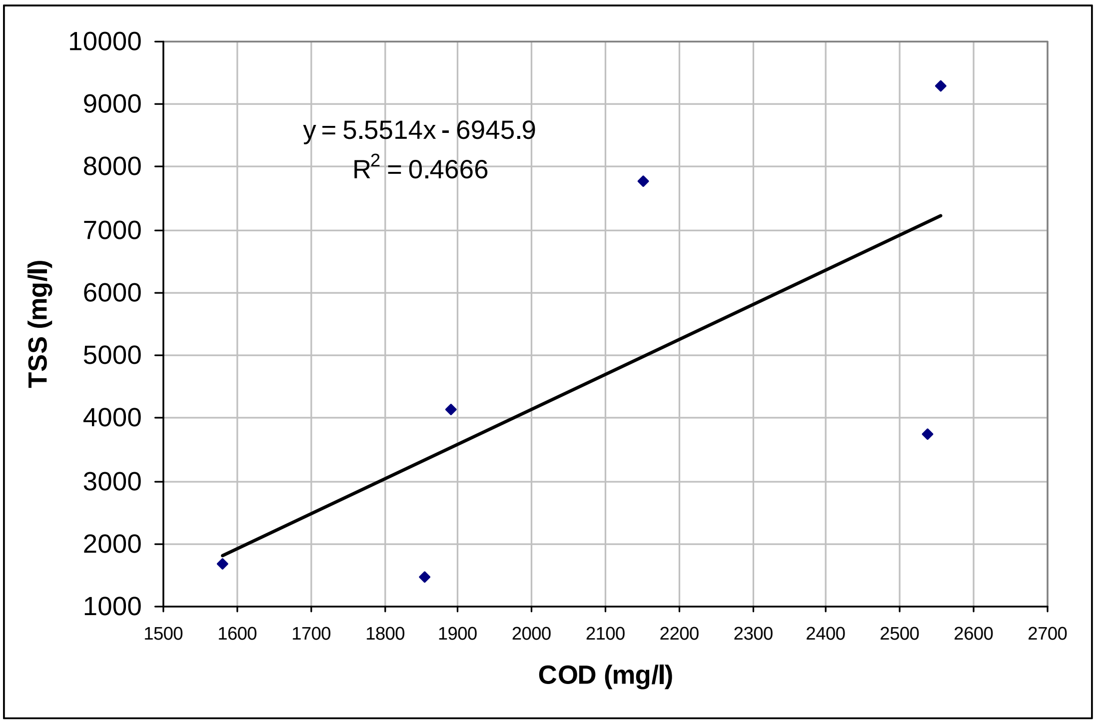


Figure (6.12): (EC, Salinity, TDS, Cl) versus wadi path length (Distance)

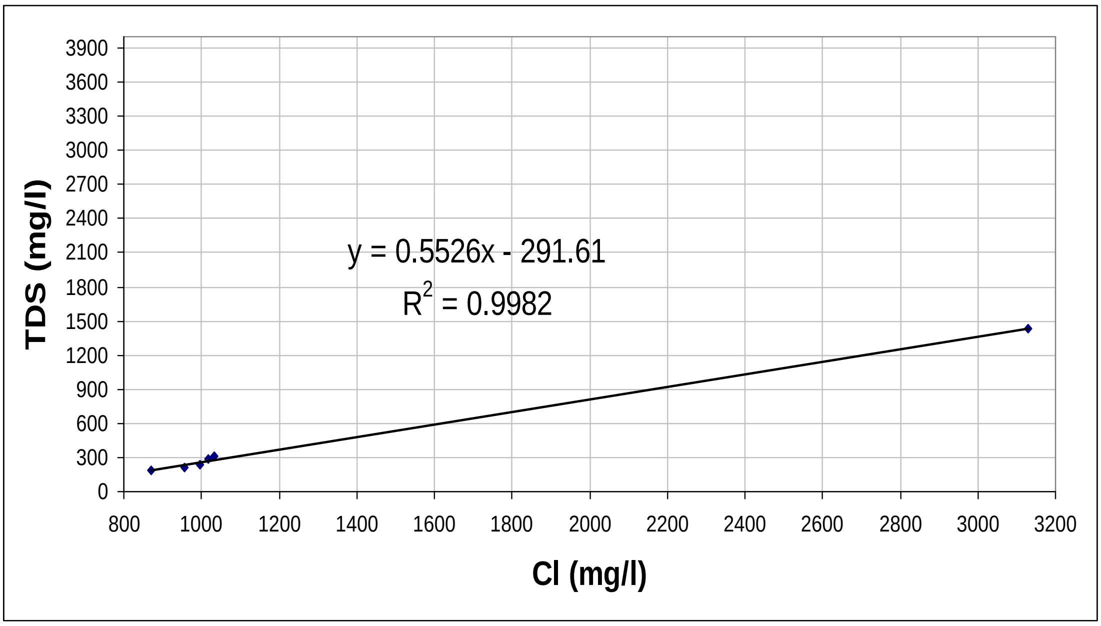
6.3 Correlation between different quality parameters

The main correlation with COD is important with TSS and shows R2 value > 0.5. This is expected because the main sources of TSS are sepatage and stone-cutting wastewater (fig. 6.17).



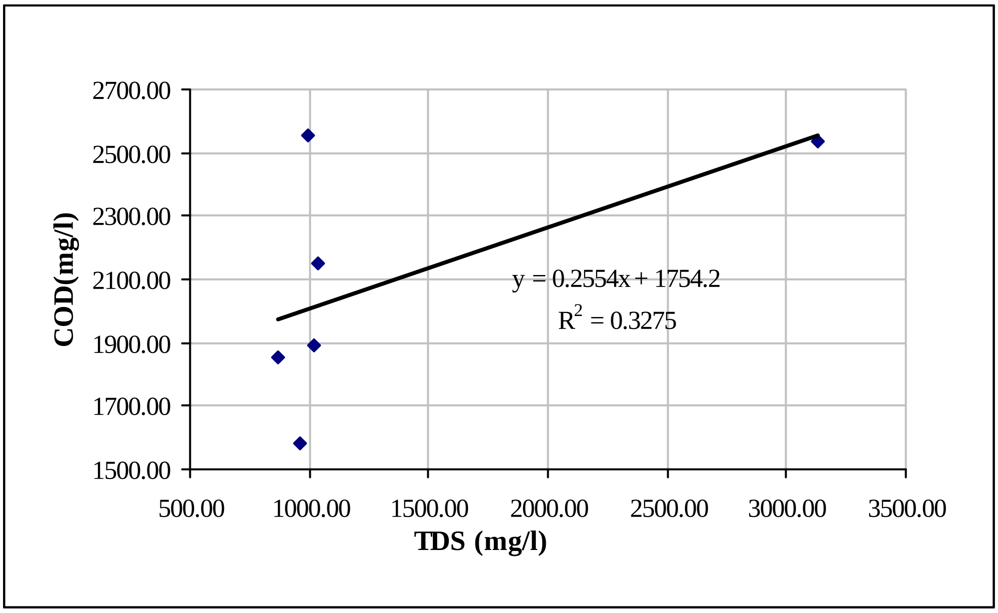
figure(6.17): TSS versus COD

Figure (6.18) shows strong correlation between TDS and Cl and this emphasis that chloride concentration is affecting TDS value rather than any ion (i.e Ca) and this emphasis sepatge high contribution to the wadi.

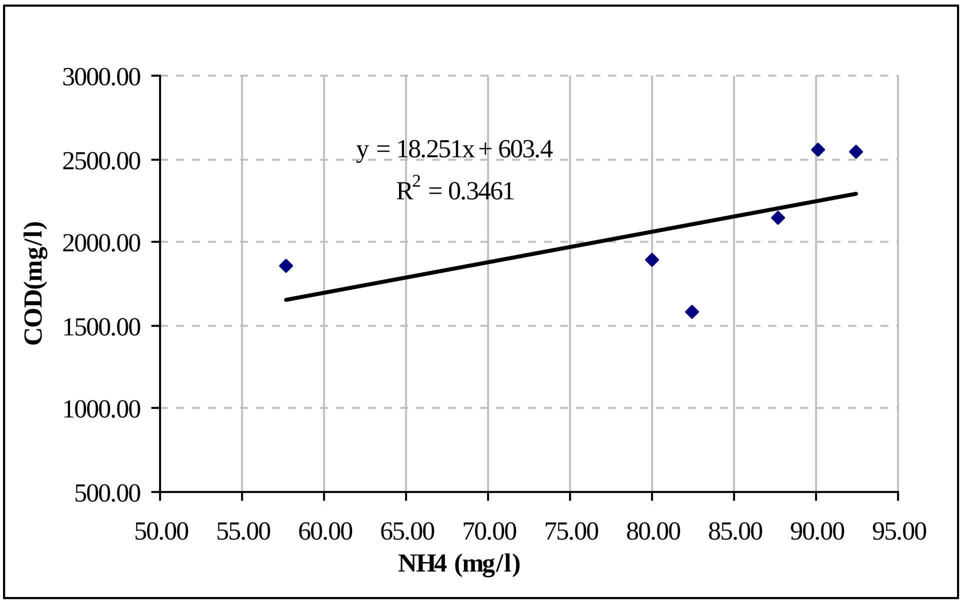


figure(6.18): TDS versus Cl

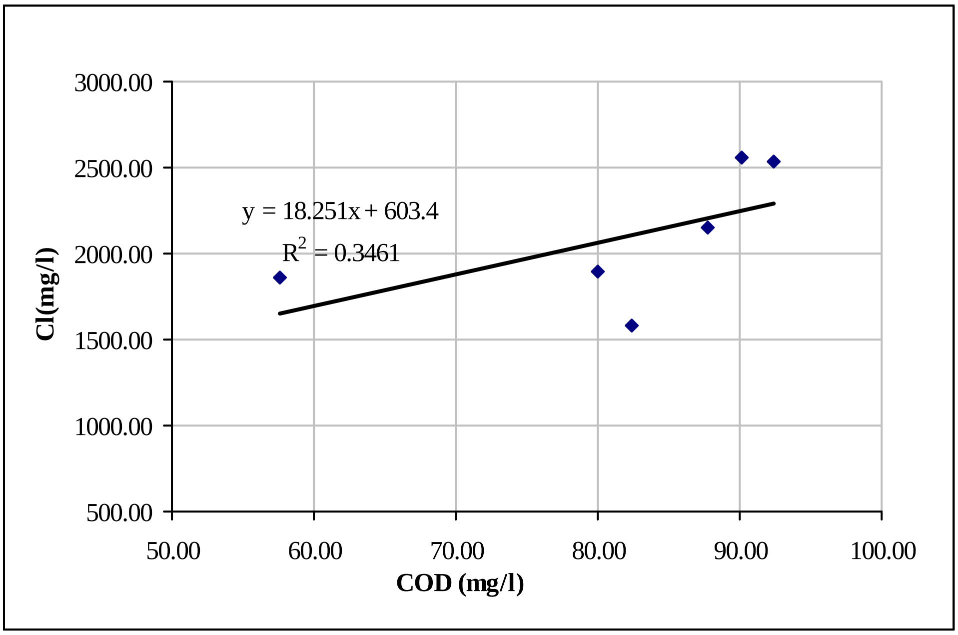
The figure (19-21) below shows weak correction between (TDS, COD),(NH4,COD),(COD,Cl), Since R^2<0.5.



figure(6.19): COD versus TDS



figure(6.20): COD versus NH4



figure(6.21): Cl versus COD

6.4 Mass loads variation

Pollution Mass Load (ML) from the wadi:

ML (Ton/day)=(C(mg/l)*Q(m^3/d)*1.44)/1000

Where:

C: TSS (mg/l)

C:Cl^-

C: NH4

Q: m^3/d

Table 6.4, shows the different parameter mass loads.

Table 6.4: Pollution Mass Load (ML**)**

Station	M.L(TSS) ton/d	M.L(Cl^-) ton/d	M.L(NH4) ton/d
a	7.361148	2.820725	0.181436
b	3.990176	0.511029	0.195334
c	10.26394	1.313633	0.399633
d	69.98935	2.775695	0.789992
e	15.35505	1.068594	0.297632
f	311.7214	7.895102	3.024758

In general, there is a clear increase in the wadi pollution mass loads at the wadi outlet. The TSS mass load is the most harmful pollution indication from environmental point of view. It should be observed that the mass loads at station *f* represents dry how conditions

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER SEVEN

Conclusions and Recommendation

7.1 Conclusions

1. The GIS mapping of the Hebron City wastewater stream shows that the wadi originates, in the Palestinian Authority areas, at the south of Hebron city, passes Yatta, Beit-Emra, Karmah, Abu-al-Asja and Daherrya communities then runs through Israel to the east and then south of Beer al-Saba', and then enters Gaza to be ended in the Mediterranean.

2. The following segments of the wadi are distinguished while the:

- The wadi extends for a distance of 38.5 km inside the Hebron District
- The wadi extends for a length of 77 km inside the 1948-Palestine
- The wadi part crossing Gaza Strip is at a length of 8.75 km

3. The wadi total length is 124.25 km starting from the sewer outfall (upstream) at Hebron City and ending at the Mediterranean Sea (downstream), of which 47.25 km are inside the Palestinian Authority area.

4. For the purpose of flow measurement and investigation of the wadi's wastewater characteristics, six stations were identified on the wadi path and located on GIS to carry out the fieldwork.

5. Dry weather flow values represented by the values measured at different stations show average flow rate value of 2.6374m^3/minwith velocity variation from 1.97 m/min to 7.36 m/min with wet cross sectional area variation from 0.31575 m^2 to 0.698 m^2.

6. On average, a COD value of 2095 mg/l, TSS of 4683 mg/l, NH4 of 82 mg/l, Cl of 445 mg/l, TDS of 1334 mg/l, TS of 2607 mg/l and pH of 7.7, characterise the whole wadi wastewater conditions.

7. The raw wastewater characteristics of Hebron city is distinguished by high chloride content (1437 mg/l) which reflects an industrial shock load. While the COD was 2538 mg/l and TSS was 3850, all of which are reflecting high strength wastewater.

8. The wadi is the main available body for receiving the emptied sepatge load of the Hebron District.

9. A reduction of 38% for the COD value occurred as the wastewater traveled from upstream station to the second station due to natural channel treatment. As the wastewater passes the third station to reach *the fourth station* an increase of 36% occurred due to wastewater loads coming from tankers which originate from sepatge and stone-cutting industry. Also the wastewater stream of al-Fawwar is combining the main wadi flow between these stations.

10. As the wastewater passes station *four* to station five, a decrease of 12% occurred for the COD which indicates natural channel treatment and absence of sepatge loads or its availability in minor volumes.

11. Finally as the wastewater flows to station six an increase in COD value of 35% took place due to availability of sepatge and stone-cutting loads again.

12. For NH4, variation trend is more or less similar to the COD trend. As the wastewater travels from station one to three, a 38% reduction of NH4 took place and this implies that, the stone cutting industry loads rather than the sepatge loads is affecting the wastewater ammonium content.

13. One of the wadi segments (stations one to three) is affected by increase in pH which allows ammonia volatilization. The wadi segment between stations three to four shows increase of ammonium due to sepatge loads while the wadi section between stations four and five shows decrease and finally section five to six shows increase due to sepatge loads availability.

7.2 Recommendations

1. The wastewater coming from the Hebron city should be diverted into a treatment plant rather than being disposed of in the wadi and causing pollution.
2. The septage coming from tankers could be disposed of in a sepatge wastewater treatment plant instead of being disposed of in the wadi.
3. Technologies for the wastewater treatment of the sepatge wastewater could simply be the wetlands.
4. Technologies for wastewater treatment of the Hebron city or al-Fawwar area could be UASB (up flow anaerobic sludge blanket) followed by wetlands.
5. Wastewater coming from industries of the Hebron city should be pretreated to reduce its salt content.
6. After treating the wastewater coming from different sources, reuse schemes should be designed to get benefit from this marginal water source.

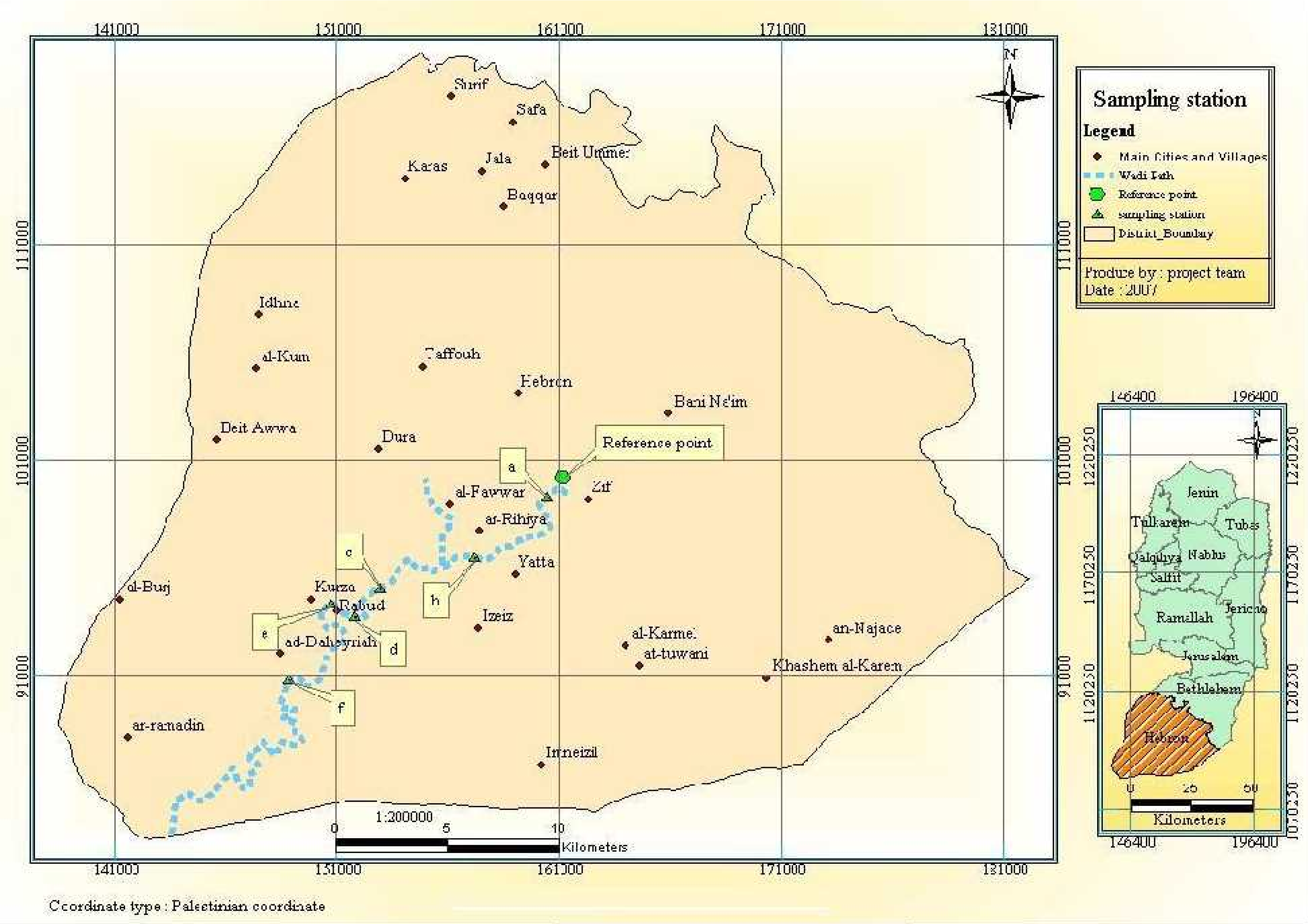


Figure (6.1): Sampling Station

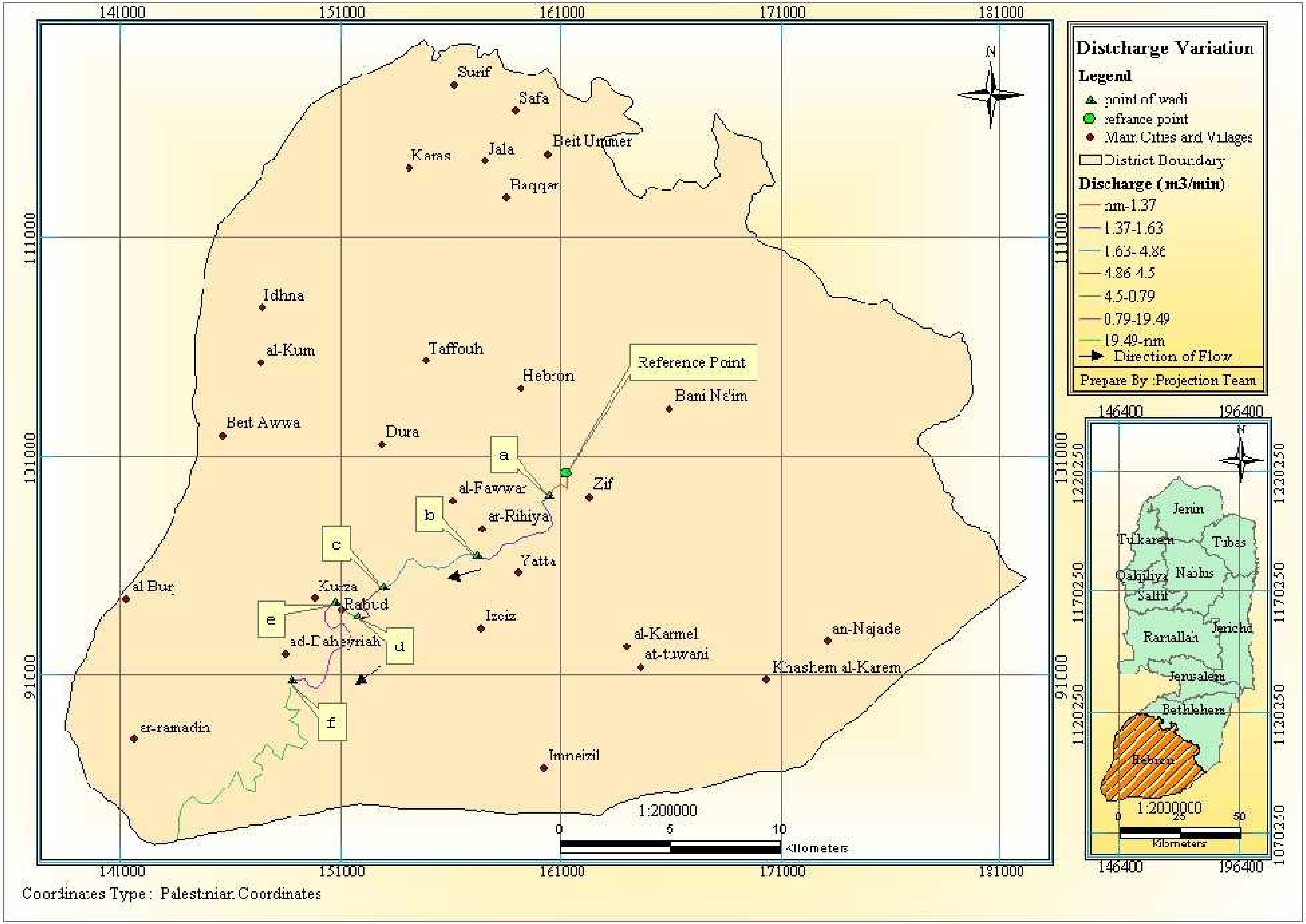


Figure (6.3): Discharge Variation

Figure (3): Disc **Figure (3):** Discharge Variation

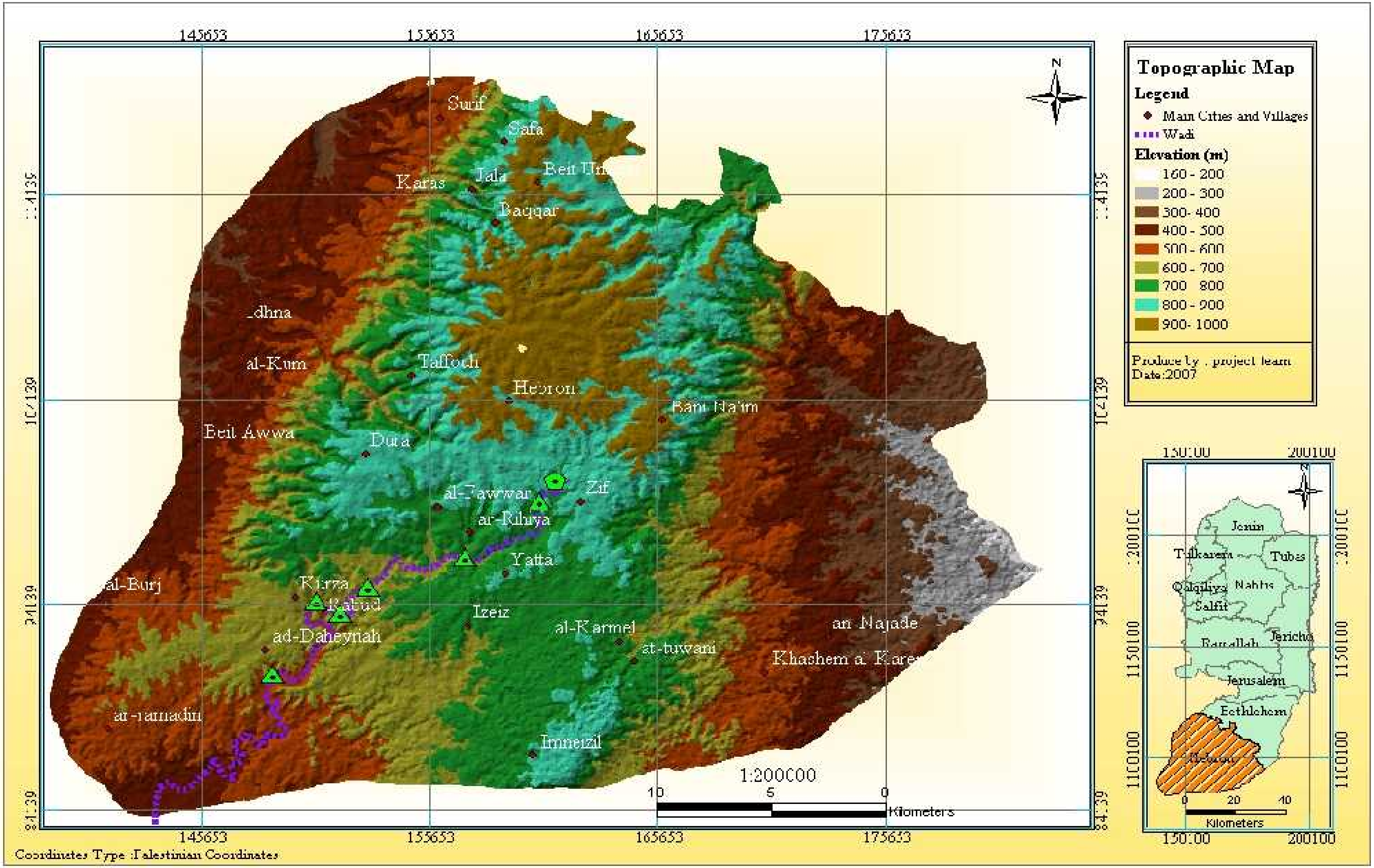


Figure (6.5): Topographic Map Contour map from Survey of Israel 2002

Figure

Figure (4): Topographic Map Contour lines from survey of Israel 2002

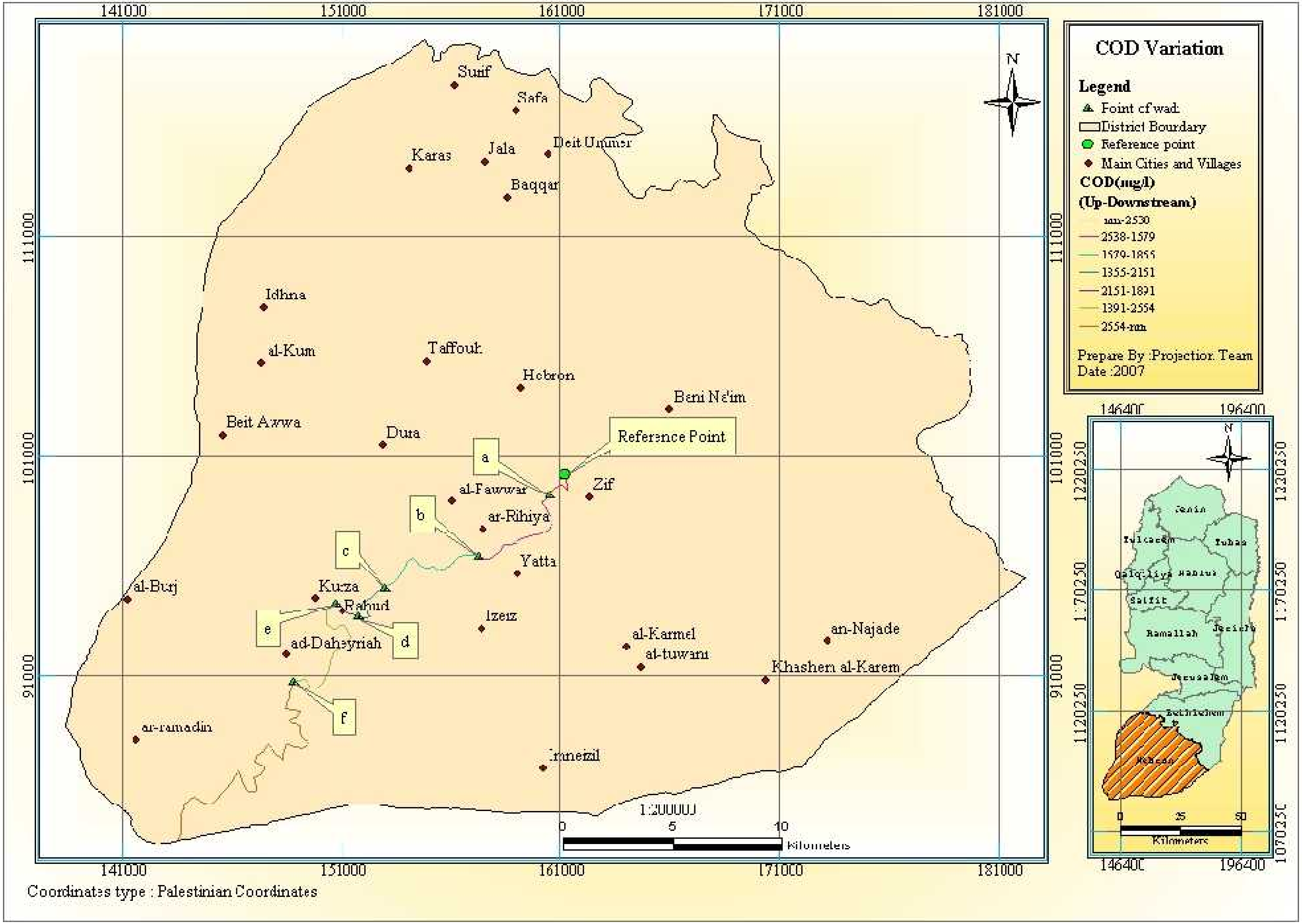


Figure (6.7) : COD Variation

Figure (7): COD Variation

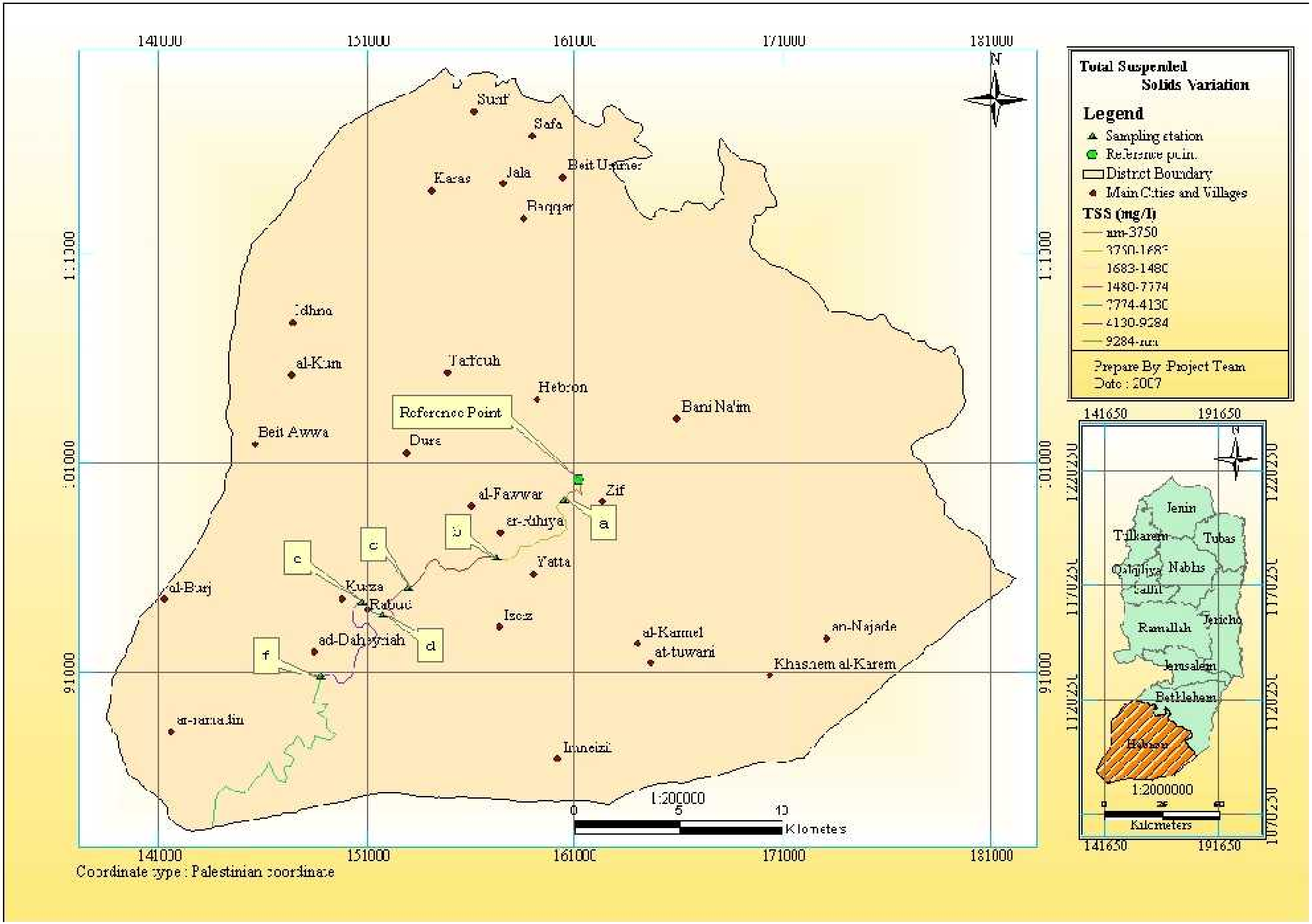


Figure (6.9): Total Suspended Solids Variation

Figure (9): Total suspended Solids Variation

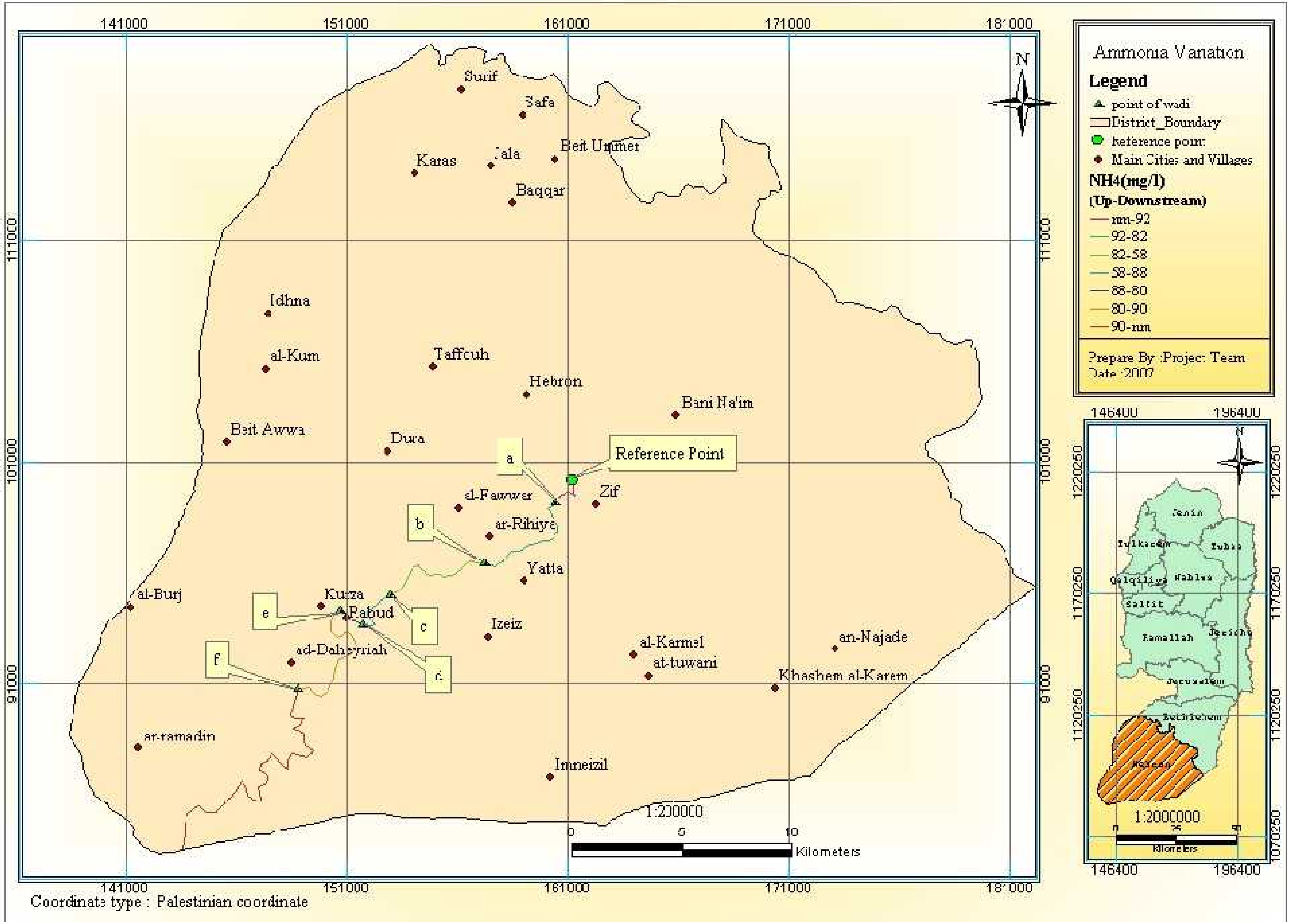


Figure (6.11): Ammonia Variation

Figure (11): Ammonia Variation

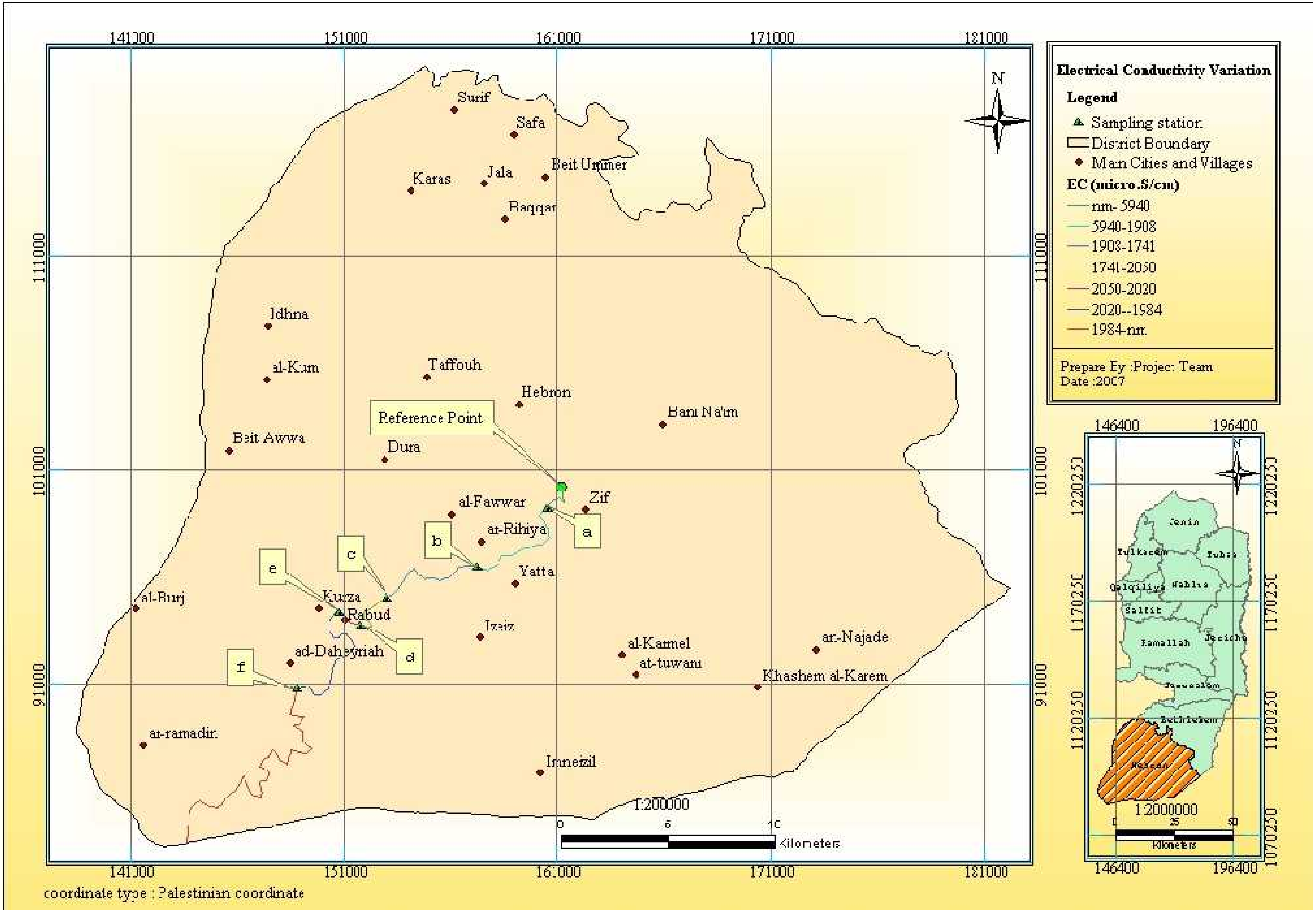


Figure (6.13): Electrical Conductivity Variation

Figure (13): Electrical Conductivity Variation

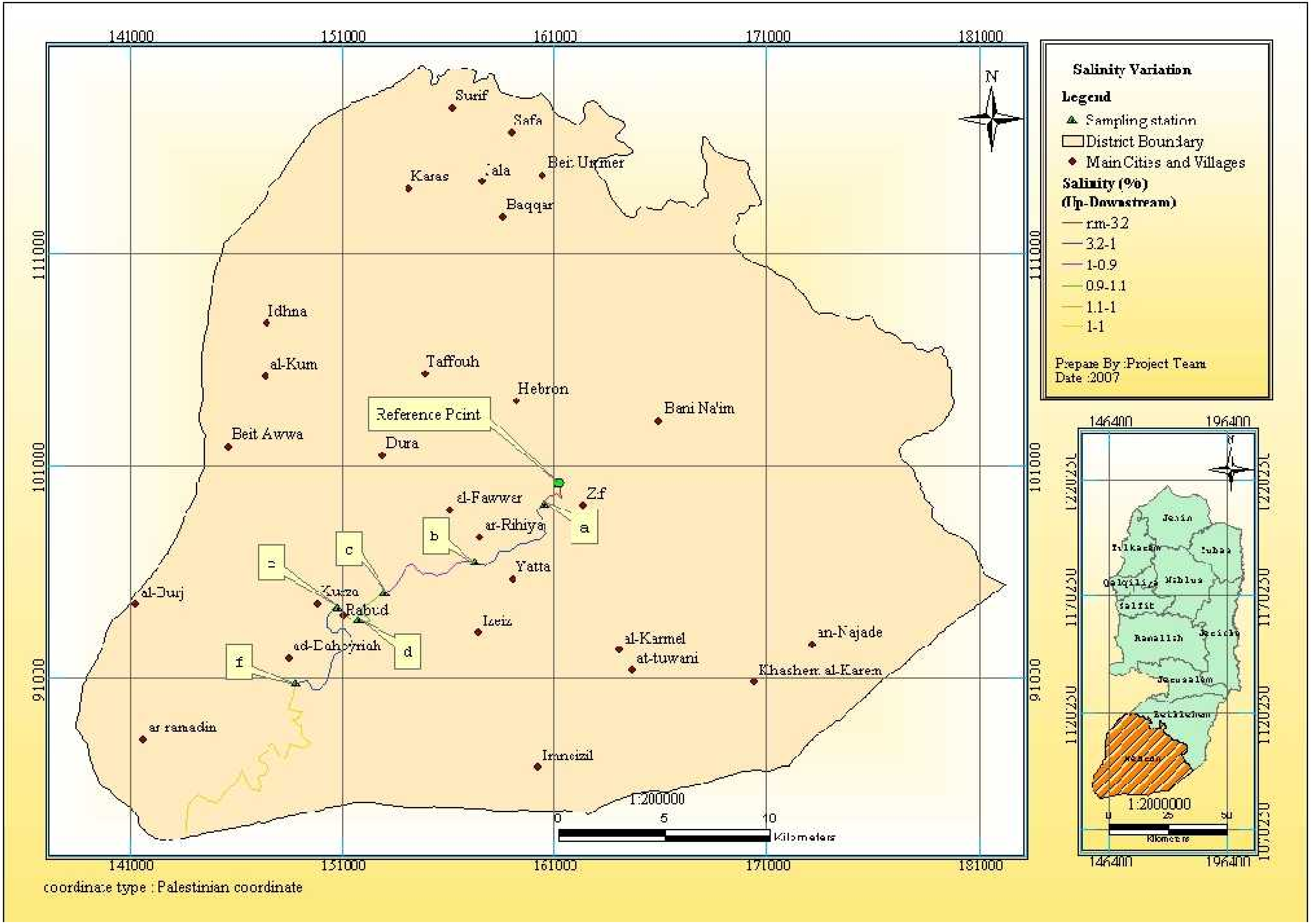


Figure (6.14): Salinity Variation

Figure (14): Salinity Variation

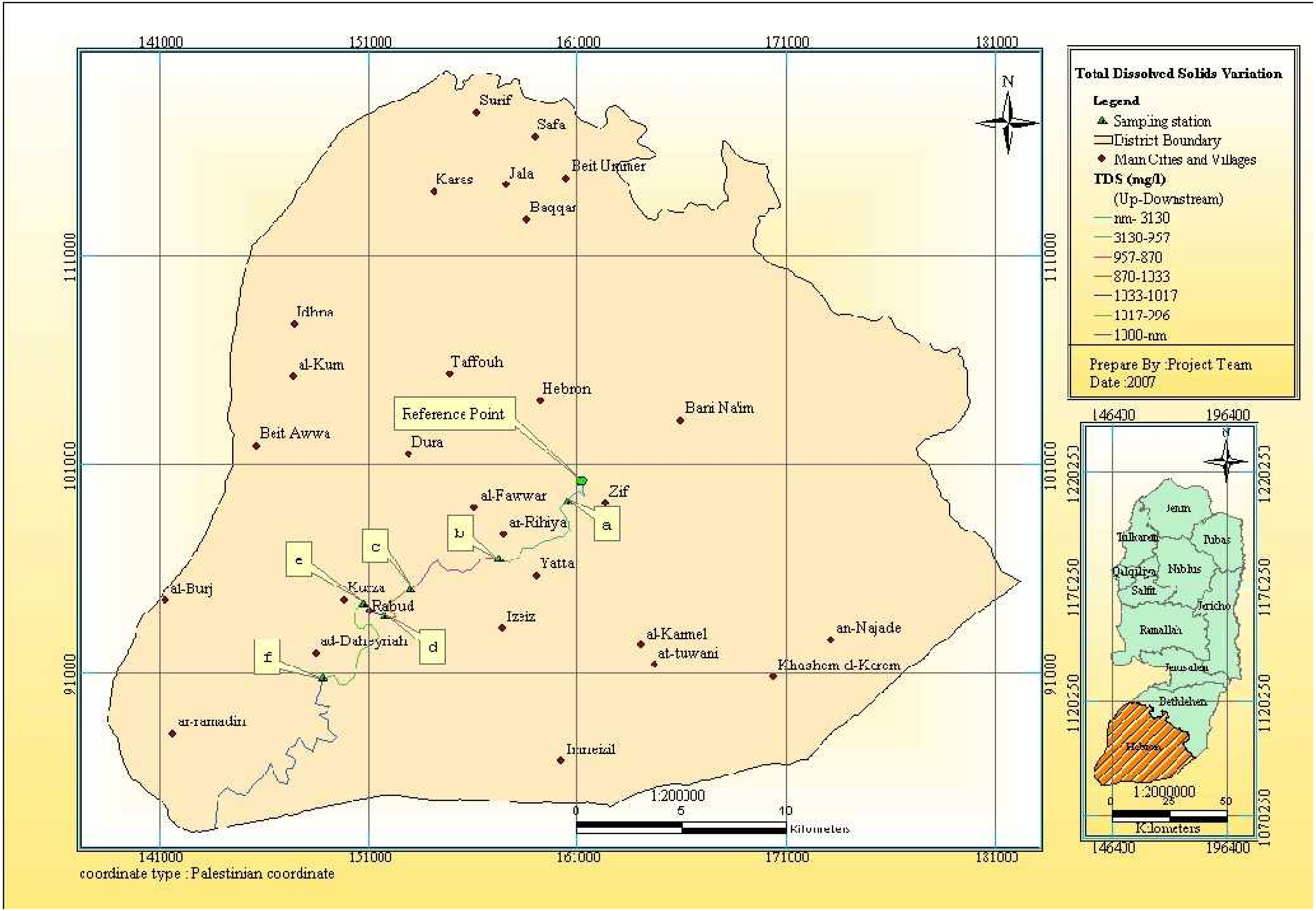
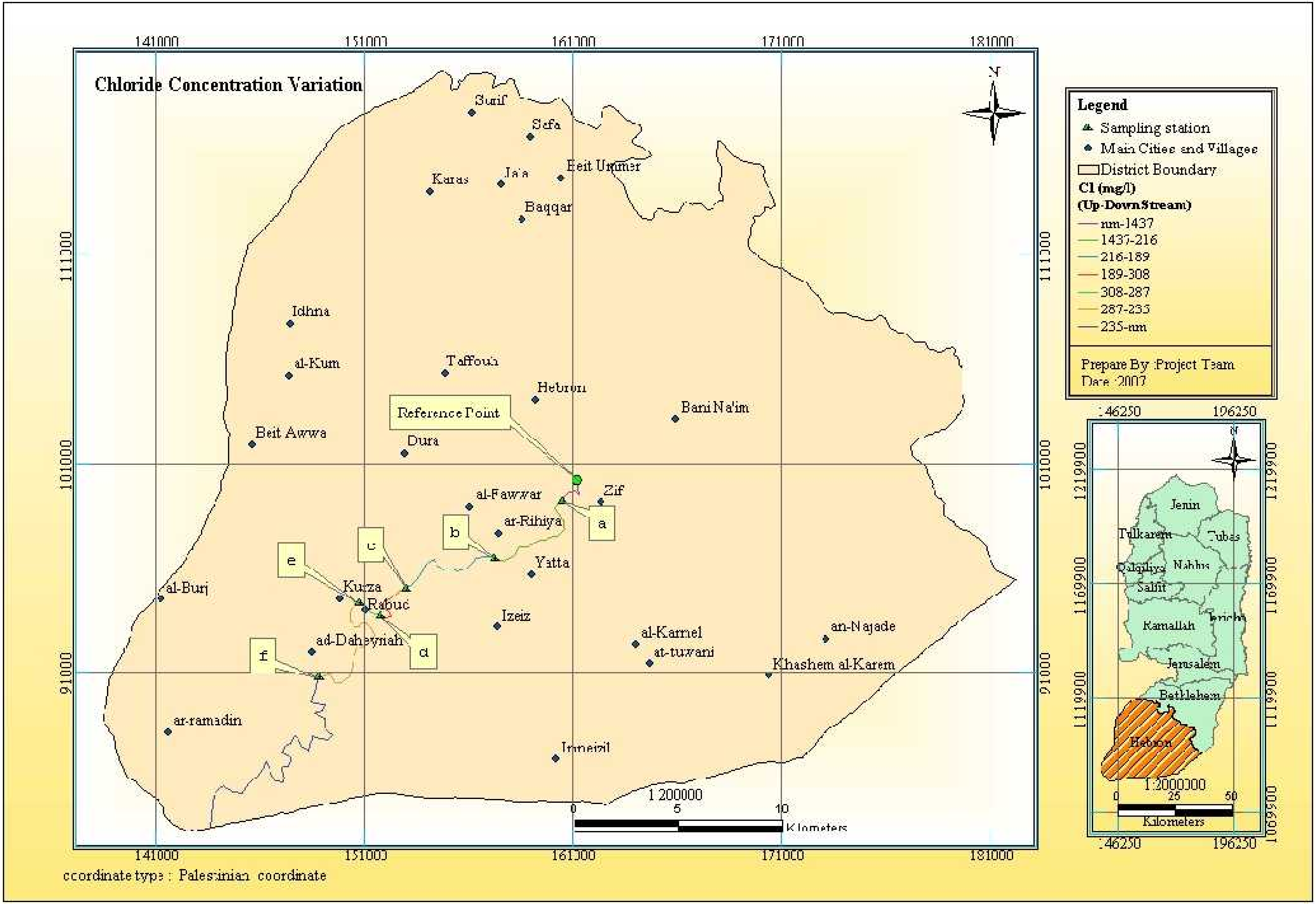


Figure (6.15): Total dissolved Solids Variation

Figure (15): Total Dissolved Solids Variation



Figure(6.16): Chloride Concentration Variation

Figure (16):Chloride Concentration Variation

APPENDIX A

GLOSSARY

GLOSSARY

1. Activated Treatment:

Purification processes used after or during secondary wastewater treatment to remove nutrients or additional solids and dissolved organics; also called tertiary treatment.

2. Aeration:

A physical treatment process which air is thoroughly mixed with water or wastewater for purification.

3. Aerobic:

Presence of dissolved oxygen.

4. Anaerobic:

Absence of dissolved oxygen.

5. Bacteria:

Microscopic singal-celled organisms that do not contain chorophyll and do not contain nourish themselves by photosynthesis.

6. Biochemical Oxygen Demand (BOD):

(1) The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) A standard test used in assessing wastewater strength.

7. Biosolids:

Treated sewage sludge; a primarily organic solid product, produced by wastewater treatment processes, that can be beneficialy recycled.

8. Chemical Oxygen Demand (COD):

It is a measure of organic matter and represents the amount of oxygen required to oxidize the organic matter by strong oxidizing chemicals (potassium dichromate) under acidic condition.

9. Color:

Fresh wastewater is light gray. Stale or septic wastewater is dark gray or black.

10. Combined Sewer:

A pipeline that may carry a mixture of sanitary, storm, and industrial sewage, common in older cities, but not used in modern construction.

11. Effluent:

Partially, or completely treated wastewater flowing out of a treatment plant, reservoir, or basin.

12. Electrical Conductivity:

(EC_w for water , EC_e for the soil saturation extract) – A measure of salinity expressed in millimhos per centimeter (mmho/cm) or decisiemens per meter (ds/m) at 25°C.

13. Gravity Flow:

Open channel flow in a pipe, ditch, or stream bed, Characterized by a free liquid surface at atmospheric pressure.

14. Heavy Metals:

Elements of heavier density than 4g/cc, which can be precipitated by hydrogen sulphide in acid solution, for examples lead, silver, mercury and copper.

15. Hydrogen-Ion Concentration:

Is indication of acidic or basic nature of wastewater. A solution is neutral at pH 7.

16. Industrail Sewage:

Used water from industrial or manufacturing facilities that carries chemical waste products.

17. Influent:

Liquid that flows into a water or wastewater treatment plant or purification process.

18. Impurities:

Constituents added to the water supply through use.

19. Land Treatment:

The controlled spreading of wastewater, sludge, or hazardous waste on selected land parcels for waste treatment and/or disposal.

20. Nutrients:

Both nitrogen and phosphorus, along with carbon, are essential nutrients for growth. When discharge to the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharge in excessive amounts on land, they can also lead to the pollution of groundwater.

21. Organic Compound:

A substance usually made up of complex molecules that comprise carbon with hydrogen, oxygen, and other elements.

22. Oxidation:

A chemical reaction involving combination with oxygen and/or loss of electrons.

23. Parameter:

A measurable factor such as temperature.

24. Preliminary Treatment or Pretreatment:

Is the very first stage, it is the removal of larger materials and grit that if not removal could hinder subsequent treatment processes. It is accomplished through the use of equipment such as bar screens, macerators, comminutors, racks and removal systems. Removal of wastewater constituents such as rags, sticks, floatables, grit, and grease that may cause maintenance or operational problems with the treatment operations, processes, and ancillary system.

25. Primary Treatment:

(1) The first major treatment in a wastewater treatment facility, usually sedimantation but not biological oxidation. (2) The removal of a substantial amount of suspended matter but little or no colloidal and dissolved matter. (3) Wastewater treatment processes usually consisting of clarification with or without chemical treatment to accomplish solid-liquid separation.

26. Protozoa:

Microscopic single-celled animals that consume bacteria and algea for food.

27. Recycling:

The reuse of treated wastewater and biosolids for beneficial purposes.

28. Reuse:

Beneficial use of reclaimed or repurified wastewater or stabilized biosolids.

29. Secondary Traetment:

(1) Generally, a level of treatment that produces removal efficiencies for BOD and suspended solids of 85%. (2) Sometimes used interchangeable with concept of biological wastewater treatment, particularly the activated sludge process. Commonly applied to treatment that consists chiefly of a biological process followed by clarification with separate sludge collection and handling.

30. Solids:

Material removal from wastewater by gravity separation (by clarifiers, thickeners, and lagoons) and is the solid residue from dewatering operations.

31. Suspended Solids:

Solids carried water or sewage that would be retained on a glass-fiber filter in a standard lab test.

32. Temperature:

The temperature of wastewater is slightly higher than that of water supply. Temperature has effect upon microbial activity, solubility of gases, and viscosity. The temperature of wastewater varies slightly with the seasons, but is normally higher than air temperature during most of the year and lower only during the hot summer months.

33. Tertiary/ Advanced Treatment:

Any physical, chemical or biological treatment process used to accomplish a degree of treatment greater than that achieved by secondary treatment. Usually implies removal of nutrients such as N and P and a high percentage of suspended solids. Terms now being replaced by preferable term, advanced treatment.

34. Total Dissolved Solids:

The sum of all dissolved solids in water or wastewater and an expression of water salinity in mg/l empirically related to electrical conductivity (EC) in mmhos/cm multiplied by 640.

35. Total Suspended Solid:

(1) Portion of organic and inorganic solids that are not dissolved. These solids are removal by coagulation or filtration. (2) portion of the total solid retained on a filter with a specified pore size, measured after being dried at a specified temperature (105°C). The filter used most commonly for the determination of TSS is the Whatman glass fiber filter, which has a nominal pore size of about 1.58µm.

36. Turbidity:

Turbidity in wastewater is caused by a wide variety of suspended solids. In general, stronger wastewaters have higher turbidity.

37. Upflow Anaerobic Sludge Blanket:

The most common type of anaerobic reactor for wastewater treatment.

38. Wastewater:

The once-used water of a community or industry which contains dissolved and suspended matter.

39. Wastewater Characteristics:

General classes of wastewater constituents such as physical, chemical, biological and biochemical.

40. Wetland:

A land area frequently submerged by surface or groundwater, and which supports vegetation adopted to saturated conditions.

APPENDIX B

PROCEDURES OF LABORATARY ANALYSIS

Measurements of Dissolved Oxygen

Name: Dissolved Oxygen

Definition: Dissolved oxygen is required for the respiration of aerobic micro-organisms as well as all other aerobic life forms.

Apparatus: Laboratory dissolved oxygen meter (sension8).

Method: APHA standard methods, 1995

Procedure:

After the probe is properly stabilized, chemically zeroed (for measurements below 1 mg/l), and calibrated, take measurements as follows:

1. Add the weight assembly to the probe if required (3 or 15 m cable versions only).
2. If the sample salinity has been measured using an Electrolytic Conductivity Meter, enter the value in setup 4. If the meter has been moved to a different elevation or if the barometric pressure has changed, enter the new values in setups 5 and 6.
3. Insert the probe into the sample to the desired depth. The probe must be deep enough to cover the thermistor (metallic button) located on the side of the probe.
4. Agitate the probe in the sample to dislodge air bubbles from the sensing area of the probe tip.
5. Stir the sample vigorously with the probe or use a stir stand and stir bar. When measuring deep bodies of water, create sufficient flow across the probe tip by pulling on the cable to move the probe up and down. When using a stir stand and magnetic stir bar, increase the speed of the stir bar until the displayed value no longer increases with the stirring rate.
6. When the reading on the meter stabilizes, record or store the value in the meter memory.

7. Press the CONC % key on the keypad to change the display from concentration in mg/L to % saturation.

Measurements of Total Dissolved Solids

Name: Total Dissolved Solids

Definition: The sum of all dissolved solids in water or wastewater and an expression of water salinity in mg/l empirically related to electrical conductivity (EC) in mmhos/cm multiplied by 640.

Apparatus: Laboratory Conductivity Meter (sension7).

Method: APHA standard methods, 1995

Procedure:

To determine TDS with the sension7 meter:

1. Press the TDS key on the keypad. The instrument will display the TDS value for the currently displayed conductivity measurement.
2. The standard method to determine TDS (Total Dissolved Solids) is to evaporate the sample to dryness at 180 °C, then weigh the residue.
3. Another way to estimate TDS is by calculating the concentration of sodium chloride that would have the same conductivity as the sample at the same temperature.
4. The sension7 meter reports a sample's TDS value in mg/L of sodium chloride by comparing the sample conductivity and temperature to data stored in the meter's memory.
5. Data were obtained from empirical procedures using sodium chloride solutions.

Measurements of Salinity

Name: Salinity

Definition: The salinity of the soil water is related to, and often determined by; the salinity of the irrigation water.

Apparatus: Laboratory Conductivity Meter (sension7).

Method: APHA standard methods, 1995

Procedure:

1. To determine salinity with the sension7 meter, press the SAL key on the keypad. The instrument will display the salinity value for the sample being measured.
2. Salinity, a measure of the mass of dissolved salts in a given mass of solution, is used to describe seawater, natural, and industrial waters. Salinity is a relative scale based on a KC1 solution. A salinity value of 35 is equivalent to a KC1 solution containing 32.4356 g KCI in 1 kg of solution at 15 °C. Salinity is measured in %o (ppt - parts per thousand).
3. The meter calculates the salinity based on the Extended Practical Salinity Scale of 1978, as referenced in 17th edition of Standard Methods, 25200 B. The applicable range is 0 to 42% and -2 to 35 °C.

Measurements of Conductivity

Name: Conductivity

Definition: The Electrical Conductivity (EC) of water is a measure of the ability of a solution to conduct an electrical current.

Apparatus: Laboratory Conductivity Meter (sension7).

Method: APHA standard methods, 1995

Procedure:

1. Determining conductivity with the sension7 meter is easy; just press the COND key on the keypad. The instrument will display the conductivity value for the sample being measured.
2. For conductivity, place the probe into the sample and make sure the slot on the end of the probe is totally immersed. Agitate the sample with the probe for 5-10 seconds to remove bubbles that may be trapped in the slot.

Measurements of pH

Name: Conductivity

Definition: pH is indication of acidic or basic nature of wastewater. A solution is neutral at pH value 7.

Apparatus: Laboratory pH Meter (sension3).

Method: APHA standard methods, 1995

Procedure:

1. Place the electrode in the sample. Press READ/ENTER stabilizing.., will be displayed, along with the sample temperature and the pH or mV reading. These values may fluctuate until the system is stable.
2. If the Display Lock is enabled, Stabilizing.., will disappear and the display will "lock in" the pH or mV and sample temperature when a stable reading is reached. If the Display Lock is off, Stabilizing.., will still disappear, but the display will show the current reading and temperature and the values may fluctuate.
3. Record or store the pH and mV value.

Measurements of Turbidity

Name: Turbidity

Definition: Turbidity in wastewater is caused by a wide variety of suspended solids. In general, stronger wastewaters have higher turbidity.

Apparatus: 2100P Turbidimeter.

Method: APHA standard methods, 1995

Procedure:

1. Measurements may be made with the signal average mode on or off and in manual or automatic range selection mode.
2. Using automatic range selection is recommended. Signal averaging uses more power and should be used only when the sample causes an unstable reading. Signal averaging measures and averages ten measurements while displaying.
3. Intermediate results. The initial value is displayed after about 11 seconds and the display is updated every 1.2 seconds until all ten measurements are taken (about 20 seconds). After this, the lamp turns off, but the final measured turbidity value continues to be displayed until another key is pressed.
4. When not in signal average mode, the final value is displayed after about 13 seconds.
5. Accurate turbidity measurement depends on good measurement technique by the analyst, such as using clean sample cells in good condition and removing air bubbles (degassing**).**

Measurements of COD

Name: Chemical oxygen demand

Definition: It is a measure of organic matter and represents the amount of oxygen required to oxidize the organic matter by strong oxidizing chemicals (potassium dichromate) under acidic condition.

Apparatus: Thermo spectronic

Method: Closed reflux

Procedure:

1. Put 0.4g $HgSO_4$ in a reflux flask. Add 20 ml of sample, or an aliquot of sample diluted to 20 ml with distilled water. Mix well, so that the chlorides are converted into poorly ionized mercuric chloride.
2. Add 10 ml of standard $K_2Cr_2O_7$ solution. Slowly add 30 ml of sulfuric acid solution which already contains silver sulfate, and swirl the flask.
3. If the color turns green, either take a fresh sample with smaller aliquot or add more dichromate and acid. The final concentration of H_2SO_4 should always be 50% or more.
4. Connect the flask to the condenser and reflux for 2 hrs. Cool and wash down the condenser with a small quantity of distilled water. Remove the flask and add about 50 ml of distilled water.
5. Reflux a reagent blank under identical conditions preferably simultaneously with the sample.
6. For determining low COD samples follow up the same procedure using 0.05 N $K_2Cr_2O_7$ and 0.025 N FAS.

APPENDIX C

PHOTOS OF LABORATARY EQUIPMENT

Figure (C.1): Measuring of pH Parameter

Figure (C.2): Laboratory Conductivity Meter

Figure (C.3): Chemical Oxygen Demand Meter

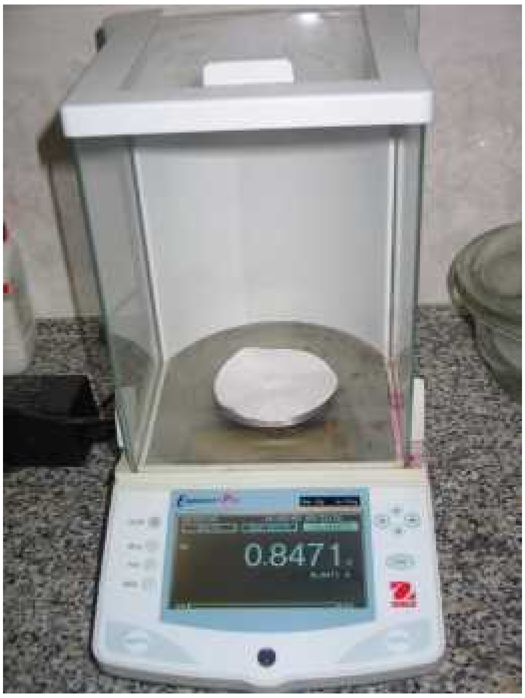


Figure (C.4): Explorer Balance

Figure (C.5): Turbidity Meter

Figure (C.6): Oven

Figure (C.7): Refrigerator

Figure (C.8): Different Appratus

Figure (C.9): Digestion Solution

Figure (C.10): SO_4

APPENDIX D

PHOTO OF THE WADI

Figure (D.1): Hebron

Figure (D.2): Al –Rihya

Figure (D.3): Karmah

Figure (D.4): Abu-Ghozlan

Figure (D.5): Abu Al-Orqan

Figure (D.6): Al-Daherrya

REFERENCES

REFERENCES

1. Abu Khlaf and Abu maizer,2005, Wastewater Treatment and Reuse in al-Fawwar Area, PPU graduation Project.

2. APHA (1998), "(Standard Methods for the Examination of Water and Wastewater, 1998), 17th Edition, American Public Health Associations, Washigton DC.

3. Hebron Municipality Report 2006, Water Demand and Supply in Hebron City

4. Metcalf and Eddy (1991). Wastewater Engineering: Treatment Disposal Reuse. 3rd edn. McGraw-Hill, Inc. New York.

5. Steel, E. W., McGhee, T. J. (1979). Water supply and sewerage. 5th edn. McGraw-Hill Kogakusha, Ltd., Tokyo.

6. Wa'el M. Awadallah, 2001, Municipal Wastewater Characteristics and Performance Analysis of Existing Waste Stabilization Ponds in the West Bank, Journal of Water and Environment, Palestinian Hydrology Group.

7. Water Measurement Manual. 1997. A Water Resources Technical Publication. U.S. Dep. of the Interior, Bureau of Reclamation. Third edition.

8. West Bank Integrated Water Resources Program Phase III, Task 8, Storm Water, Domestic Wastewater and Industrial Wastewater Master Plan for Hebron, July (2001)

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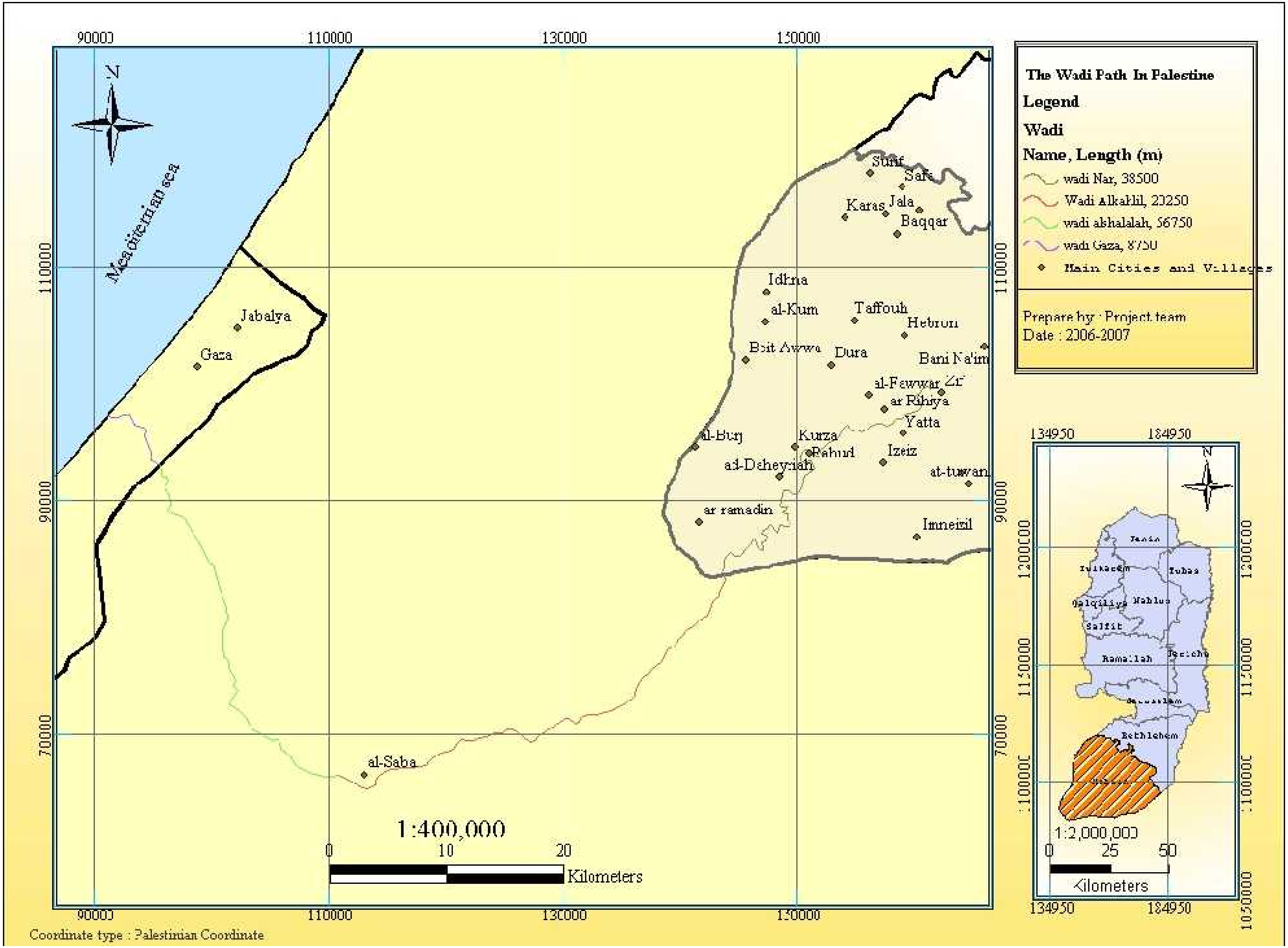
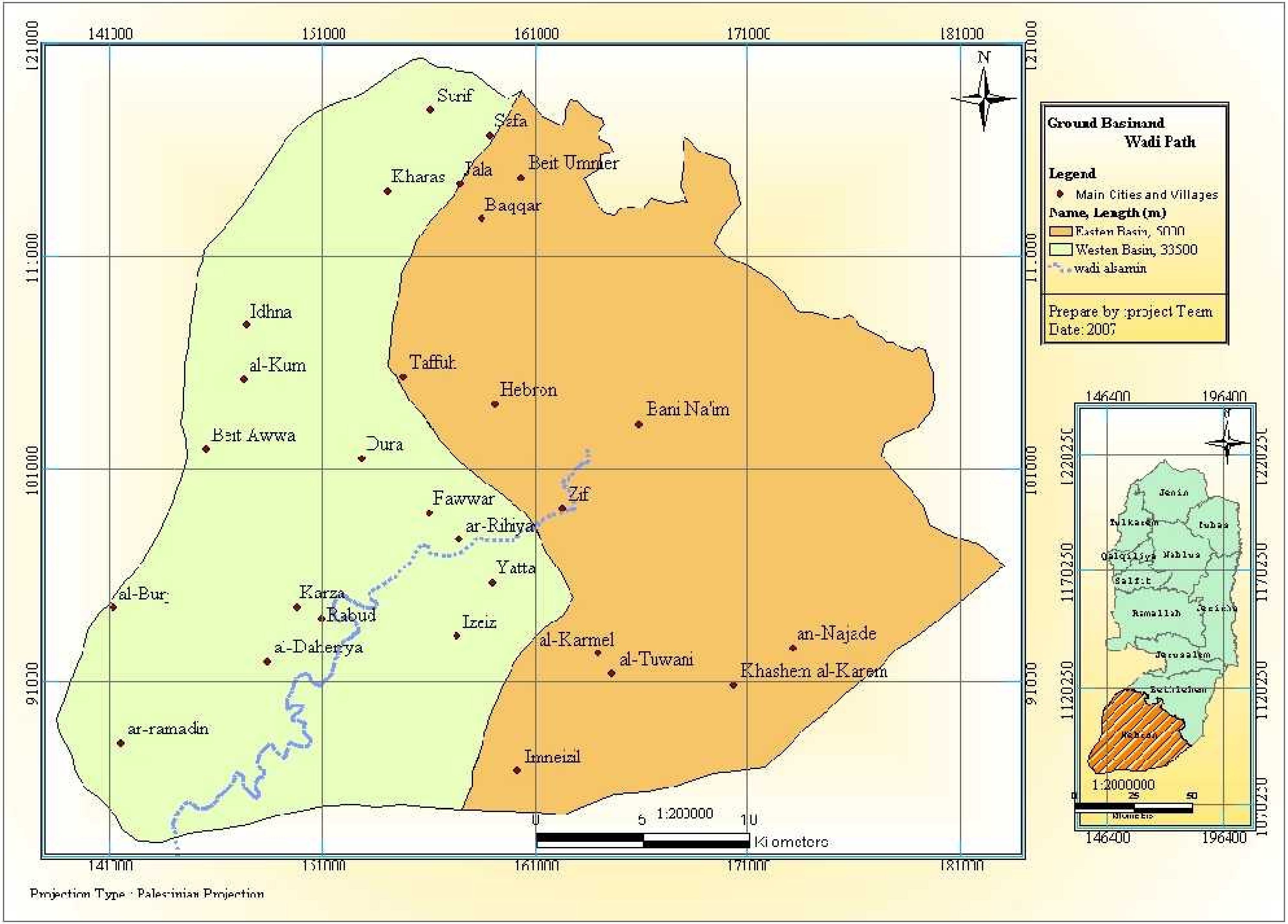
Table 6.3: wadi wastewater characteristics at different stations

Distance	**pH**	**EC**	**Salinity**	**DO**	**TDS**	**TSS**	**TS**	**COD**	**NH4**	**Cl**	**Q**
m	mg/l	microS/cm	%	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	**m^3/min**
1837.149	7.03	5940.00	3.20	0.32	3130.00	3750.00	6880.00	2537.67	92.43	1436.97	1.363176
7802.702	7.51	1908.00	1.00	1.30	957.00	1683.00	2640.00	1579.25	82.39	215.54	1.646438
12828.97	7.57	1741.00	0.90	0.64	870.00	1480.00	2350.00	1855.41	57.62	189.42	4.816036
14445.01	8.53	2050.00	1.10	2.70	1033.00	7773.67	8806.67	2151.36	87.74	308.29	6.252353
16645.78	7.78	2020.00	1.00	2.63	1017.00	4129.67	5146.67	1891.45	80.05	287.39	2.582104
24203.82	7.52	1984.00	1.00	0.50	996.00	9284.00	10280.00	2553.92	90.09	235.14	23.3168
Min	7.03	1741.00	0.90	0.32	870.00	1480.00	2350.00	1579.25	57.62	189.42	1.36
Max	8.53	5940.00	3.20	2.70	3130.00	9284.00	10280.00	2553.92	92.43	1436.97	23.32
Average	7.66	2607.17	1.37	1.35	1333.83	4683.39	6017.22	2094.84	81.72	445.46	6.66
Median	7.55	2002.00	1.00	0.97	1006.50	3939.83	6013.33	2021.40	85.07	261.27	3.70
Variance	0.243667	2678079	0.810667	1.150177	777675	10231459	10461735	154913.99	160.9587	237907.2	70.16736

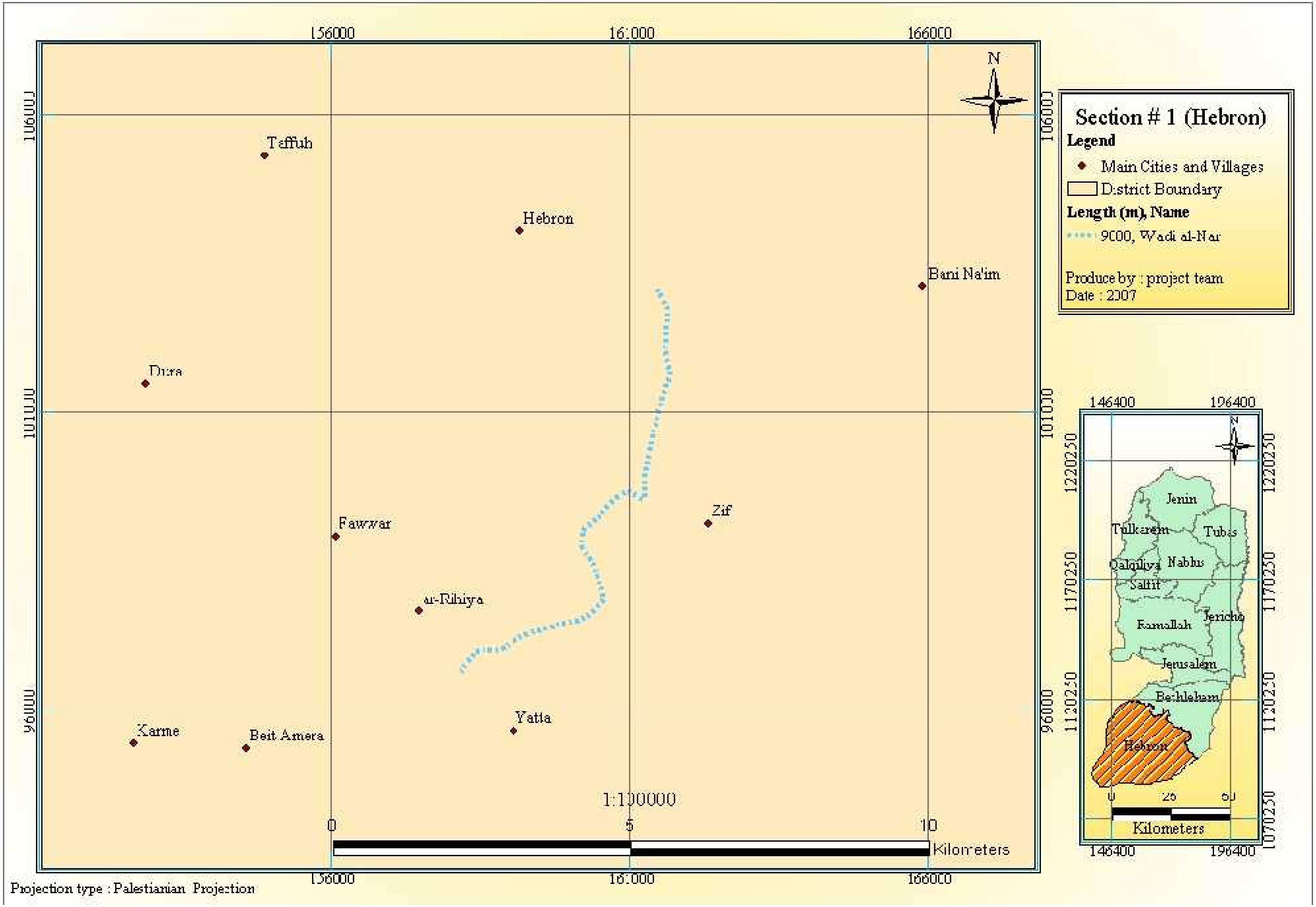


Figure(5.1): Wadi Path in Palestine (Atlas of Palestine)

Figure (5.1):Wadi Path In Plastine

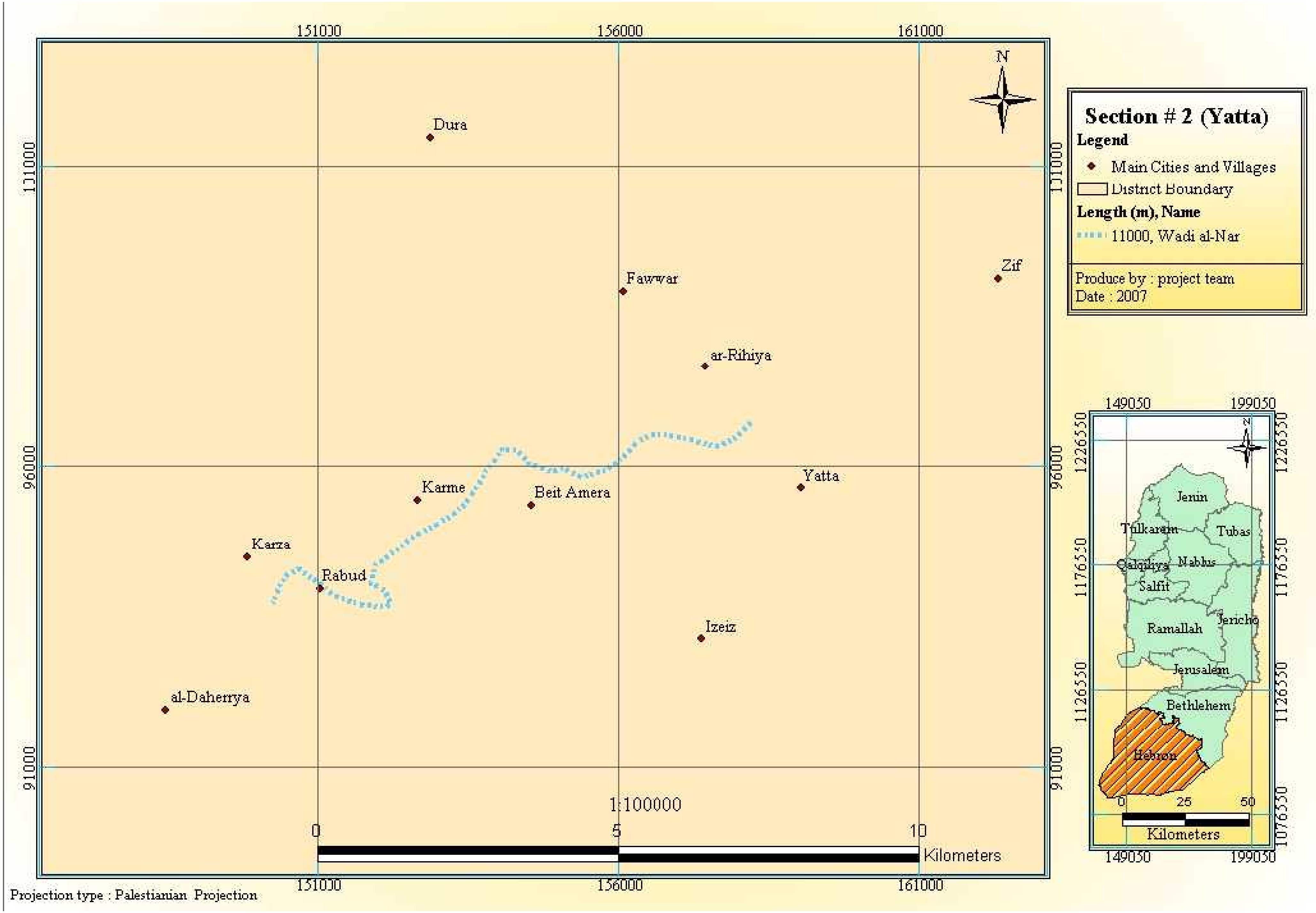


Figure(5.2): Ground Basin (Atlas of Palestine)



Figure(5.3): section # 1 in Hebron (Atlas of Palestine)

Figure (5.3): Section #1 (Hebron) (Atlas of Palestine)



Figure(5. 4): section # 2 of Yatta (Atlas of Palestine)

Figure (6): Section #2(Yatta) (Atlas of Palestine)

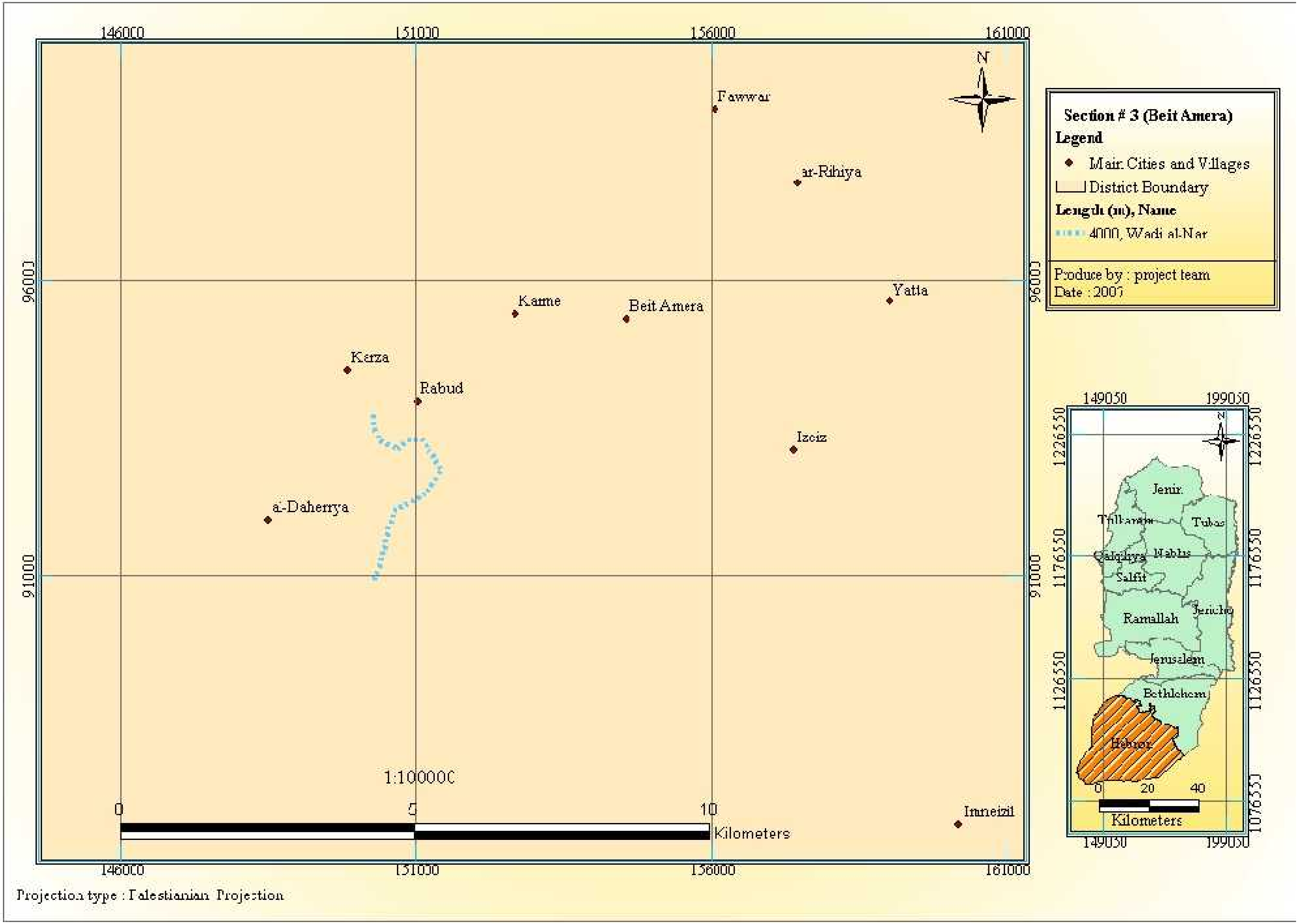


Figure (5.5): Section #3 of Beit Amera (Atlas of Palestine)

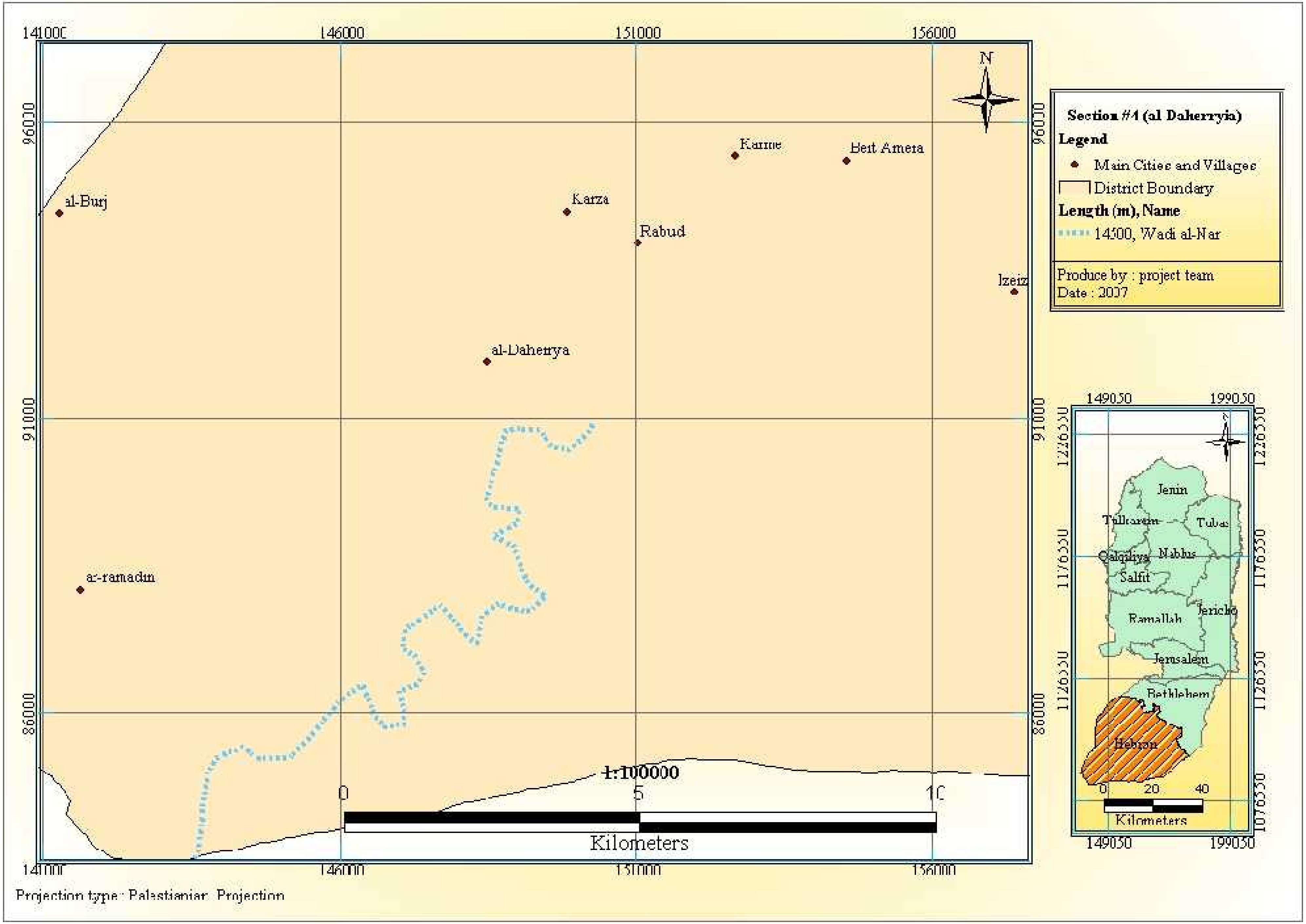


Figure (5.6): section # 4 of al-Daherryia (Atlas of Palestine)

Figure (5): Section #4(al Daherryia) (Atlas of Palestine)