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Determinations of Zones Risks of Inundations in the City of Meknes by Using G.I.S and Tools of Hydraulic Modelling

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Original Research Article

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Abstract: At the present time, environmental risks are becoming more and more of a danger to material and human goods, especially in urban environments. In the first place, the risks of floods in the city of Meknes. Because it is crossed by three valleys which are: boufekrane valleys, Bouishak valley and the Ouislane valley on one side. urbanization and development of vulnerable areas that are exposed to these risks. It is in this context that our research, through this scientific paper, becomes our intervention to manage, prevent and predict while delineating risk areas by modeling tools and geomatics and solve this phenomenon that threaten the lives of the people.
Keywords: planning, floods, urbanization, management, prevention and prevision.

INTRODUCTION

The geographical situation of the city of Meknes, its topography, its urban evolution is as many main factors generating some urban risks. Also, its membership in the Sebou basin which considers itself one of the most watered basins of Morocco, and the fact that it is crossed mainly by three valleys Boufekrane Wadi, Bouishak and Ouislane, makes this agglomeration an area vulnerable to risks. flooding and especially in the urban contact zones of the Boufekrane valley and on the quarry cliffs.

This has been aggravated by human actions through the proliferation of illegal habitat that is gaining more and more space on the banks and beds of the valleys, on rough terrain with steep slopes, etc.

This anarchic urban expansion finds its justification in the complexity of the legal status of the property tax base and in the inadequacy of urban planning documents with reality. Even worse, the Meknes development plan has become obsolete while its master plan approved urban development in 2001 is being revised despite being valid until 2020.

The risks of flooding call into question the sustainability of the city of Meknes and complicate its resilience if they are not taken into account in the urban policy and planning of the city and in the absence of a management plan, forecasting and prevention of these risks.

General framework of the study

Geographic and topographic setting

The agglomeration of Meknes is composed of three essential communes namely: Meknes, Toulal and Ouisslane. It is located on the plateau known as Meknes. Despite its small size (S≈ 3200 Km²), 80 km long and 30 km wide, this plateau is the sub-regional area of Meknès-Tafillalet best endowed with natural and human resources, and the most privileged by its geographical position and the quality of its links with modern communication networks [1]. Also, it is bounded by the valley of the Beht wadi and the central plateau to the west, the plain of Fez to the east, the mountains of Pre-rif in the North and the Middle Atlas Mountains to the south. Which ensures Meknes plateau a broad cover over the fresh and humid west winds, also on the dry easterly winds, cold in the winter and hot in the summer.

Indeed, this plateau is cut by the of several valleys and valleys along a South-West, North-East axis, the city of Meknes is compartmentalized in several parts of plateau extended, separated from each other by valleys with significant depths, the width of which varies from upstream to downstream and from valley to valley. Also, it is of great interest to point out that the city of Meknes is on the north side of the plateau Sais-Meknes which separates it from the pre-Rifine hills, overlooking the depression gathering the tributaries of the R'dom (Bouishak valley, valley of Boufekrane and ouislane valley), is marked by a relatively tormented topography. This plateau of Meknes, or Western Sais occupies part of the perched Karst called by the geographers "the lake basin of Meknes-Fez" which forms the northern part of the South Rifain furrow [2].

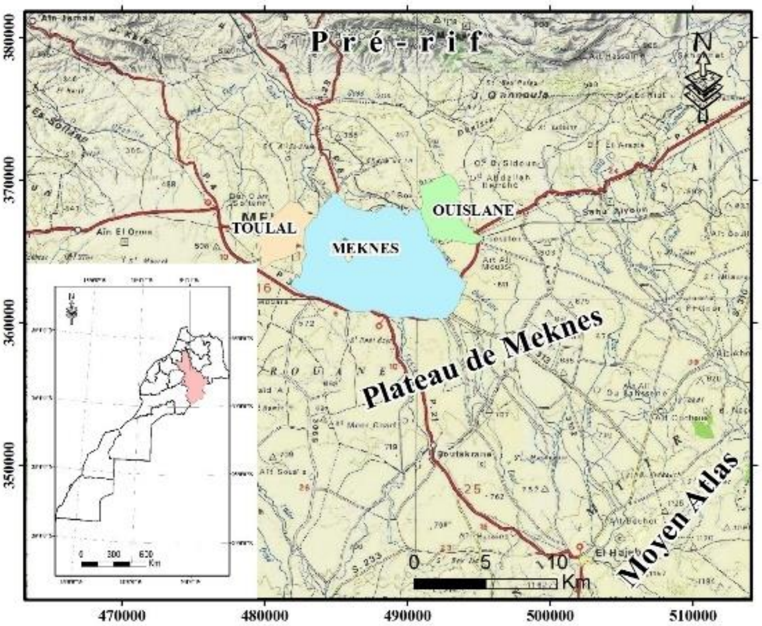

Fig-1: Geographical situation of the city of Meknes

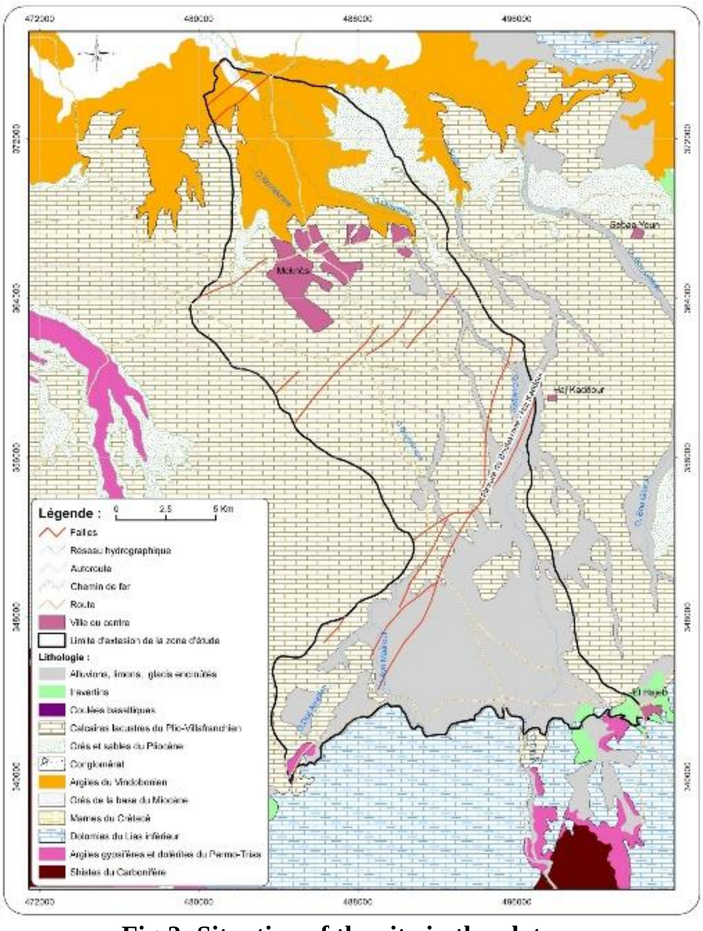

Fig-2: Situation of the city in the plateau

Geomorphological and geological framework

From a geomorphological and geological point of view, the city of Meknes belongs to Western Sais, said Plateau Meknes occupying a good part of Karst perched. To the south and south-east, its limits follow at the footmont of the Middle Atlas, that is to say the limits of the old Pliocene, by cons, against a good part of limestone frame especially at the level of R'dom from Meknes to the north and west has been eroded.

According to EL IDRISSI RAGHNI, 1992[2] the plateau of Meknes represents about 2/3 of Sais. Its limits are fairly closely associated with the extension of lacustrine limestones that outcrop. It is delimited:

- To the North by the hills and wrinkles pre-Rifaines argilo-marginal;
- In the South, by the calcaro-dolomitic atlastic mean causse;
- In the east by the limestone plain of Fez, depressed by about 100 m;
- In the West, by the Kell Wadi and the West Beht Valley, which extend through the central plateau, which is essentially schistose.

Geologically, the bedrock of the basin is formed mainly by the dolomites and limestones of the Lias, and locally by the clays of the Triassic or the shales of the Primary. The stratigraphic series of the basin is as follows [3, 4]:

From a lithological point of view, the city of Meknes is located in a region in a geological context which is composed of a series of stratified layers in ascending chronological order of formation from top to bottom:

- Primary schists;
- Jurassic limestones;
- Gray marl;
- Wild sands;
- Hard lake limestones:
- Quaternary formations (colluvium, alluvium, basalt);

The plateau of Meknes itself is composed of 3 essential levels namely: gray marl Tortonian, tawny sands and limestones lacustrine (dominating the air of Meknes).

Climatological framework

Temperatures

Like any city belonging to the Mediterranean sub-floor, Meknes undergoes continental influences during the winter and summer seasons. But since the region is characterized by geological diversity, it makes each of its natural components of the climate. Henze a semi-arid climate.

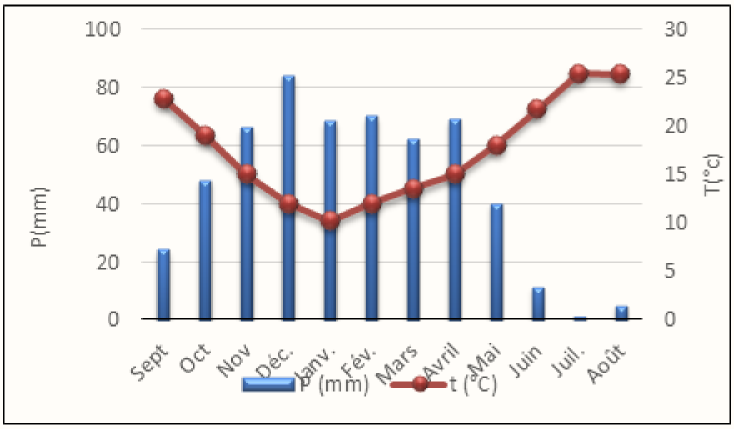

Fig-3: Ombrothermic diagram

The thermal region of Meknes is marked by the remoteness of the coasts, resulting in a large extreme thermal amplitude extinguishing 25.4 °. The temperature of the hottest month varies between 29 ° and 38 °, and that of the coldest month varies between 2 ° and 7 ° [5]. In general, the temperatures vary from one period to another. These temperatures are as follows:

- From January to April: the monthly rise in temperature is gradual and regular. It is of the order of 1 to 2 per month.
- From April to August: a monthly increase is of the order of 3 ° to 5 °: the average monthly peak temperature is reached in August, or 35.6 °.
- From August to December: a decrease of about 2 ° to 4 ° per month.

Precipitation

The most important rain period is from October to May, with 9 to 10 days of rain per month. Supposedly, an average rain that is estimated at 84 days and an average rainfall that reaches 500 mm / year. The distribution of rainfall during the year is characterized by heavy rains in autumn, a slight decrease in winter with a relative maximum in early spring.

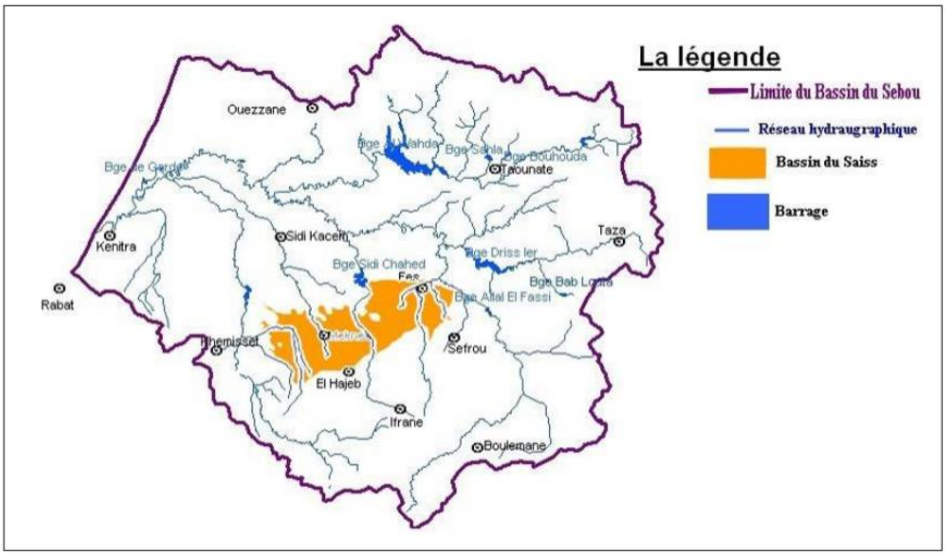

Fig-4: Geographical location of the Sais plain [5]

Climate Framework

The climate of the Sais basin is semi-arid continental, characterized by data from the Fez and Meknes stations to the east and west of the basin. The annual rainfall is quite high compared to other areas of the basin, ranging from 455mm / year at the Fez station and 550mm / year at the Meknes station. The rainfall map of the Sebou basin shows that the average rainfall in the Fes-Meknes basin is about 500mm / year. Rainfall since.

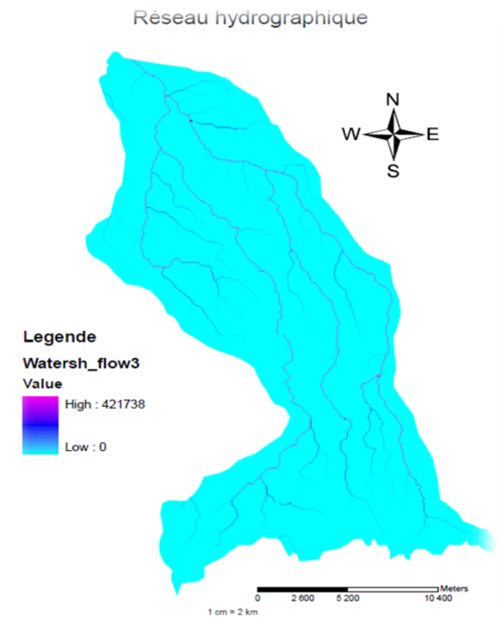

Fig-5: Hydrographic network

Hydrographic network characteristics

As previously demonstrated, the watershed of the Boufekrane wadi valley has an elongated shape. Nevertheless, if we want to study the vulnerability of downstream flood risk zones, especially in the city of Meknes, we can say that this form is not specific for a better analysis of the study area. where it is better. to study the factors favoring these "exogenous" risks and to study mainly the main characteristics of the B.V. Boufekrane river system.

This hydrographic network has been regenerated automatically using the Arc hydro extension whose main steps are:

- Flow direction
- Flow accumulation
- Streams link

We can already consider four salient factors influencing the behavior of this network namely:

- The geology of the basin;
- The climate;
- The pace of the terrain (slope);
- And anthropic action (human presence)

METHODOLOGY AND MATERIAL

The methodology consists firstly of collecting within a GIS the relevant geographical information such as:

* Urban map;
* Topographic map;
* Aerial photography.

Application of HEC-GEORAS

Using this HEC-GEORAS software, it was possible to adopt a hydraulic and modeling approach while exploiting the parameters of the Wadi Boufekrane watershed. This approach allows numerical simulation of hypothetical floods, allowing to characterize the hazard in space - time; as it allows from the reference flows (project Q: 10, 20, 50, 100 years) to simulate: Water depths, flood zone extensions, submersion times, and flow velocities.

This approach has been especially used, first for its effectiveness in simulating floods. On the other hand, the other approaches, historical and hydro geomorphological are difficult to achieve. Returning to archives and historical texts to extract the indices of spatialization of floods or to examine the historical traces of past floods, we have not found all the information necessary to better analyze. It is the same for the hydro geomorphological approach based on field research, hydro geomorphological markers recognized in the Boufekrane valley; it is based on:

- Morphological and altimetry criteria (beds and bed slopes): Minors; average (ordinary); major and exceptional.

- sedimentological criteria (granulometry and geochemistry);
- chronological criteria (dating);

Apart from the minor bed, these beds could not be defined spatially because of anthropogenic actions through embankments and residues of building materials that erased the traceability of the beds of the valley.

Analysis of available studies (Results and Discussion)

An analysis in the form of a critique was made in 2004 by the Sebou Watershed Agency, on existing studies in this direction and which are oriented towards the validity of the methods used for the determination of flood flows and the possible readjustments to be made. to the results obtained. The analysis of flood discharge predetermination methods undertaken by the ABHS is based on empirical methods, the Gradex method, the rational formula and the Francou-Rodier formula. The results obtained are deduced from the specific flows adopted considering an active basin of 30% of the Boufekrane wadi basin without a conclusive physical justification:

Board1: recurrence of floods over time

T (years)	Q10	Q20	Q50	Q100
Qp (m3 / s)	33.79	44.49	56.39	70.79

- Francou Rodier's formula gives only one envelope value of the highest observed floods corresponding to a maximum flow of a frequency of about 1/100 and cannot be claimed to apply it at higher frequencies 1/5; 1/10; 1/20 ...
- The Gradex method is applied from the 1/10 frequency whose reference flow is estimated by the CRUPEDIX method (basins of South East France).

There was confusion between the average flood discharge and the reference peak flow. The author applies the method by taking the value of 67m3 / s obtained by the Caqot and Crupedix formulas as the average decadal flow rate, whereas it is a peak flow [5].

In addition, the Boufekrane wadi basin seems to have a notoriously high saturation threshold, which implies that, the 1/10 frequency reference flow rate is insufficient in this case, the other remarks deduced are:

- The empirical formulas, Fuller, Malet Gautier and Mac Math, lead to too high data rates due to the lack of knowledge of the parameters with acceptable accuracy.
- The available specific flows are deducted for catchment areas that are too small compared to the Boufekrane basin.

Resuming the calculations from the study of the Adarouch dam on the upper Beht (630 Km²) (Tigrigra), we obtain the following values: Q10 = 68 m3 / s; Q50 = 114 m3 / s and Q100 = 152 m3 / s. The hydraulic modeling of the wadi Boufekrane at its crossing of Meknes is based on maximum flood flows provided by the ABHS without specifying the origin. The quantiles (Q10, Q20, Q50, Q100 and Q1000) retained are respectively 10, 20, 90, 120 and 236m3 / s. The first two values Q10 and Q20 are considered abnormally weak. The coefficient of frequency Q100 / Q10 is too strong in this sense and would lead to implausible statistical distributions.

The hydraulic simulations carried out for this study for streets 1/10, 1/20, 1/50, 1/100 and 1/1000 made it possible to establish the areas flooded for different sections of the valley of the wadi. Boufekrane in the city of Meknes.

It has been highlighted that the sections of the crossing structures of Ain Maaza, Bab Bouameir and Dardoura (Portuguese bridge) cause high water levels rise upstream from the flood of frequency 1 / 20.

ANZAR Approach Advice: SCS Method (Soil Conservation Service)

This method is widely used in hydrology that allows directly involving in addition to rainfall, the state of moisture, nature and landing use. It consists in making the following hypothesis: at a given instant t, the ratio between the cumulative infiltration up to the instant t and the potential infiltration at the beginning of the episode is equal to the ratio between the cumulative runoff and the rain cumulative that is:

$$P(t) - R(t)) / J = R(t) / P(t)$$

P (t) height of rain fallen between 0 and t
R (t) net blade elapsed between 0 and t
J maximum infiltration capacity

P (t) - R (t) cumulative infiltration between 0 and t

However, when the rain begins to fall, there is no immediate runoff, part of the precipitation is held on the surface by vegetation and depressions. Studies have shown that this initial retention can be estimated at 0.20 to 0.25 * J. By replacing P (t) with P (t) - 0.20J. So we have: R (t) = (P (t) -0.20 J) 2 / (P (t) + 0.8J): function called production
With J = 25.4 (1000 / CN - 10)

CN (Curve Number) is a "runoff coefficient" which is taken here equal to 60 to 70. This coefficient depends on the nature of the soil and the rainfall history. For the watershed of Boufekrane wadi, the initial retention threshold varies for these two values of CN between 22 and 34 mm, which reduces the average production function to the following expression:

R (t) = (P (tc) -27) 2 / (P (t) +109)

The time of concentration estimated by different formulas (Kirpich, Giandotti, Spanish, SCS, Brandy Williams ...) shows significant differences.

A flood survey was undertaken to better assess the maximum flow rate of extreme events and the base time of the Boufekrane hydrograph at the entrance to Meknes. According to the residents surveyed, the total duration of the highest flood observed extends between 1-2 hours in the morning and around 16 hours the next day. That is, a run-off time of some 14 hours[5].

Mallet Gautier's formula

$$Q_T = 2 \times k \times \log_{10}(1 + aH) \times \frac{A}{\sqrt{L}} \times \sqrt{1 + 4 \times \log_{10} T - \log_{10} A}$$

With
Q: Maximum flow rate in m3 / s for a return period T
K: Coefficient ranging from 0.5 to 6 (we take k = 1.5)
H: Average annual rainfall in the vicinity of the study area. In the city of Meknès it is: 573 mm
A: Watershed area in Km2
a: Coefficient ranging from 20 to 30 (in Morocco, we take a = 20)
L: Length of the main drain in Km
T: Return period in years
We have thus represented the watersheds of the rivers of the city of Meknes as well as the various rainfall stations located in the study area.
The study of these rivers will be based on empirical methods and the Gradex method.
Thus, for the realization of the study of the floods, the IC proposes to follow the
Hazan and Lazarevic's formula

$$Q1000 = a\, S^b \cdot \frac{1 + \log T}{1 + \log 1000}$$

With:
S: Area in km2.
A and b parameters equal to 13.51 and 0.613 respectively for the region
T: return period in years

According to M. OURAHHOU, [6]. The time of concentration of water on a BV is defined as the time taken by a drop of water that has fallen on the furthest point (hydrologically) of the outlet to reach it. This value is influenced by various morphological characteristics mentioned above, which are:

The size (the surface);
The shape (surface and length);
And the relief of the basin (length and slope)

To these factors are added the soil type, the vegetation cover and the hydrological characteristics of the hydrographic network. This time is estimated in different ways, starting from:

Minimum time between the ends of the homogeneous rain on the basin of the end of flow (Tc); The time between the center of gravity (or peak) of the corresponding histogram (the response time);

Rise time of simple floods.

To do this we adopted some empirical formulas, namely:
Calculation of the centennial flow using the rational method to an area of means and big basins:

$$\mathbf{Q = C_r \times I_{TC} \times {}^{S}/_{3.6}}$$

I_{TC}: average intensity of rain (in mm / h) during the concentration time Tc.
S: area in Km2
Cr: runoff coefficient (clay = 0.60)

MONTANA FORMULA
I (t, T) = a (T) /t b (T)
With **a** and **b** are coefficients depending on the frequency of the rain,
T: return period,
t: rain duration in mm.

According to the table relating to the hydrological calculation of DPE / DRE AZILAL:
For the case of Meknes when the period varies:

We have: For 0 <T <90 → {a = 6.24 and b = - 0.55}
For 90 <T <1440 → {a = 11.25 and b = - 0.69}
Also, for Tc> 90: a = 2.47 and b = - 0.49
For 20 <Tc <90 → a = 3.26 and b = - 0.55
For Tc <20 → a = 3.26 and b = - 0.55
Otherwise,

If we take the concentration time calculated by the method of Kirpich = 90.18mn
I (t, T) = a (T) /t b (T)
Intensité I (t, T) = a (T) /t b (T)
I (24h, 100) = 11.25 × 53.1-0.69
= 0.73mm / h

Applying the formula of the rational method, we obtain:
Q 100 = 0.6 × 0.73 × 383.94 /3.6
= 46.71 m3 / s

In order to determine the flow rates relative to the different return frequencies of the BV, we have based essentially on an empirical formulas approach which allows calculating the concentration time. The latter is retained from the mean of the concentration times calculated by the formulas of Ventura, Turraza and Passini which give comparable and similar values. The Kirpich formula gives a shorter concentration time and that of Giondoti gives an overestimated concentration time for small watersheds [5], quite weak for the Boufekrane wadi and very far from the values calculated by the other formulas.

Moreover, the article published in the Moroccan Journal of Civil Engineering No. 62 of March 1996 confirms that Giondoti's method on widely estimates the concentration times and that the Kirpich formula is more appropriate for mountain basins and therefore gives a short time of concentration. An average of the sum of the concentrations calculated in the table above is equal to 71.98, for that we retain the concentration time calculated using Kirpich's formula which is in the order of 90.18 since it is, he which is close to the average.

Analysis of the urban spatial evolution of Meknes with G.I.S and HEC-RAS

Through the digital processing of satellite maps, we have been able to establish the evolution of the city of Meknes over time from the year 1974 to the year 2006. The contribution of remote sensing made it possible to understand and to analyze the urban dynamics with respect to natural risks, particularly the risk of flooding, especially in the sites along the valleys. After these images, one can deduce that urban growth is very rapid in the agglomeration of Meknes. The main objective is to appreciate globally this dynamic during this period. In addition, remote sensing has a large capacity that can detect changes in land use and allows for a better understanding. spatial mutations occurring in the Meknes territory while assessing the extent of the changes, with the aim of understanding the process of urbanization in its space-temporal dimension. Therefore, multi-date satellite images are a better source of information.

After the creation of our project and after having created its main parameters, we defined the geometric characteristics of the modeled system while limiting ourselves to a TIN (or Triangulated Irregular Network) covering only the city of Meknes and its immediate neighborhood, also at a urban plan and a Land Use which is in the form of a geographical layer comprising urban areas and their Nvalues which fix the coefficient of each zone.

And it is the module HEC-Geo RAS which is automatically responsible for creating the layers that are needed by using RAS Geometry. From then on, we move on to the digitization of the different layers: the central flow, River banks, flaw paths and cross sections. To obtain in the end this diagram which constitutes the base of all the rest of work of hydraulic modeling.

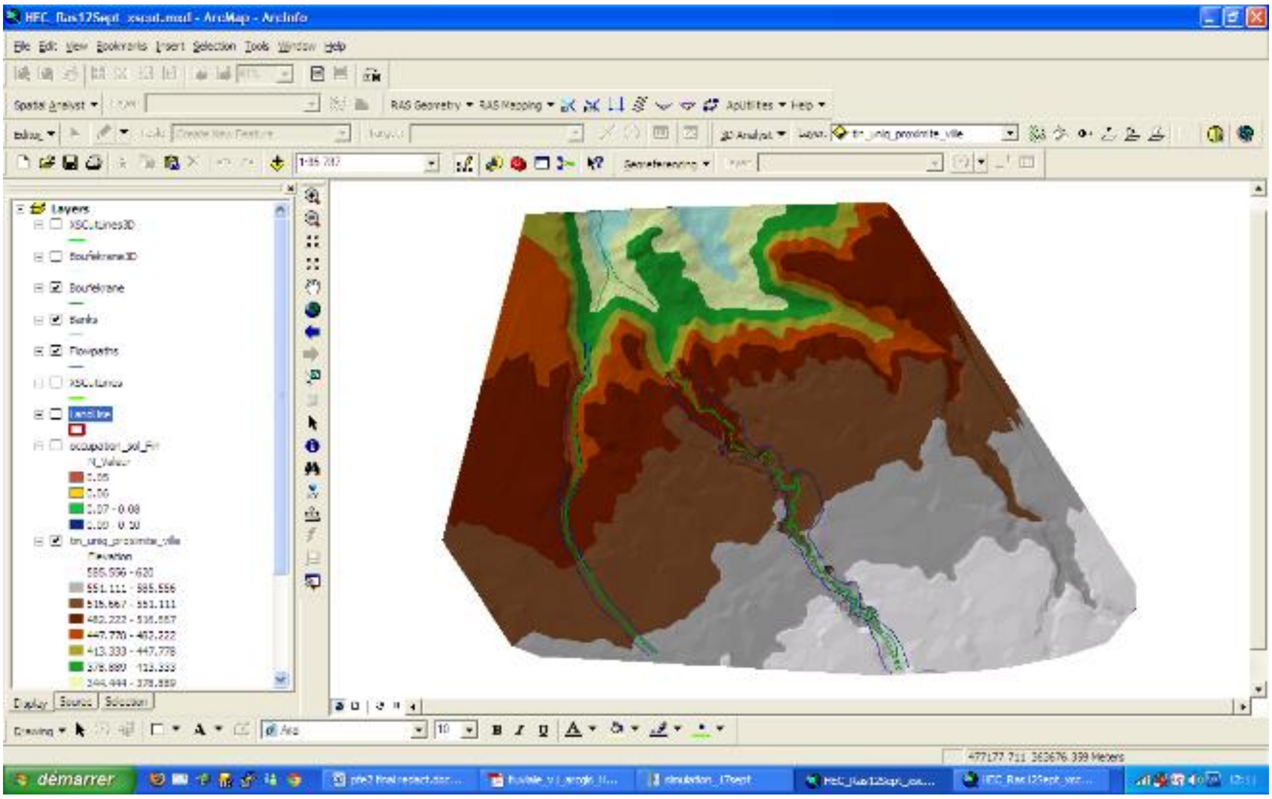

Fig-6: T.I.N

As soon as we finish with the creation of these layers in ArcGIS, we will export them to HEC_RAS. But before this, it is necessary to complete the last task of bringing the values of Manning to each cross section. For this it is necessary to use the geographic layer of land use that was previously reported, and which is none other than the layer Land Use.

Board-2: Attributes of LandeUse

Attributes of LandUse

Shape *	OBJECTID *	Shape_Length	Shape_Area	LUCode	N_Value
Polygon	1	8506.198947	3828098.884111	Industrielle	0.1
Polygon	2	7871.212206	1842178.089226	Habitat	0.05
Polygon	3	6412.895355	1604491.709326	agricole	0.06
Polygon	4	3511.639789	727463.941566	Industrielle	0.1
Polygon	5	6511.971521	1333907.792183	HabitatDense	0.08
Polygon	6	12868.423259	3525089.897441	Habitat	0.05
Polygon	7	8242.014378	4577946.915145	industCaserne	0.1
Polygon	8	16868.383871	10928188.099419	Habitatdense	0.08
Polygon	9	3748.246924	642533.278359	Habitat	0.05
Polygon	10	21146.750773	10216766.528989	HabitatDense	0.08
Polygon	11	26714.374157	13939760.691091	Habitat	0.05
Polygon	12	24589.600108	21936871.677244	Agriculture	0.06
Polygon	13	12768.030824	5878375.707804	agricultuer	0.06
Polygon	14	10805.198518	5480910.419429	agriculture	0.06
Polygon	15	3239.264038	593735.952836	Habitatdense	0.08

Simulation under HEC_RAS

In this phase the GIS data were imported and transformed into HEC_RAS geometric data

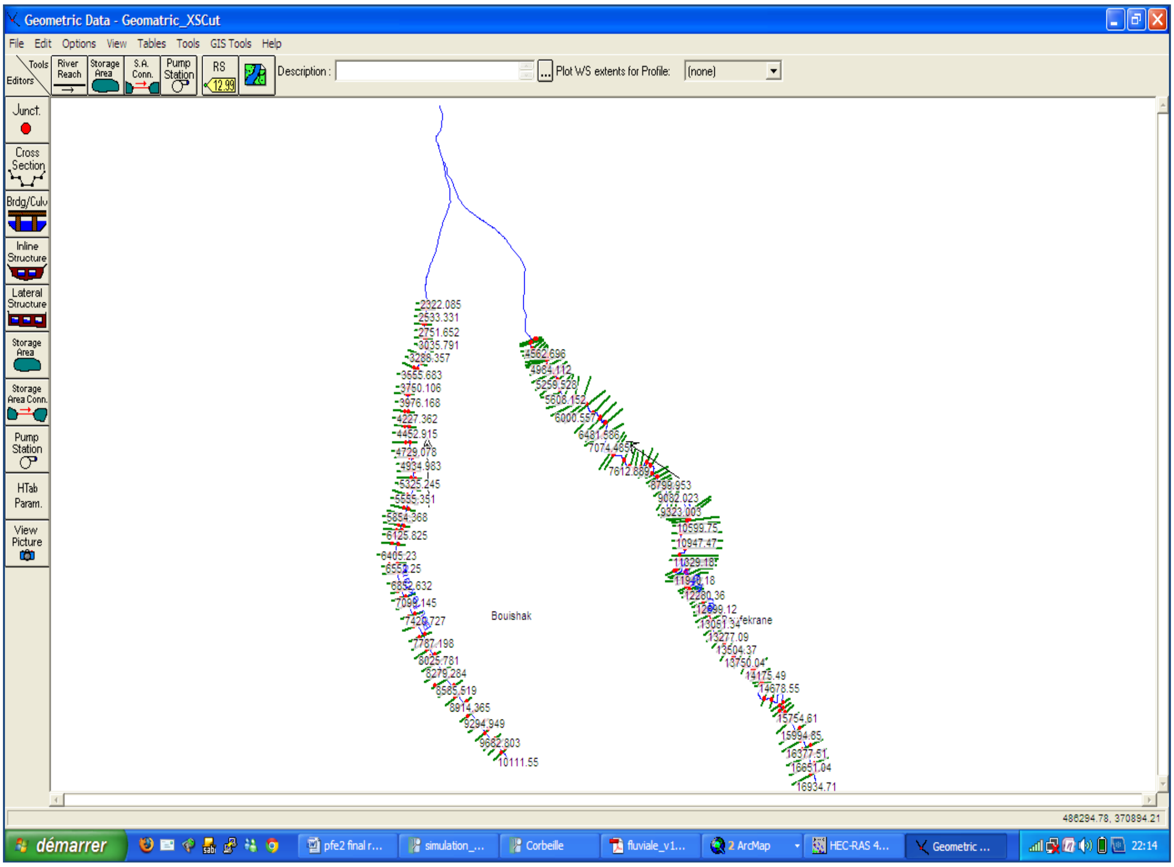

Fig-7: différents sections cross

The advantage of these geometric data is that they can be used without necessarily having to use the steps of importing the GIS data.

Creating flow data with boundary conditions: In this phase one introduced in HEC_RAS the hypothetical conditions in the profile.

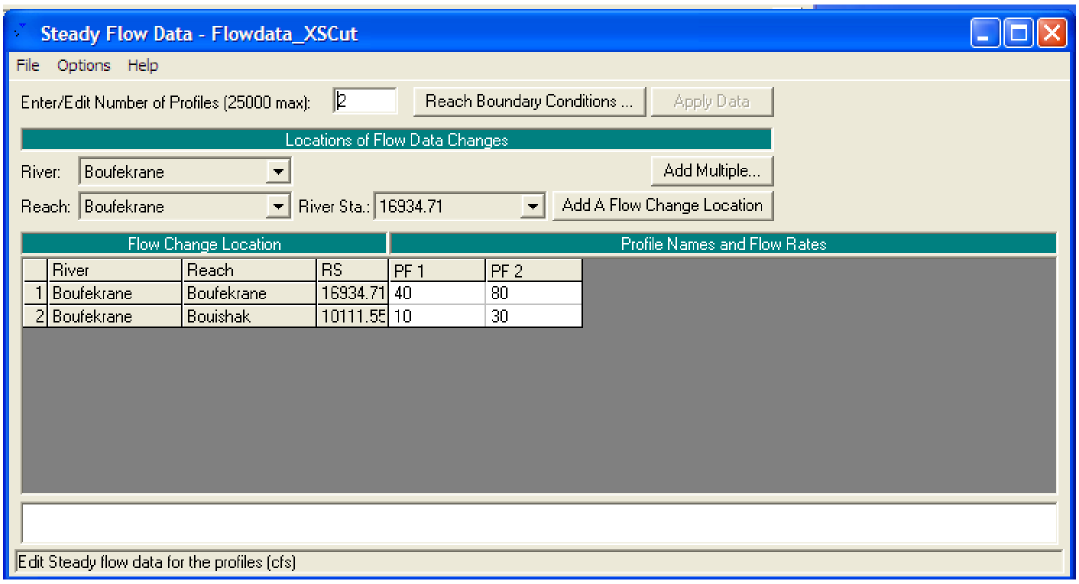

Fig-8: Flow data

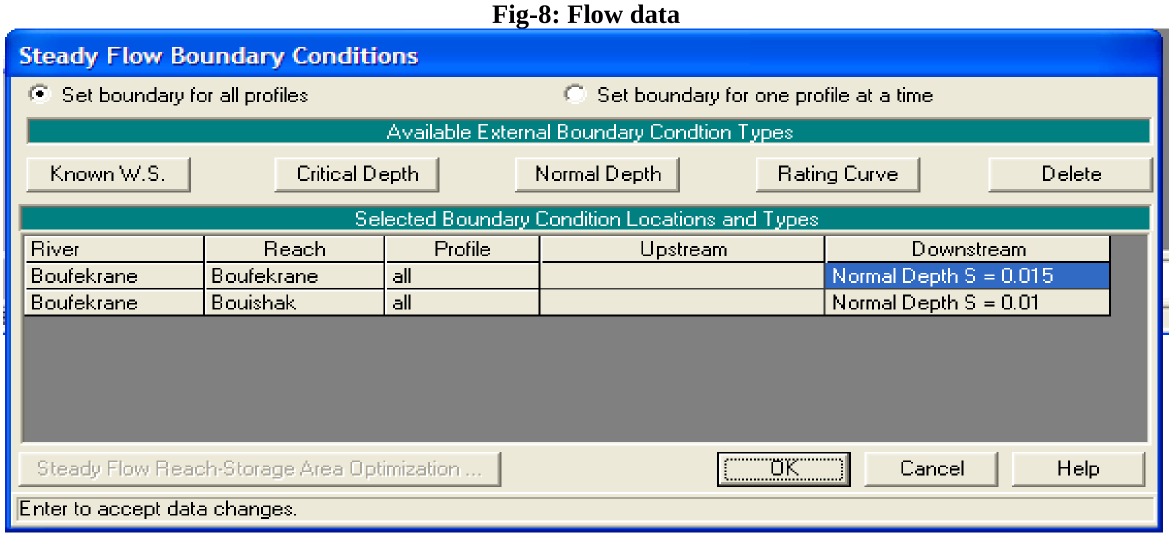

Fig-9: Boundary conditions

Then, by Reach boundary conditions the necessary data was introduced in the downstream column and in Normal Depth.

Flood simulation and visualization of simulation results in ArcGIS

We did the simulation using HEC_RAS while clicking on Run, Steady flow analysis then giving an identifier to our analysis, then Subcritical flow regime, finally on Compute.

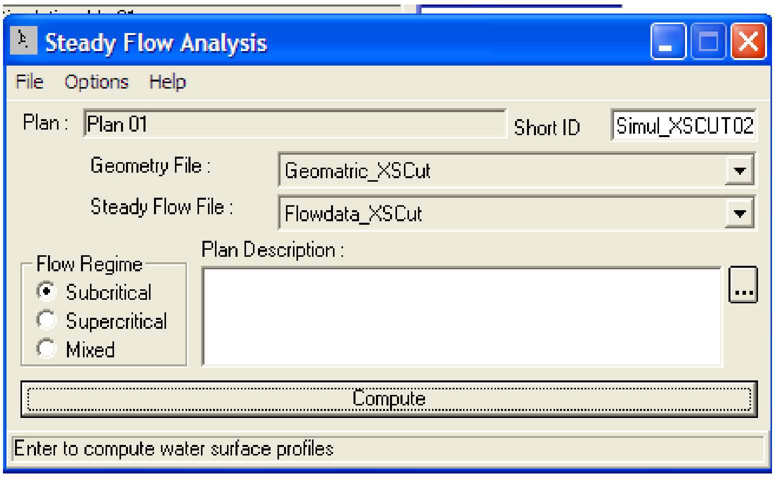

Fig-10: Steady Flow analysis

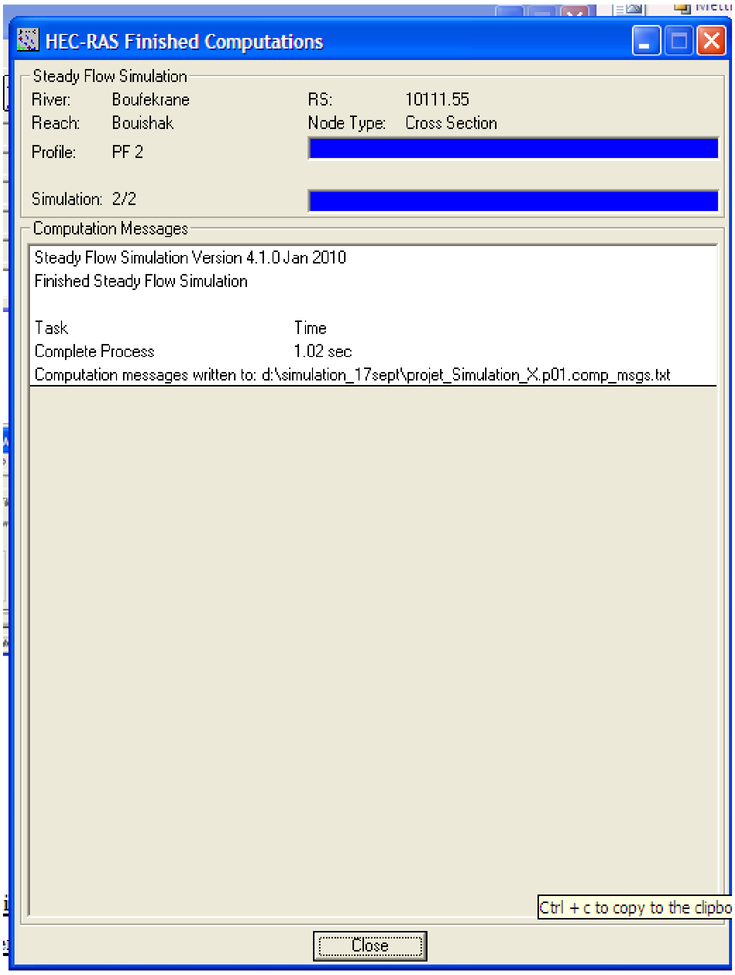

Fig-11: HEC-RAS finished compilations

To view the results in ArcGIS, you must first retransform the HEC_RAS data into an ArcGIS-readable format. To do this, you need to convert the sdf file to an xml file by using Import RAS sdf from HEC_GeoRAS.

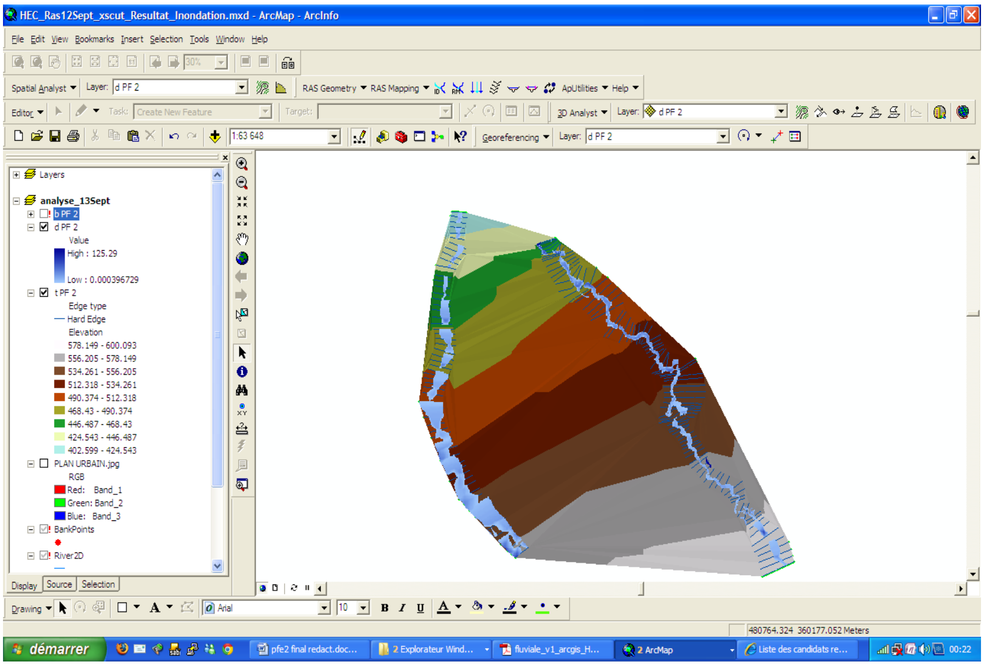

Fig-12: Flooded areas on T.I.N

Finally, we created the flood zone while clicking on Ras Mapping, Inundation Mapping, Water surface generation, then we validated our profile. Then we converted the TIN which represents the water into a Raster file. So, the shape file represents the flooded area and the raster the water height. The figures, maps and profiles below illustrate these results.

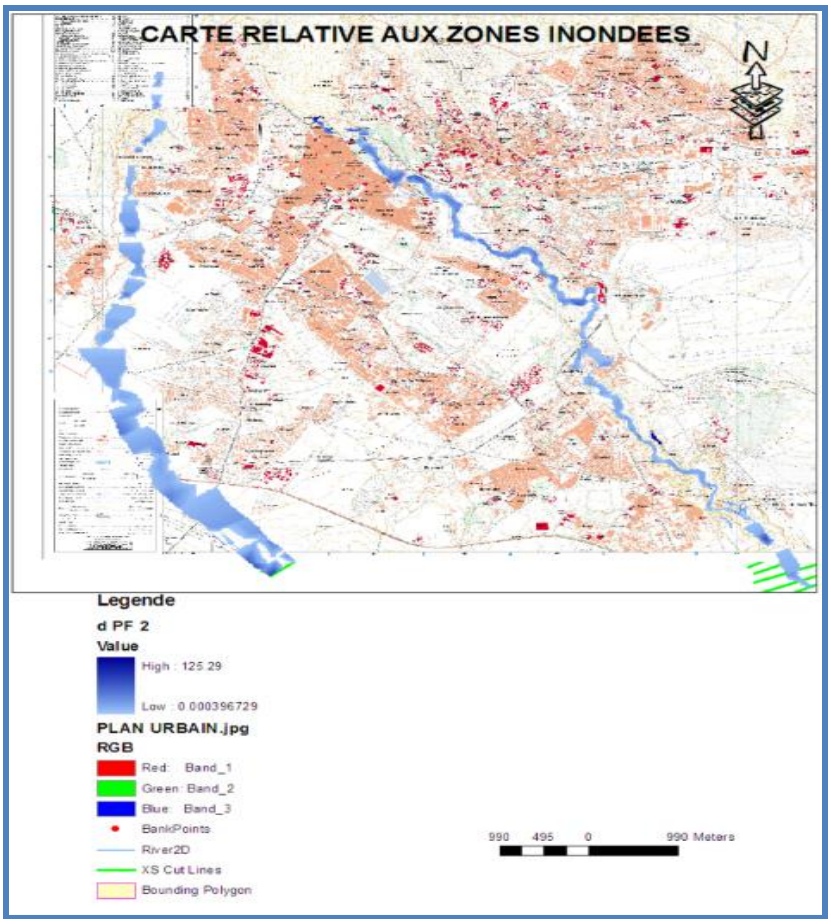

Fig-13: Flood zones on the urban map of Meknes

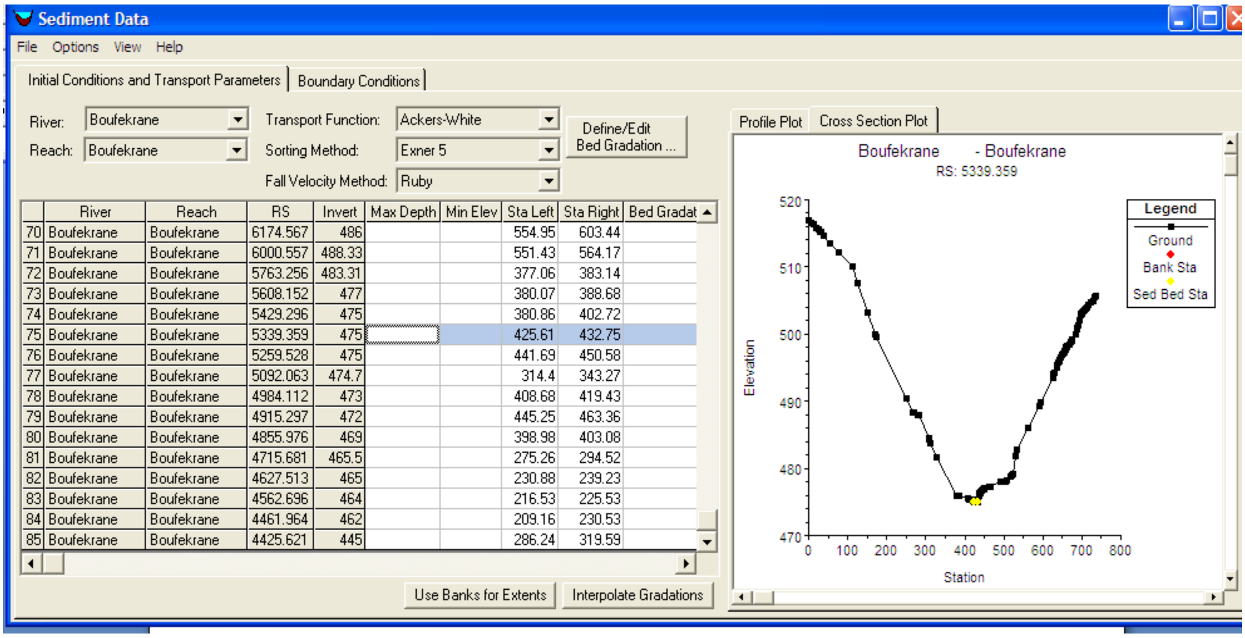

Fig-14

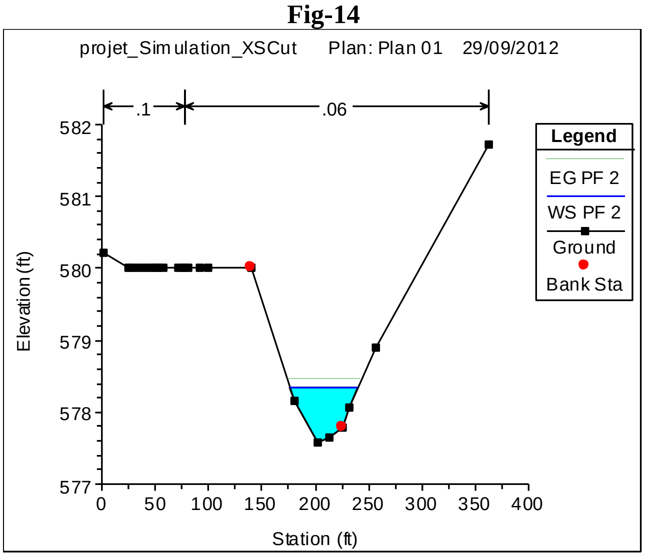

Fig-15: Cross-section valley Oued Boufekrane - cross section


Picture 1


Picture 2


Picture 3



Picture 4 **Picture 5** **Picture 6**

Some photos illustrating the floods in areas open to urbanization. They are taken at the end of October 2018 in the city of Meknes

CONCLUSION

The urban growth processes described as non-regulatory, on both sides of the Boufekrane valley and in most of the peripheral sectors of the Meknes agglomeration; make these areas suitable for a whole range of natural hazards. Such as floods and landslides. Indeed, these forms of precarious housing develop in risk areas; in old quarries, near wadi beds, or on steep slopes. They spread on land of low land value or on land with a confused legal status. The steep slopes, the geotechnical nature of the formations and the geomorphological evolution of the Boufekrane valley and adjacent land are all factors that can exclude these areas from any form of urbanization. the process of clandestine urbanization has been accelerated during the last decades and blatantly on lands generally not urbanized and which are struck by easements not prohibited area for construction according to the regulatory provisions of urban planning documents, and this by the fact that they are unfit for urbanization for geotechnical, hydrological, geological or topographical considerations. These urban occupations described as anarchic and unregulated in risk areas call into question the responsibility of man and the socio-anthropic dimensions of the phenomenon.

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