

# Groundwater Monitoring at Yemen

(Case Study: Wadi Tuban Delta, Lahj Gov.)

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# National Groundwater Monitoring & Data Dissemination System

## 1. Background

- a. Since its establishment in 1996, NWRA has been monitoring, controlling and tracking rainfall, torrential flows and groundwater reserves using ordinary devices that operate manually to collect the required field information and deal with it using Excel and World system.
- b. In 2008, the use of modern electronic devices began in the field and office, and the formation of a new advanced computer database system (NWRMIS), starts working on which continued until 2010, then unfortunately stopped due to what was called the youth revolution in February 2011, and the cessation continued after that due to the war that broke out in the country.

# National Groundwater Monitoring & Data Dissemination System

## 1. Background – Continued

- c. In late 2021, the Ministry of Water and Environment worked to resume and activate the water monitoring system through NWRA and the Emergency Unit, with funding from donors supporting the water sector. A field survey was conducted of the inventory of wells in the governorates of Aden, Lahj, Al Dhale'a, Abyan, Shabwa, and Hadramaut, collecting the necessary field information related to the geographical locations and specifications of open and tube wells, and collecting water samples, which were analyzed in a laboratory to determine its physical, chemical, or biological quality.
- d. The results of the survey and analysis varied between positive and negative, as it was observed that fluoride spread at a high concentration exceeding what is permissible for drinking purposes, as per WHO Standard, in many water basins. The highest concentration was around 12 mg/litre in the Al-Dhale'a Basin, causing health problems for the beneficiaries of the water there, in addition to The spread of environmental pollution resulting from human feces in more than one water basin, specifically in the delta basin in Lahj, which extends to Aden Governorate.

# National Groundwater Monitoring & Data Dissemination System

## 1. Background – Continued

- e. In 2021, 8 Loggers groundwater level monitoring devices were installed in the Tehama Delta/West Coast with funding from SI, and they are being dealt with by the water resources branches in Taiz and Hodeida governorates.
- f. In 2022, 4 Loggers monitoring devices for groundwater levels were installed in the Tuban Delta, by the Habitat organization, affiliated with the supervision of the climate change project in the country affiliated with the Environmental Protection Authority in Aden. These devices were installed as part of a comprehensive study being prepared by the same organization to evaluate The delta in terms of the presence of water resources, agricultural activity, and the various irrigation facilities and others in the delta.
- g. In the current year 2023 AD, the Water Resources Authority (NORA) is conducting a field survey similar to what was done in the previous item No. (3), of the well stock in the governorates of Aden, Lahj and Abyan, with funding from the Swedish Committee for Refugees (NCR) in the country. The field surveys have been completed and are currently being processed and analyzed. Desk information obtained for dissemination.
- h. The Ministry of Water and Environment is currently reviewing, developing and expanding the NWRMIS information system, to include information about the sectors affiliated with the Ministry and relevant sectors in other ministries, with funding from UNICEF in Aden.

## Case Study to Wadi Tuban Delta (Basin), Lahj Gov.

2. This case study is focused on the Wadi Tuban Delta (Basin), to highlight it's main physical parameters, as follows:

- a. Geographically, Wadi Tuban (WT) is located to the north of the Capital Aden, ranging in heights from 0 level to 3,065m, in the highlights of Yemen.
- b. Geomorphologically, consists of a flat delta varies in elevation between 11m and 323m, surrounded by mountainous highlands to the east and north.
- c. Geologically, consists of the presence of Precambrian metamorphic rocks overlain by Jurassic limestone rock, then topped by Cretaceous sandstone and Basalt volcanic rocks of Tertiary period, surrounding the delta from the east and north sides.
- d. In addition to the various deltaic sediments, which are found at a thickness of 30 meters to 200 meters in the upper part, then this thickness increases to more than 400 in the lower part of the delta where the Aden Water Corporation fields are existed.

## Case Study to Wadi Tuban Delta, Lahj Gov.-continued

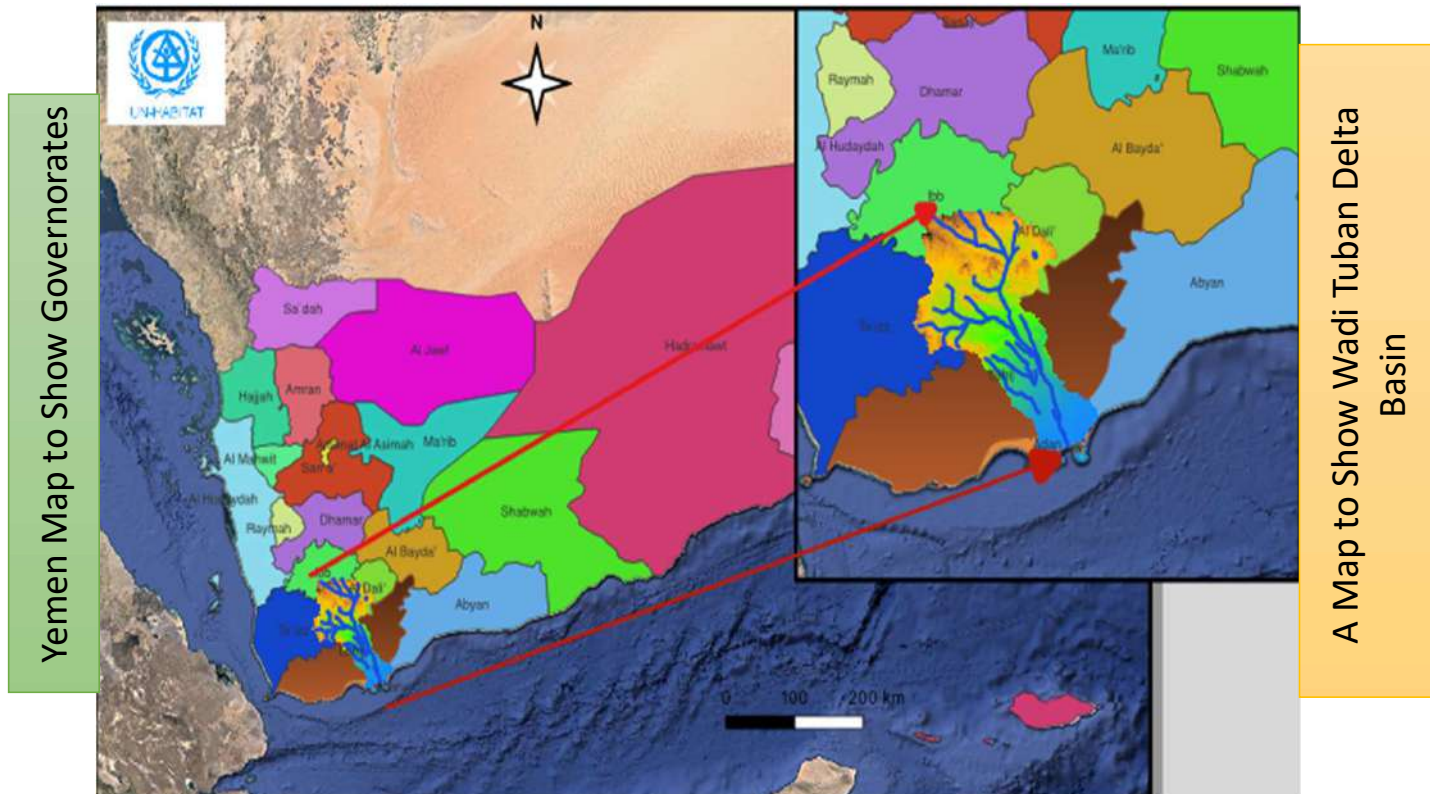
- e. DT is considered one of the most important major water basin in the country, as its water/ catchment area is about 5,300km<sup>2</sup>, and torrents flow into it annually at different rates, the largest of which was recorded in 1982, that reached a rate of **153** million cubic meters, and continued flowing beyond the delta until it reached the northern part of Aden city, specifically Khor Maksar District, where the country's international airport is located.
  
- f. The area of the delta is about 700 km<sup>2</sup>, which represents fertile agricultural land that supplies the local market with various agricultural products, including fruits, vegetables, fodder, grains, and others, through practicing diverse agricultural patterns on an agricultural area of no less than **6,000** hectares.

## Case Study to Wad Tuban Delta (Basin), Lahj Gov.-continued

- g. It is characterized by a flat flow that facilitates the movement of surface water and the reclamation of as much arable land as possible. It supplies the residents of Aden Governorate and the residents therein with drinking water.
- h. The Delta meets the needs of development projects in the region for various building materials such as stones, gravels, sand, clay etc.
- i. There is a network of asphalt roads to connect the capital, Aden, to the rest of the governorates.
- j. It is inhabited by about 40 thousand people, representing about...a population center.

# Case Study: Wadi Tuban Delta, Lahj Gov.

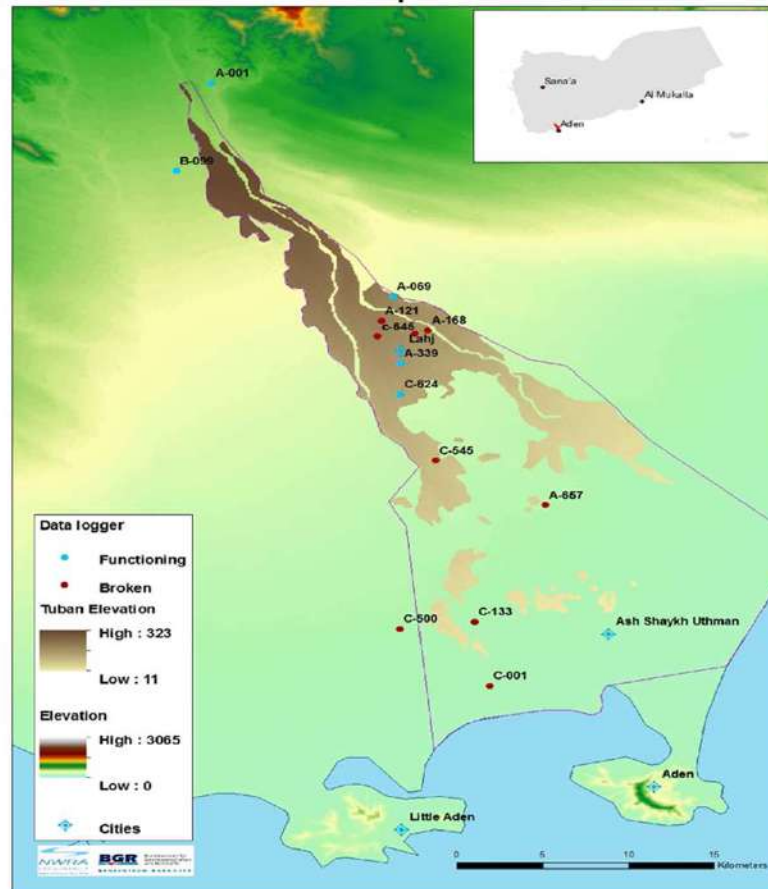
## 3. Location of Wadi Tuban Delta





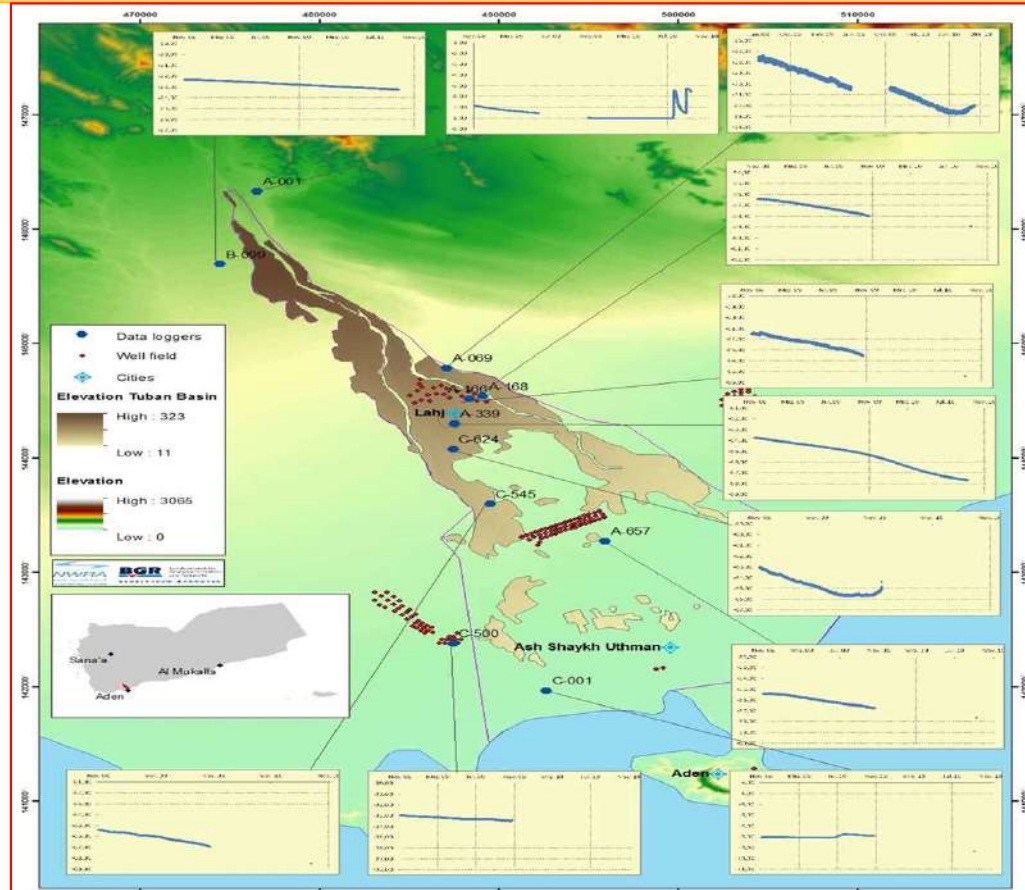
## 4. Groundwater Monitoring; Hydrographs

The loggers used in the field were  
GERO Type PL01



Overview of Data Logger  
(in Wadi Tuban, (September 2010)

## 5. Monitoring Hydrographs from November 2008-2010-continued



# 6. Monitoring; Water Level Variation(m)

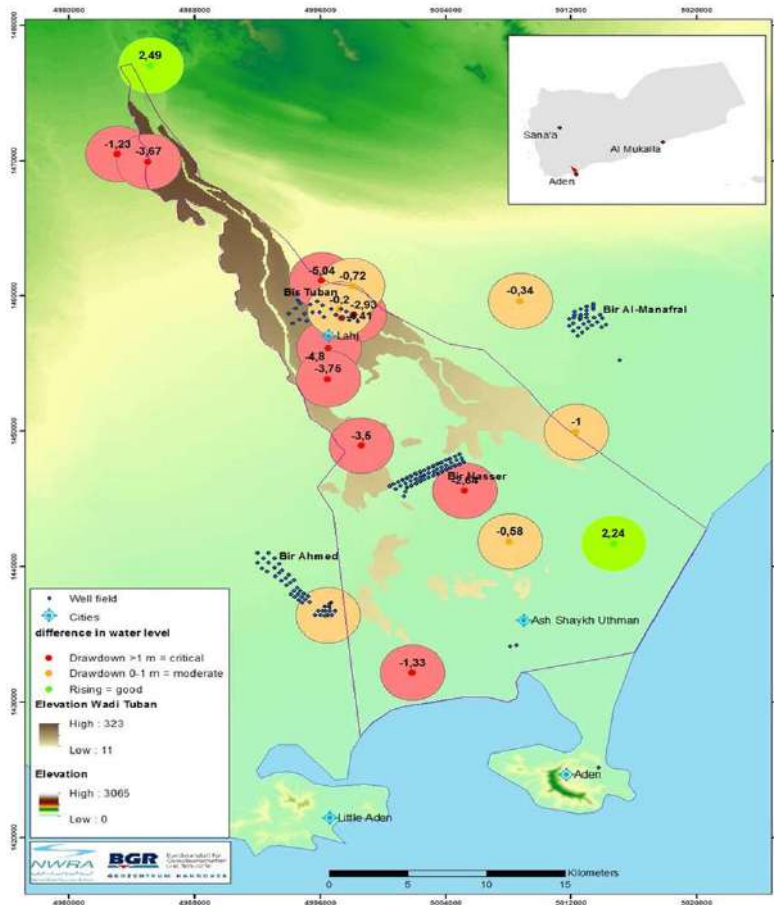
Table (1): Measurement point used for the calculation of groundwater level variation [m] in the Tuban Delta (May 2009-May 2010)

StationName	UTM_E	UTM_N	May 09 GL (m)	May 10 GL (m)	Difference '09-'10	Typ
D-004	488966	1447469	28,22	29,00	-0,78	manual
D-209	476353	1456425	16,70	18,70	-2,00	manual
D-156	499135	1433829	42,90	44,00	-1,10	manual
D-162B	498737	1429092	30,15	30,00	0,15	manual
D-311B	489798	1436168	66,10	67,65	-1,55	manual
D-323	495072	1430734	48,60	49,70	-1,10	manual
A-831	502759	1430673	17,70	18,20	-0,50	manual
A-159	488184	1445777	57,35	57,75	-0,40	manual
B-274	499396	1446393	37,10	37,38	-0,28	manual
Alwaht-B	486993	1433663	55,45	59,10	-3,65	manual
B-378B	483022	1451519	19,90	28,35	-8,45	manual
A-001	476494	1463335	7,45	7,99	-0,54	logger
A-069	487082	1447872	30,04	32,08	-2,04	logger
A-166	488343	1445180	62,20	64,55	-2,35	estimated
A-168	489088	1445415	57,10	58,40	-1,30	estimated
A-339	487513	1443013	64,40	66,79	-2,39	logger
A-657	495934	1432749	56,00	57,30	-1,30	estimated
B-099	474444	1456971	22,48	23,01	-0,53	logger
C-001	492677	1419653	8,05	8,75	-0,70	estimated
C-500	487439	1423783	33,30	33,85	-0,55	estimated
C-545	489522	1435986	66,00	67,80	-1,80	estimated

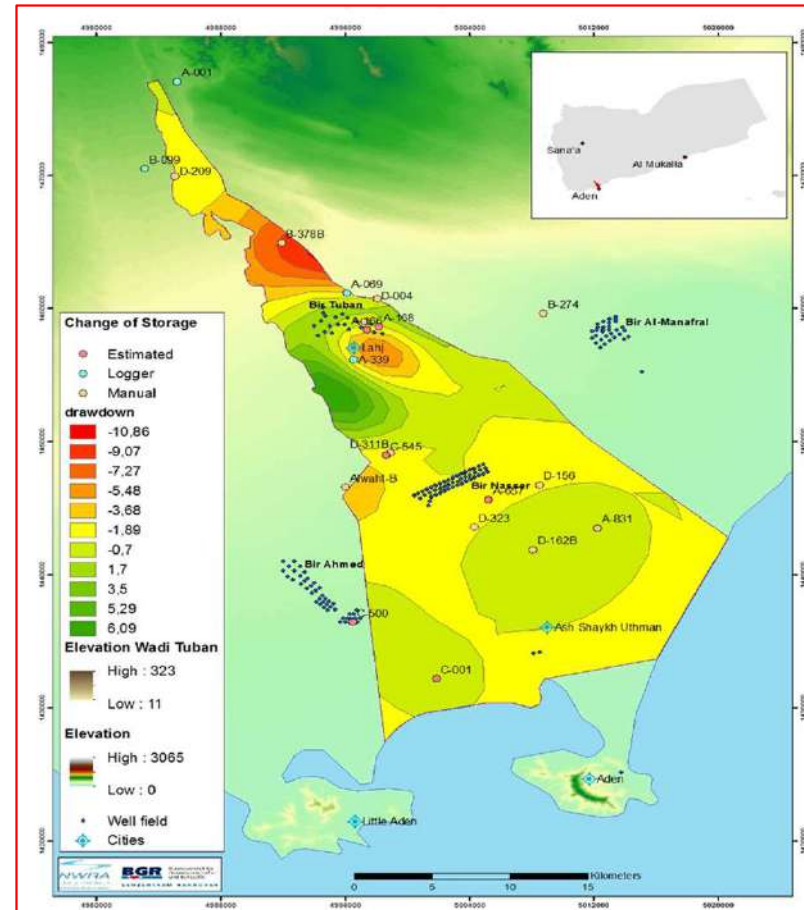


Location of Measurement Points used for the estimation of water level variation in the Tuban Delta

## 7. Monitoring ;Water Level Variation (m) (November 2008-October 2010)

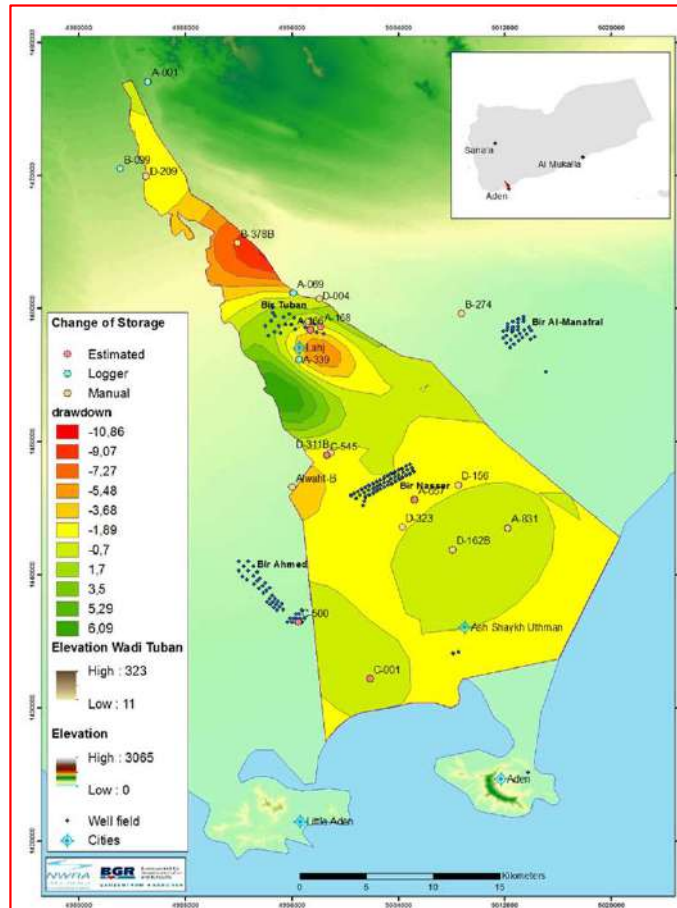


Represented By Circles & Colors



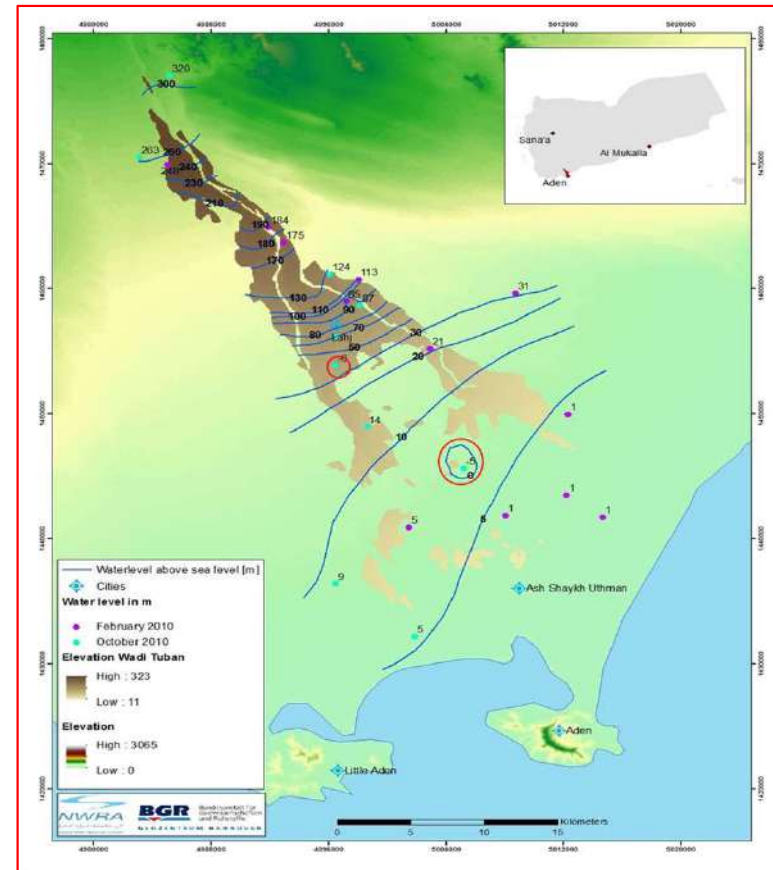
Represented by Contouring Lines

## 8. Deference in Groundwater Level(m), May 2009-May 2010

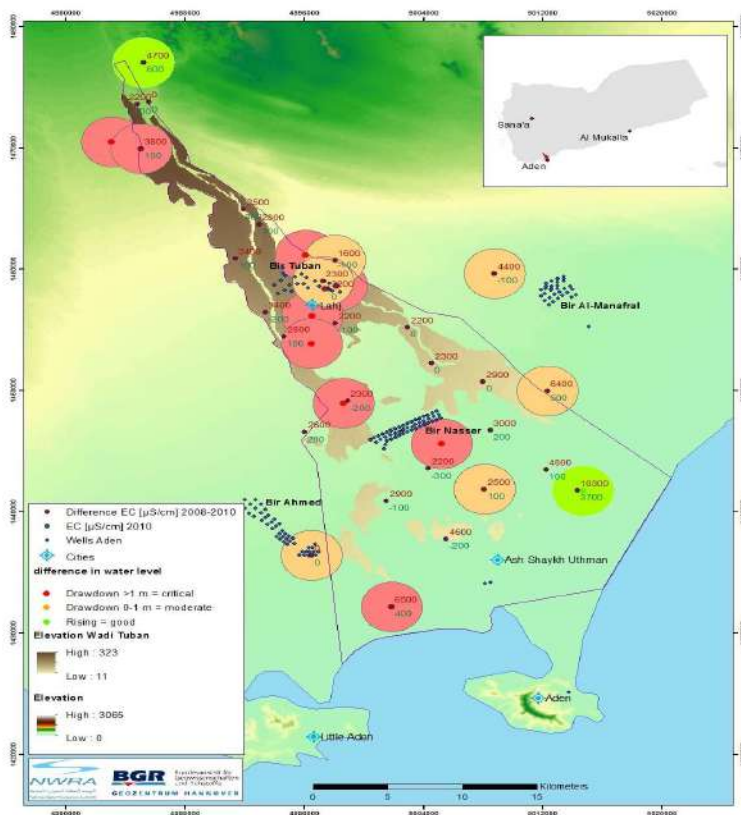


## 9. Groundwater Piezometer levels in meters(asl) (Tuban Delta- September 2010)

ID	UTM_E	UTM_N	Type	Elevation m
A-001	476494	1463335	Logger	325
A-069	487082	1447872	Logger	156
A-121	486374	1446099	broken	160
A-166	488343	1445180	Logger	155
A-168	489088	1445415	Logger	146
A-339	487513	1443013	Logger	138
A-657	495934	1432749	Logger	52
B-099	474444	1456971	Logger	286
C-001	492677	1419653	Logger	15
C-133	491810	1424296	broken	29
C-500	487439	1423783	Logger	43
C-545	489522	1435986	Logger	82
C-624	487468	1440783	Logger	67
c-645	486175	1444956	broken	60
KHAIR	488966	1447469	Manual	139
AL_SALAM	476353	1456425	Manual	266
MANSOOR	498737	1429092	Manual	30
MAHAT	502851	1436979	Manual	29
IMAD	505165	1428958	Manual	12
Tuban_8	488184	1445777	Manual	143
Almanaserah	499396	1446393	Manual	68
AL_HUSSEINY	484014	1450356	Manual	201
AL_MAGHAFa	493728	1442084	Manual	81
GAAWALAH	492329	1428157	Manual	40
Al Madenah Al Khdraa	502759	1430673	Manual	18
Al kedhad	483022	1451519	Manual	212



## 10. Data Results of Monitoring Correlation of EC (mS/cm) & WL (m) Variation for 2010



1. The correlation of groundwater electrical conductivity (mS/cm) and measured drawdown gives indication of salt water intrusion, in Coastal Region.
2. If pumping rates continue at the actual pace, salt water intrusion might render some aquifers unusable in the future.

# 11. Data outcomes of Monitoring

- a. Generally, the water levels decline throughout the whole study area indicating overexploitation of the aquifer studied.
- b. Great importance was attached to the presentation of the groundwater situation and a first estimation of the annual aquifer storage losses, as follows:
  - Two interpolation methods, Kriging and Inverse Distance Weighting, are applied. Results of total losses are similar counting for some 50.5 (49.5) MCM, in Tuban Delta, with an assumed storage coefficient of 0.08, and approximately 28 MCM (27 MCM for the Kriging method and 29.7 MCM for the IDW method in Delta Abyan (Sibson, 1981), with an assumed storage coefficient of 0.07, according to both the interpolation methods.
- c. The estimation made on surface area of TD Aquifer is around 532.4 km<sup>2</sup>, and of DA Aquifer is around 493.9 km<sup>2</sup>




## 12. Groundwater Balance in the Delta

Delta	Estimated Recharge	Aquifer Storage Loss	Estimated Abstraction	Remarks
Tuban	112Mm <sup>3</sup> /a	50Mm <sup>3</sup> /a	162 Mm <sup>3</sup> /a	Komex 2002

Many thanks for your kind attention

Ended •



تحسين إدارة المياه الجوفية في المنطقة العربية من  
خلال تعزيز الوصول إلى البيانات والمعلومات  
والتقنيات المبتكر

المياه الجوفية في اليمن  
وزارة المياه و البيئة  
الهيئة العامة للموارد المائية  
القاهرة ديسمبر 2023م

م/ منصور جعفر علي

# تضاريس اليمن

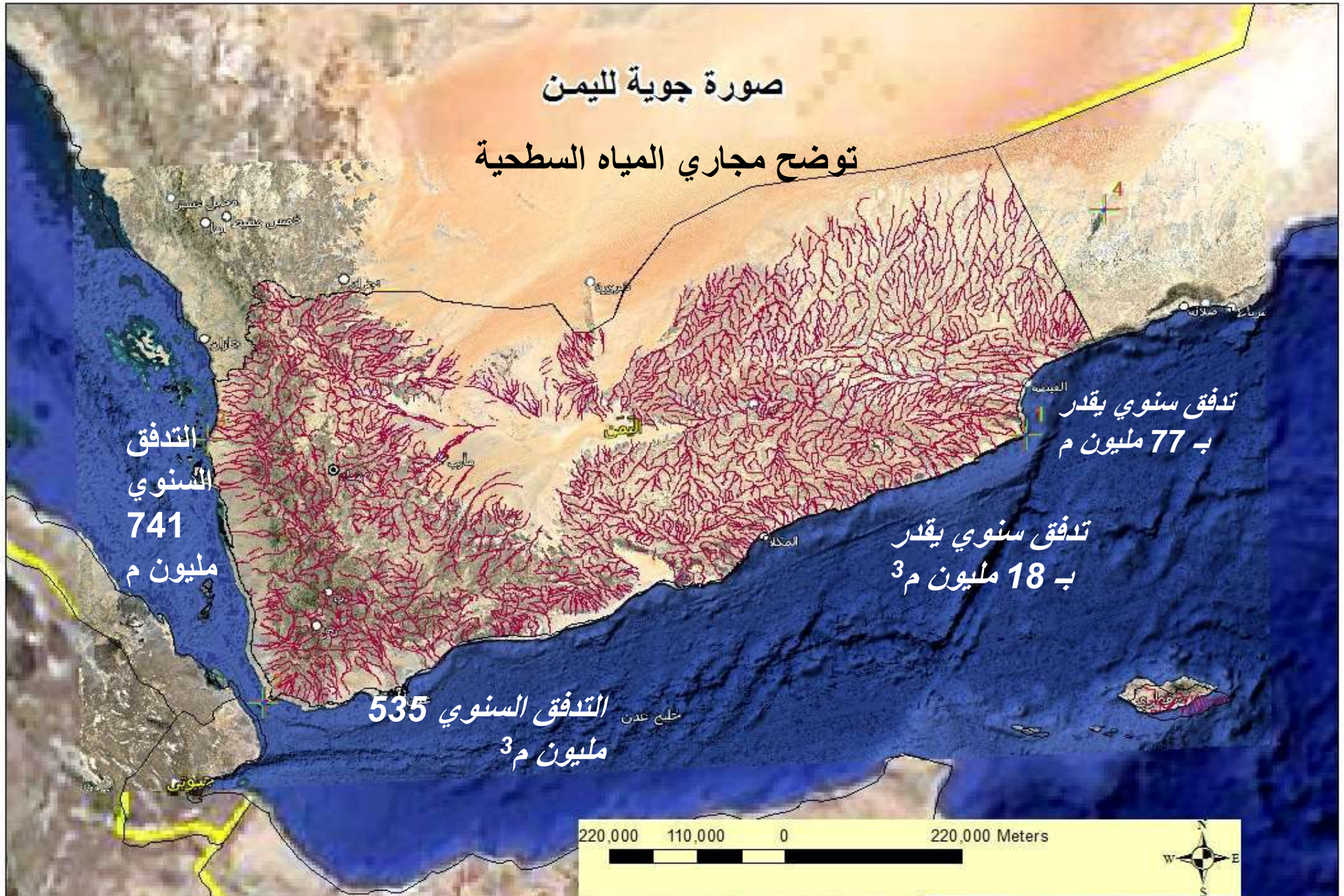


# الهطول المطري

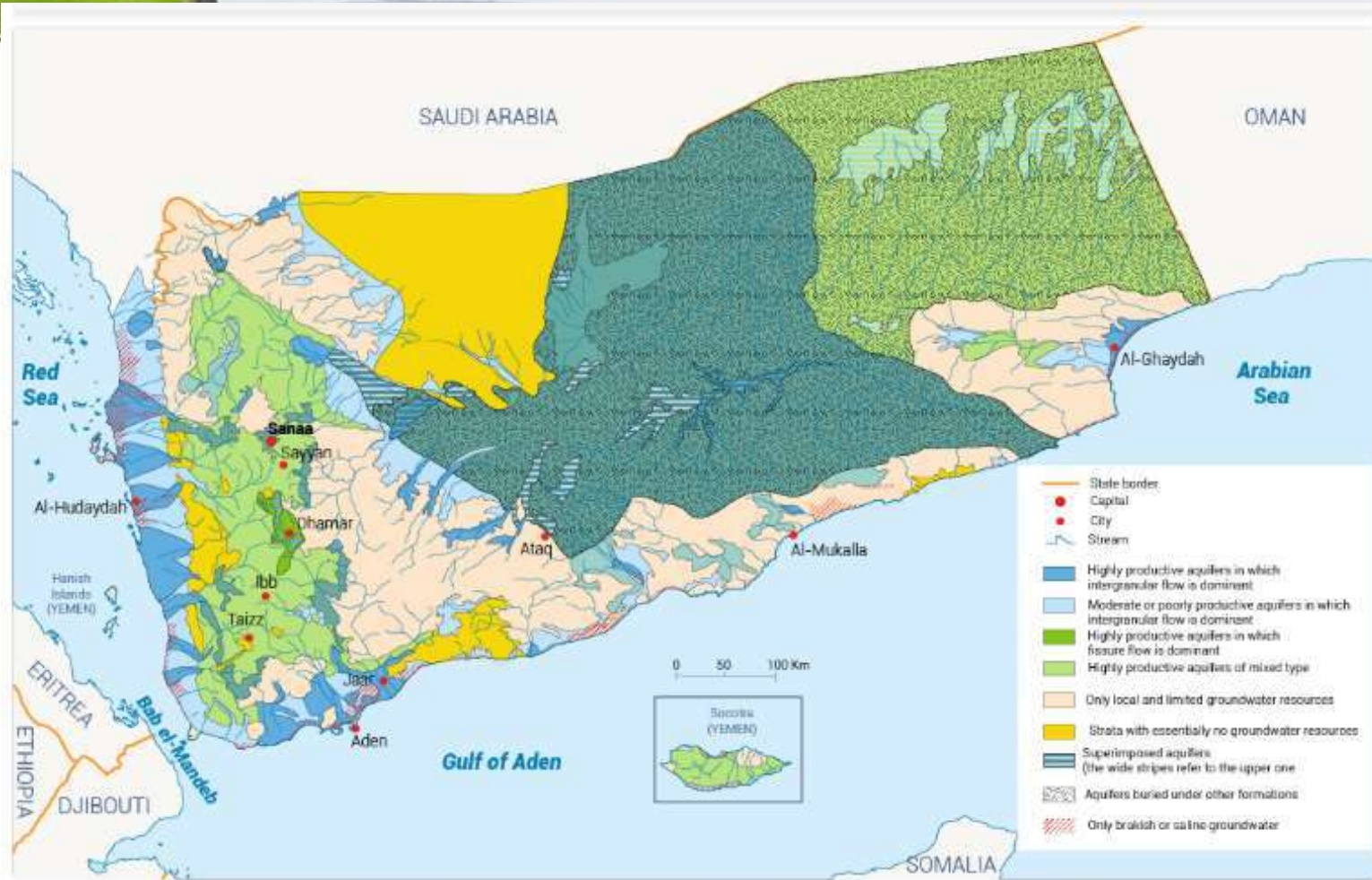
MEAN ANNUAL RAINFALL  
IN THE REPUBLIC OF YEMEN

إجمالي مياه الأمطار  
الهائلة علي اليمن حوالي  
68 مليار م<sup>3</sup> / سنوياً  
المتوسط العام السنوي  
للأمطار الهائلة في اليمن  
لا يتعدى 157 ملم / سنوياً

# المياه السطحية

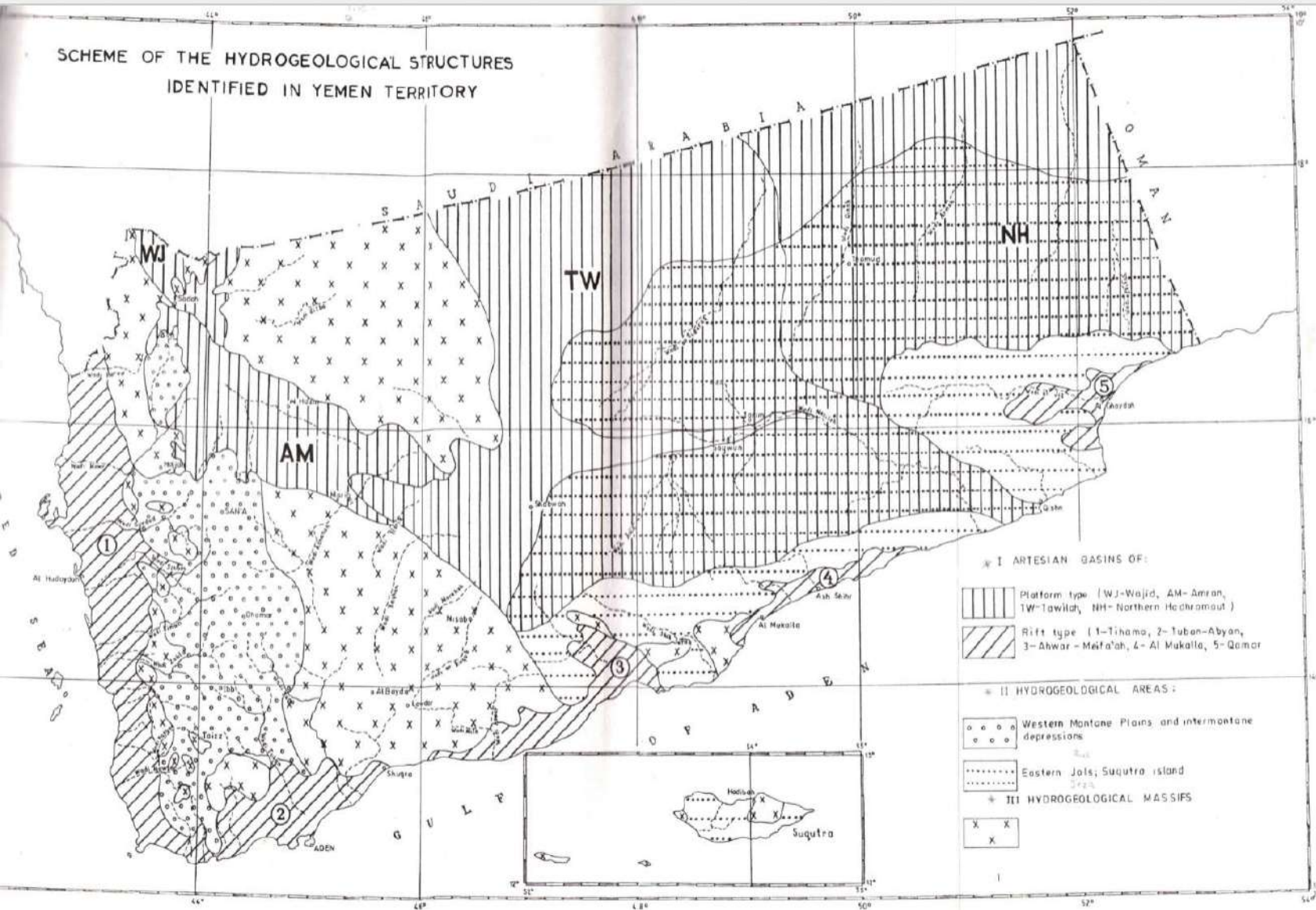


# الأحواض المائية الجوفية



يقدر إجمالي  
المياه المخزونة  
بحوالي 10370  
مليار م<sup>3</sup> منها  
1525 مليون  
م<sup>3</sup> مياه متجددة  
أي بنسبة  
0.02% من  
إجمالي المياه  
الجوفية

# الاحواض المائية في اليمن



يقدر إجمالي المياه  
المخزونة بحوالي  
10370 مليار  
م<sup>3</sup> منها 1525  
مليون م<sup>3</sup> مياه  
متجددة أي بنسبة  
0.02% من  
إجمالي المياه  
الجوفية



# الدراسات السابقة

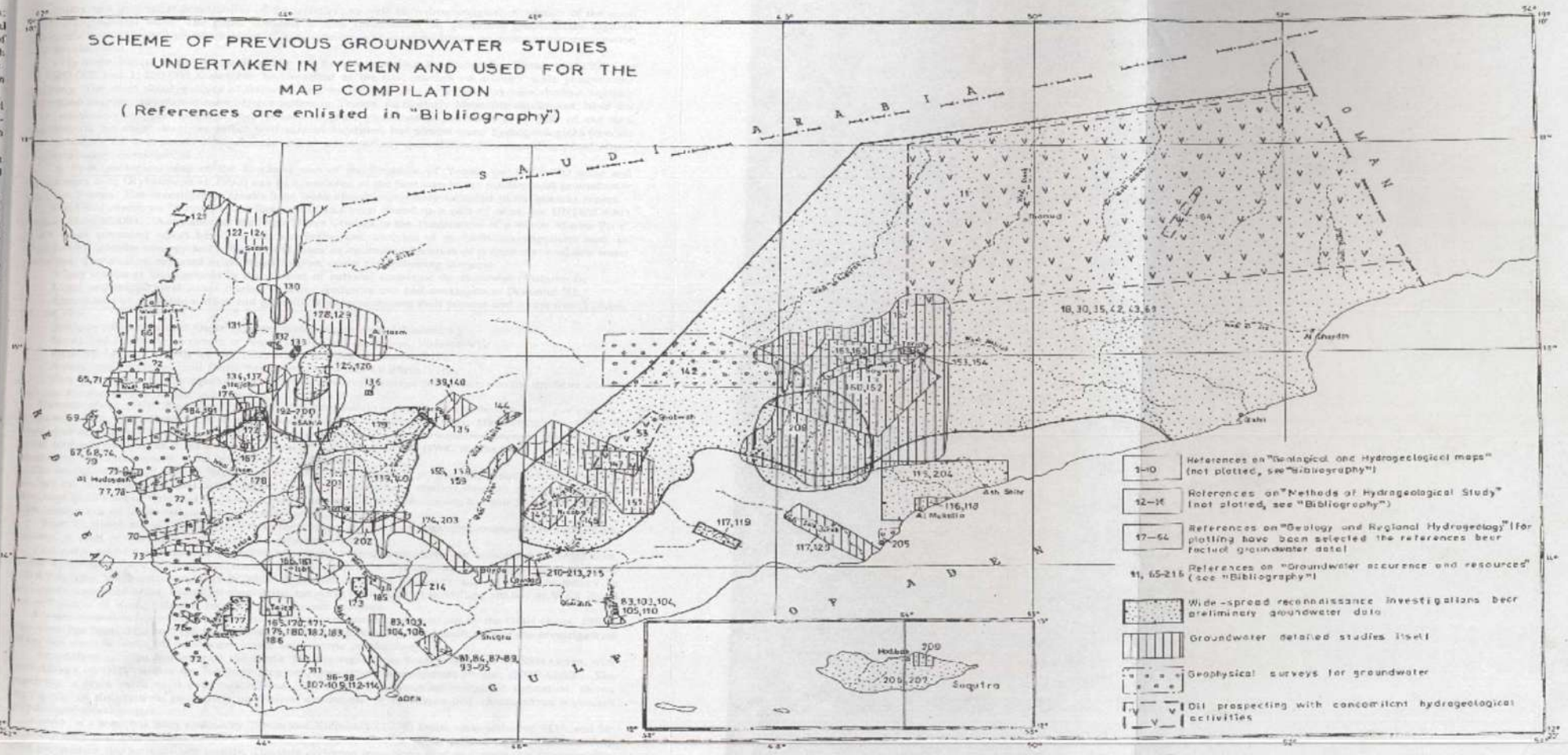


Fig. IV.1. Scheme of Previous Groundwater Studies Undertaken in Yemen and used for the Map Compilation.