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The Technological Evolution in Flood Risk Estimation

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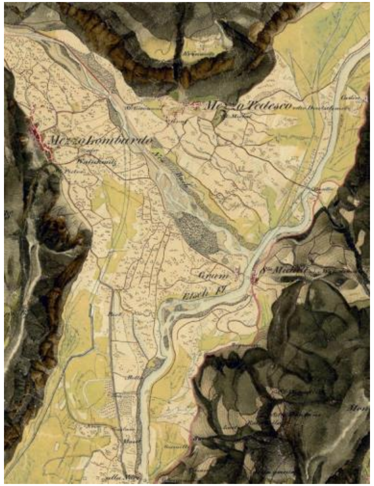
Contents

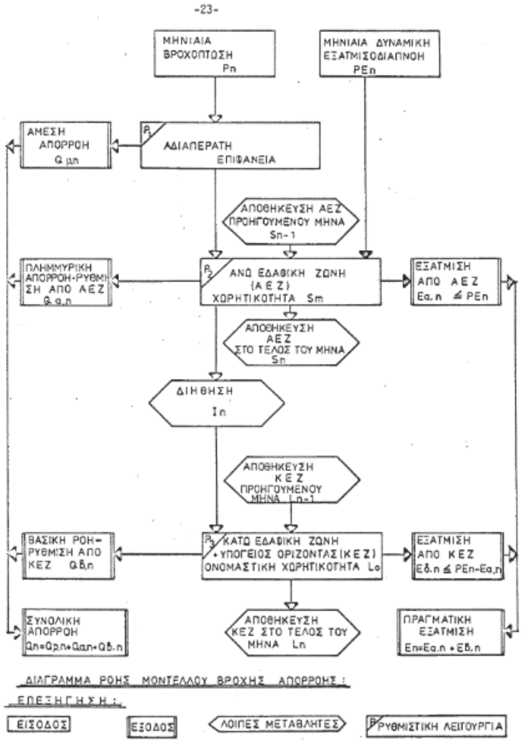
Introduction

- The advancement of technology has transformed flood risk estimation from rudimentary manual calculations to sophisticated computer-based models.
- This research traces the evolution of flood risk assessment methods, comparing the analog approaches of the 1970s with modern digital tools.
- In the past, engineers relied on basic hydrological formulas, manual data collection, and physical models to estimate flood risks, often resulting in limited accuracy.
- Today, modern software like HEC-RAS, digital elevation models, and satellite imagery have revolutionized this field, providing highly detailed and precise flood hazard maps.
- In this research, we applied the above tools to the Pikrodafni river in the Attica region as a case study to showcase the impact of technological advancements on flood risk management, emphasizing on how digital tools enable better mitigation strategies and contribute to urban resilience against flood hazards.

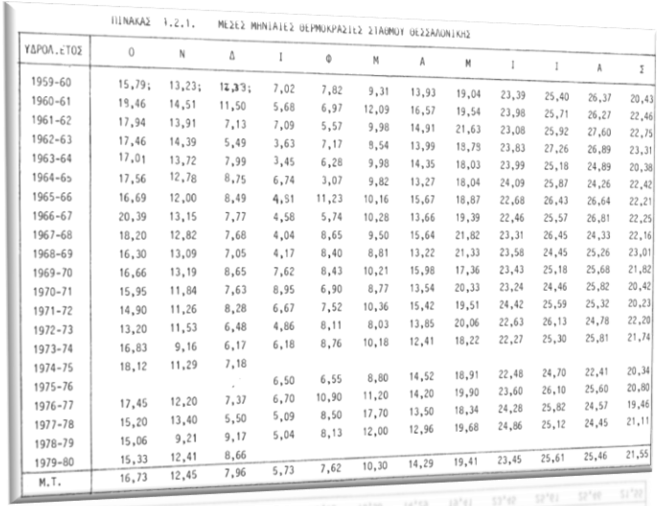
Historical approaches of flood risk studies



A detail, close to the Noce-Adige rivers junction, north to Trento, of the map of the “Second Military Survey”, alsonamed Franziszeische Landesaufnahme, sketched between 1816 and 1823 for the Adige river area in 1:28.800 scale.[1]



Flow chart of the rainfall-runoff model [2]



ΠΙΝΑΚΑΣ 1.2.1. ΜΕΣΕΣ ΜΗΝΙΑΙΕΣ ΘΕΡΜΟΚΡΑΣΙΕΣ ΣΤΑΘΜΟΥ ΘΕΣΣΑΛΟΝΙΚΗΣ

ΥΔΡΟΛ.ΕΤΟΣ	Ο	Ν	Δ	Ι	Φ	Μ	Α	Μ	Ι	Ι	Α	Σ
1959-60	15,79;	13,23;	12,33;	7,02	7,82	9,31	13,93	19,04	23,39	25,40	26,37	20,43
1960-61	19,46	14,51	11,50	5,68	6,97	12,09	16,57	19,54	23,98	25,71	26,27	22,46
1961-62	17,94	13,91	7,13	7,09	5,57	9,98	14,91	21,63	23,08	25,92	27,60	22,75
1962-63	17,46	14,39	5,49	3,63	7,17	8,54	13,99	18,79	23,83	27,26	26,89	23,31
1963-64	17,01	13,72	7,99	3,45	6,28	9,98	14,35	18,03	23,99	25,18	24,89	20,38
1964-65	17,56	12,78	8,75	6,74	3,07	9,82	13,27	18,04	24,09	25,87	24,26	22,42
1965-66	16,69	12,00	8,49	4,51	11,23	10,16	15,67	18,87	22,68	26,43	26,64	22,21
1966-67	20,39	13,15	7,77	4,58	5,74	10,28	13,66	19,39	22,46	25,57	26,81	22,25
1967-68	18,20	12,82	7,68	4,04	8,65	9,50	15,64	21,82	23,31	26,45	24,33	22,16
1968-69	16,30	13,09	7,05	4,17	8,40	8,81	13,22	21,33	23,58	24,45	25,26	23,01
1969-70	16,66	13,19	8,65	7,62	8,43	10,21	15,98	17,36	23,43	25,18	25,68	21,82
1970-71	15,95	11,84	7,63	8,95	6,90	8,77	13,54	20,33	23,24	24,46	25,82	20,42
1971-72	14,90	11,26	8,28	6,67	7,52	10,36	15,42	19,51	24,42	25,59	25,32	20,23
1972-73	13,20	11,53	6,48	4,86	8,11	8,03	13,85	20,06	22,63	26,13	24,78	22,20
1973-74	16,83	9,16	6,17	6,18	8,76	10,18	12,41	18,22	22,27	25,30	25,81	21,74
1974-75	18,12	11,29	7,18									
1975-76				6,50	6,55	8,80	14,52	18,91	22,48	24,70	22,41	20,34
1976-77	17,45	12,20	7,37	6,70	10,90	11,20	14,20	19,90	23,60	26,10	25,60	20,80
1977-78	15,20	13,40	5,50	5,09	8,50	17,70	13,50	18,34	24,28	25,82	24,57	19,46
1978-79	15,06	9,21	9,17	5,04	8,13	12,00	12,96	19,68	24,86	25,12	24,45	21,11
1979-80	15,33	12,41	8,66									
M.T.	16,73	12,45	7,96	5,73	7,62	10,30	14,29	19,41	23,45	25,61	25,46	21,55

Monthly meteorological data [2]

Hydrological study

Data collection			
Task	Past	Present day	Remaining challenges
Rainfall data acquisition	Engineers collected and digitized data contacting related services	Data are widely available in public databases.	An amount of data is still privately handled and non-digitized.
Land use data acquisition (infiltration)	Engineers performed field investigation or relied on literature estimates.	Public land use databases exist.	Changes in land use may not be well-represented in remote sensing data and field investigation may still be necessary.
Runoff data acquisition	Data not widely available. Sparse data collected and digitised by engineers contacting related services	Some open databases exist. Flood-extent satellite-based estimates are available in some cases. Crowdsourcing data can be used for validation purposes.	Reliable gauge-based runoff data are still sparse and not publicly available.
Locating and registrating of previous storm - flooding events	Engineers attempted loose-format interviews with citizens during field-work.	The communication with the citizens can be achieved through in-line questionnaires, in Municipalities sites, etc, in a more flexible manner.	Information upon previous flooding incidents should be gathered from a certain institution (Municipality, Political Protection, Firefighting).

Methodology			
Task	Past	Present day	Remaining challenges
Design rainfall estimation	Engineers performed simplified probabilistic analyses using data from a few stations.	Design rainfall information is already available at the country-level.	Robust design rainfall estimation is still challenging at the spatial scale.
Hyetograph estimation	Standard design practices applied manually or in a spreadsheet environment.	Standard design practices applied in spreadsheet environments or using software.	
Rainfall-runoff transformation	Related methods had to be studied and applied manually by engineers.	A multitude of rainfall-runoff transformation methods is available in open-source and ready to use hydrologic software.	Selection of the best method is subject to uncertainty due to the lack of rainfall-runoff data for many basins.

Hydraulic study

Task	Past	Present day	Remaining challenges
Data collection			
Survey studies.	Engineers collected and digitized data contacting related services	Data are widely available in public databases, and easier collected.	An amount of data is still privately handled and non-digitized.
Land use data acquisition specialized for Manning's roughness values.	Engineers performed field investigation or relied on literature estimates.	Public land use databases exist.	Changes in land use may not be well-represented in remote sensing data and field investigation may still be necessary.
Sensitivity analyses by generating thousands of scenarios with different parameters' input set.	Non-applicable.	High computational power.	Low even more the computational burden to extend the sensitivity analyses and perform surrogate scenarios.
Flood extent data.	No data.	Satellite images, crowd sourcing data.	Image quality, availability
Methodology			
Flood parameters in 2D (depth, velocity and runoff).	Physical hydraulic models and empirical estimations mainly in 1D.	Hydraulic software.	Increase even more the accuracy of the hydraulic models without further increasing the computational burden.

Modern methodology for the field research

ΠΡΟΓΡΑΜΜΑΤΙΚΗ ΣΥΜΒΑΣΗ ΜΕ ΤΗΝ ΠΕΡΙΦΕΡΕΙΑ ΑΤΤΙΚΗΣ 2021

ΕΚΤΙΜΗΣΗ ΚΙΝΔΥΝΟΥ ΠΛΗΜΜΥΡΑΣ - ΜΕΘΟΔΟΛΟΓΙΑ ΓΙΑ ΤΙΣ ΑΥΤΟΨΙΕΣ

1. ΠΡΟΕΠΕΞΕΡΓΑΣΙΑ ΟΜΑΔΑΣ ΣΥΝΤΟΝΙΣΜΟΥ

Εγκαθιστούμε το Google Earth Pro στον υπολογιστή μας, μελετούμε το υδρογραφικό δίκτυο και τις διαθέσιμες πηγές πληροφοριών (master plan, μελέτες, παρατηρητήριο πλημμυρών, google earth, ΕΛΣΤΑΤ), και τοποθετούμε πινέζες στα κρίσιμα σημεία (από κατάντη προς ανάντη), σύμφωνα με την κωδικοποίηση του Πίνακα 1.

Εξάγουμε ένα kmz, το οποίο το χωρίζουμε για κάθε μία υποομάδα εργασίας ανάλογα με την περιοχή που θα καλύψει, από κατάντη προς ανάντη.

2. ΠΡΟΕΤΟΙΜΑΣΙΑ ΟΜΑΔΑΣ ΑΥΤΟΨΙΩΝ

Εγκαθιστούμε το Google Earth στο κινητό, παίρνουμε τις πινέζες από τον υπολογιστή, και κάνουμε sign in στο Google Photos (κάθε ζευγάρι θα δημιουργήσει ένα κοινόχρηστο φάκελο) όπου δημιουργούμε ένα λεύκωμα για κάθε ημέρα αυτοψίας με κωδικοποιημένη ονομασία ώστε να φαίνεται η ημερομηνία και τα άτομα ως εξής: 2021-03-13-Sigourou+Tsouni.

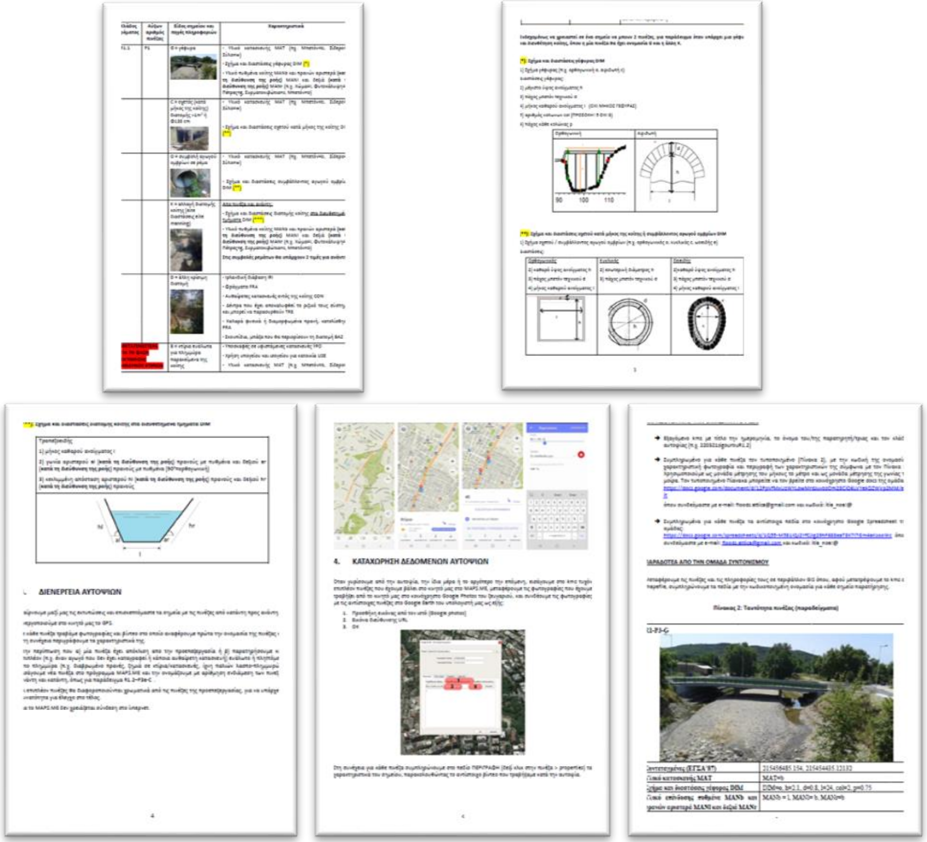
Εγκαθιστούμε το πρόγραμμα MAPS.ME στο κινητό μας τηλέφωνο και κατεβάζουμε τον χάρτη της Αττικής. Μελετούμε και εκτυπώνουμε τις ΟΔΗΓΙΕΣ ΓΙΑ ΤΙΣ ΑΥΤΟΨΙΕΣ και τον ΠΙΝΑΚΑ 1.

ΟΔΗΓΙΕΣ ΓΙΑ ΤΙΣ ΑΥΤΟΨΙΕΣ

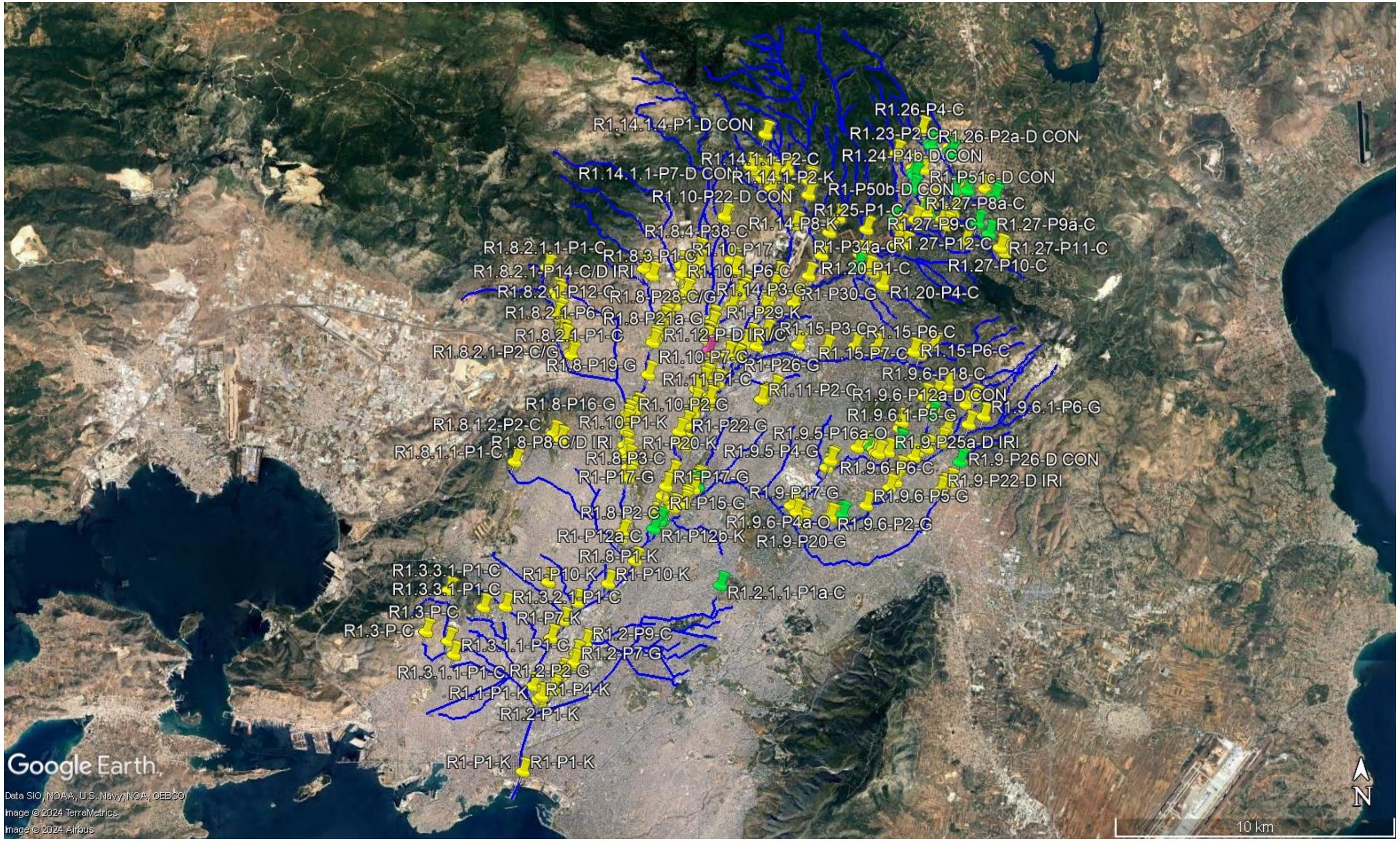
Δεν μπαίνουμε σε ξένες ιδιοκτησίες χωρίς άδεια. Προσέχουμε την ευστάθεια των πρανών όταν πλησιάζουμε στην κοίτη. Δεν διακινδυνεύουμε τη σωματική μας ακεραιότητα σε καμία περίπτωση. Σε περίπτωση που μας πλησιάσει κάποιος/α και μας ρωτήσει σχετικά με το έργο, ενημερώνουμε ευγενικά ότι πρόκειται για νέο έργο της Περιφέρειας Αττικής που αφορά στην αντιπλημμυρική προστασία των Δήμων. Τηλέφωνο ανάγκης: 6974461210, Αλεξία Τσούνη (Εθνικό Αστεροσκοπείο Αθηνών).

Στην περίπτωση που επιθυμούμε να μετακινηθούμε από ένα σημείο σε ένα άλλο και χρειαζόμαστε τοποθεσία στο Google Maps για να χρησιμοποιήσουμε την πλοήγηση, πατάμε παρατεταμένα στο Google Earth πάνω στο σημείο που επιθυμούμε να πάμε (είτε πρόκειται για πινέζα είτε για άλλο σημείο), κι αυτό εμφανίζεται ως «τοποθετημένη πινέζα». Στη συνέχεια αντιγράφουμε τις συντεταγμένες και τις επικολλούμε στο Google Maps, και έτσι είμαστε σε θέση να πλοηγηθούμε στη συγκεκριμένη τοποθεσία.

1



Modern field research

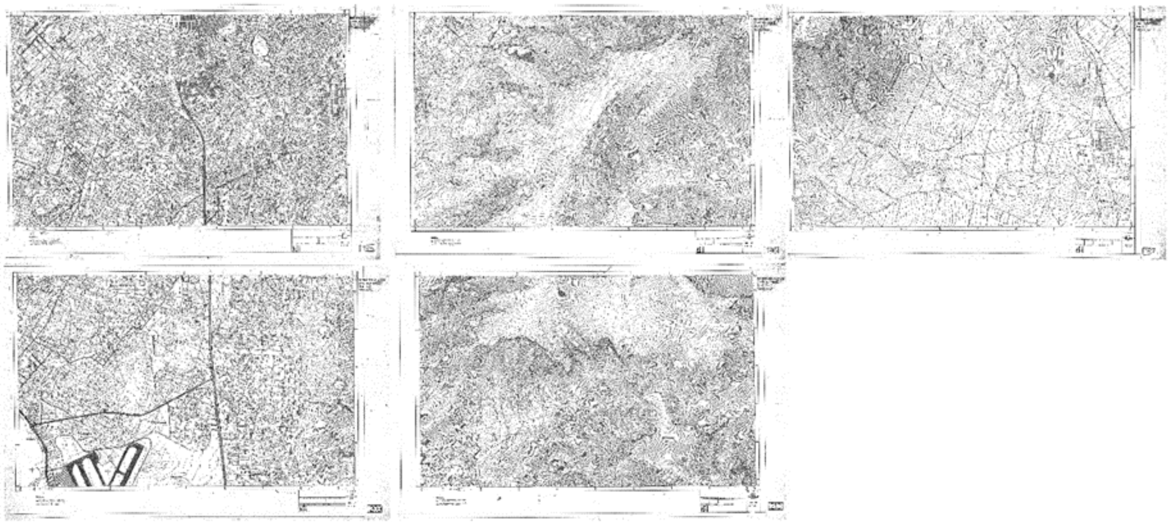


[3, 4, 5]

370 positions

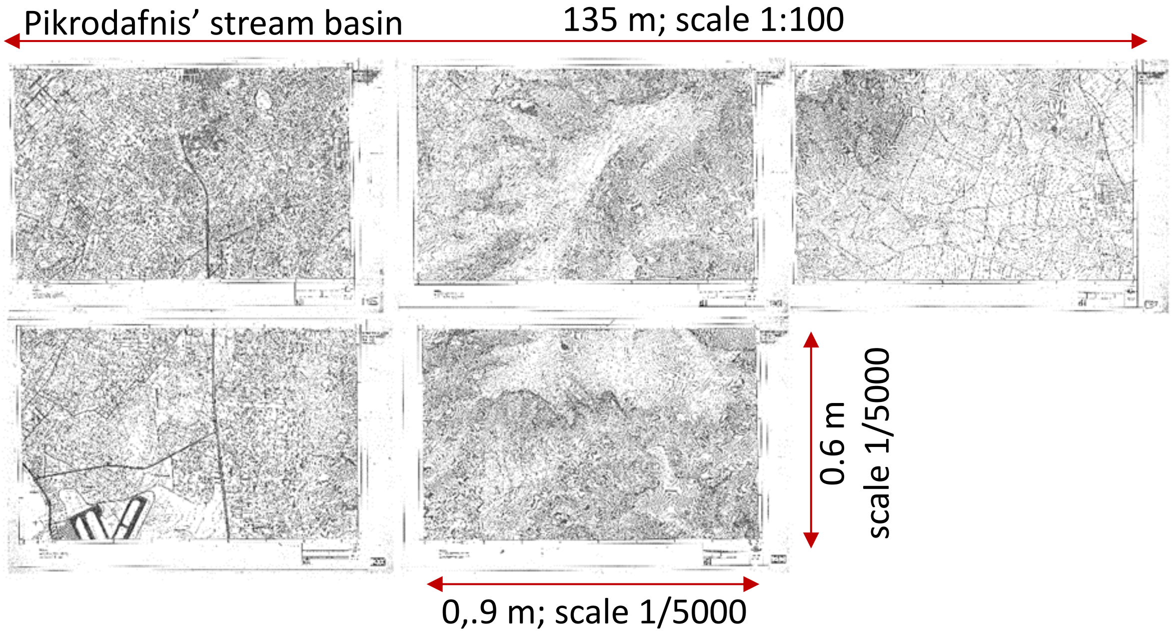
Survey study

Pikrodafnis’ stream basin



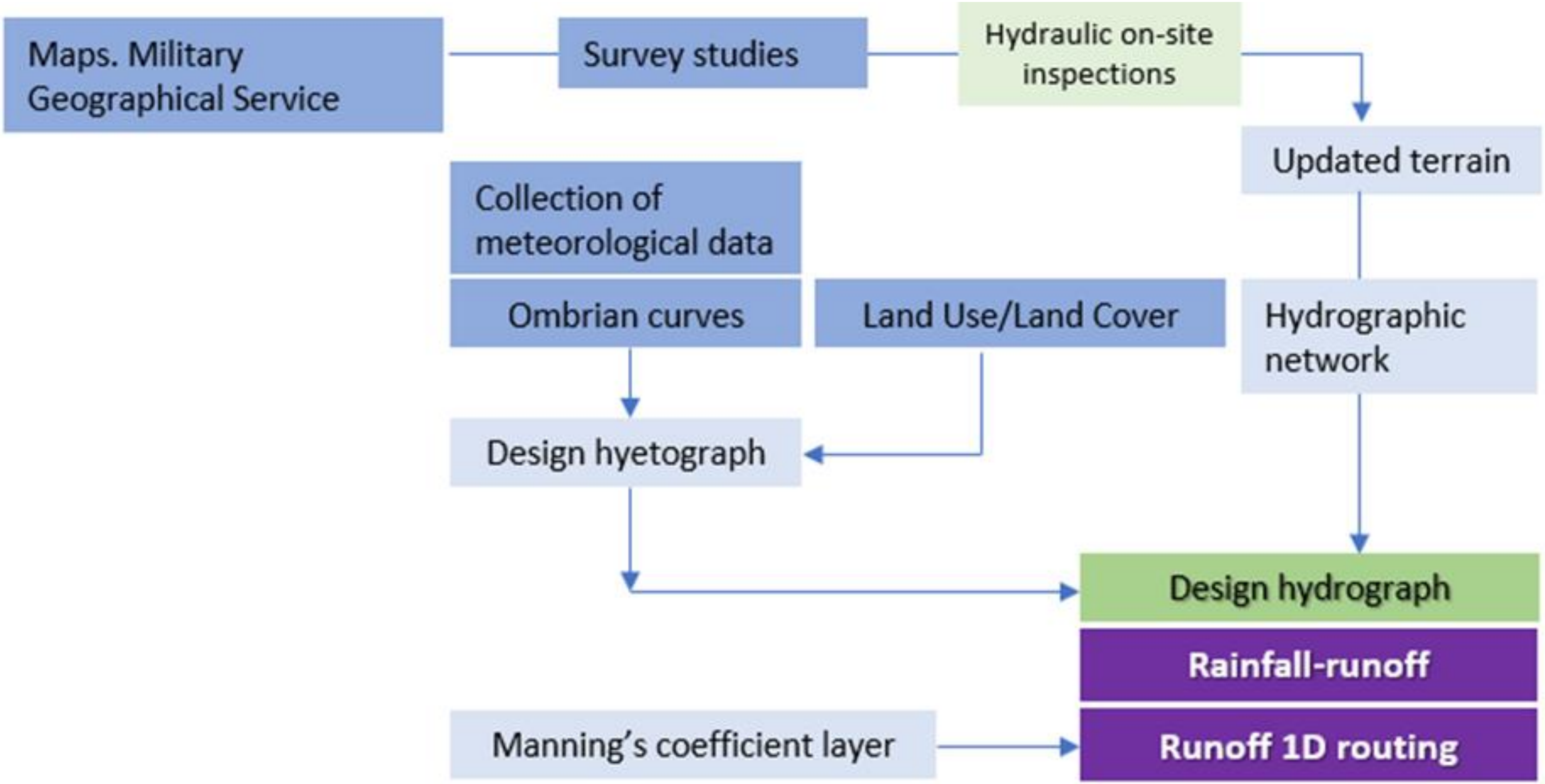
- Each map in scale 1:5000, represents an area about 4.5 km horizontally and 3 km vertically.
- The physical dimension of each map (without borders) is 0.9m×0.6m

Evaluation of historical and modern mapping tools

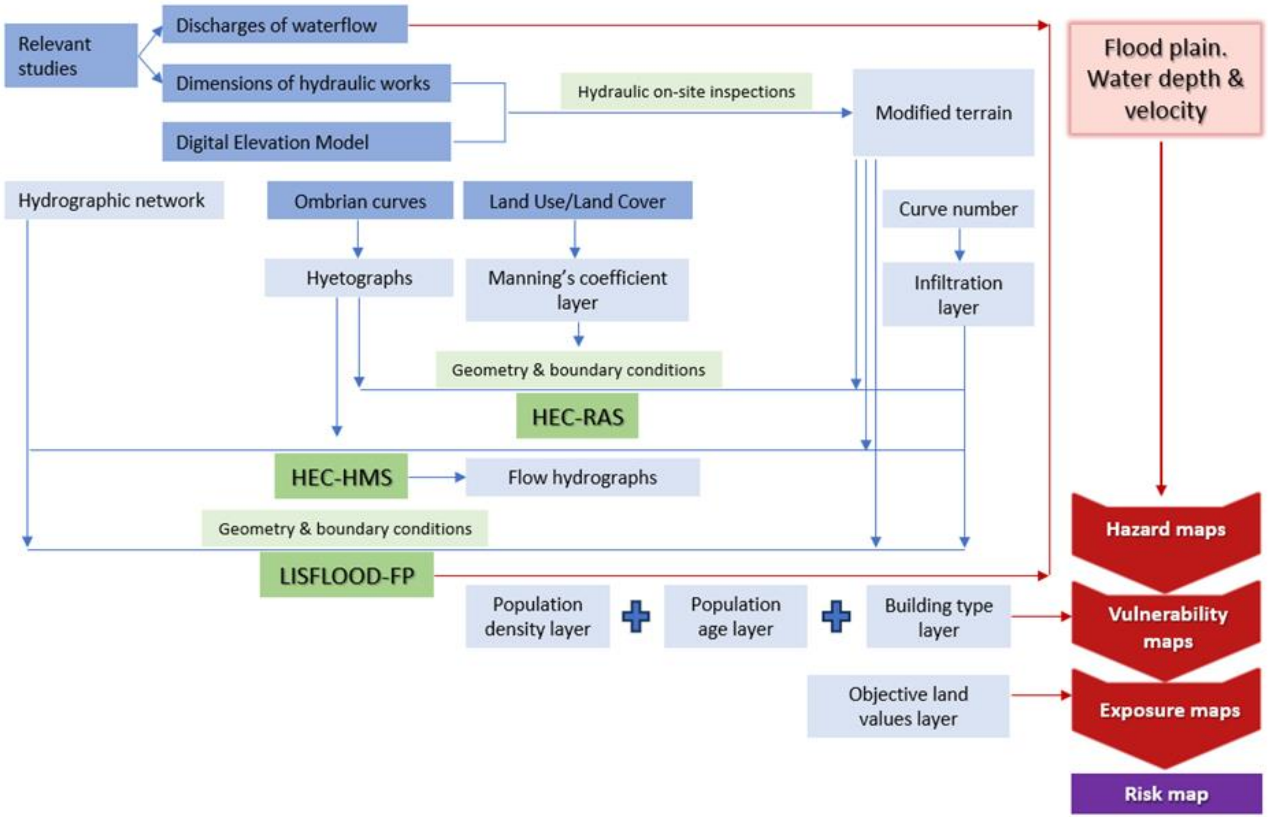


- The information given by Google Earth are corresponding with a map in scale 1:100
- The dimensions of the map of Pikrodafnis' basin in scale 1:100 will be about 135×60 m

Historical approaches of flood risk studies

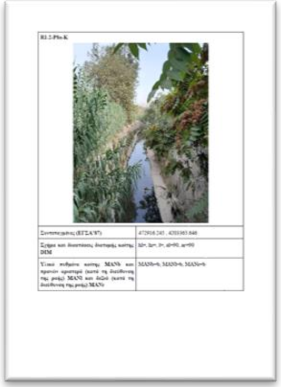


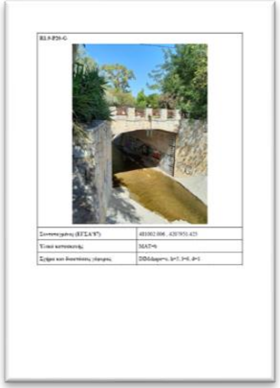
Modern approaches of flood risk studies

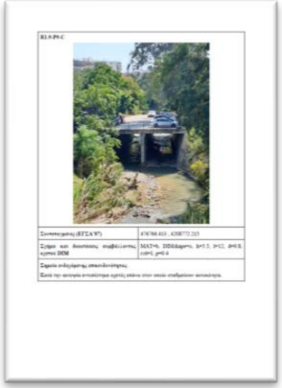


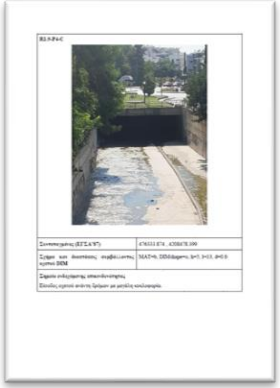
[3, 4, 5]

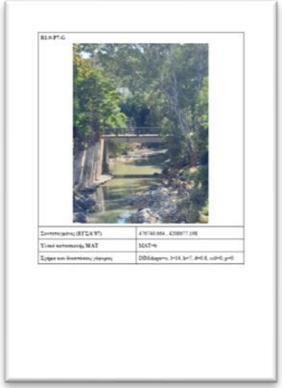
Report of flood risk study and field research (1)

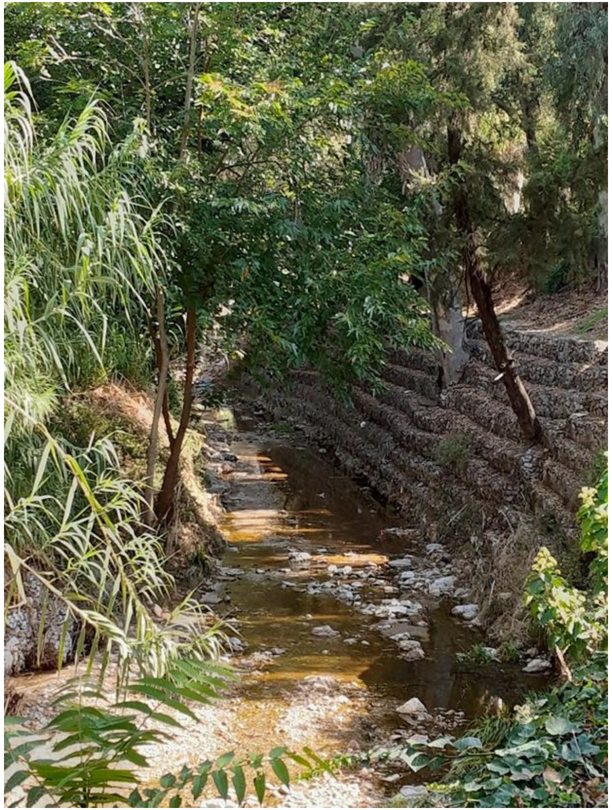




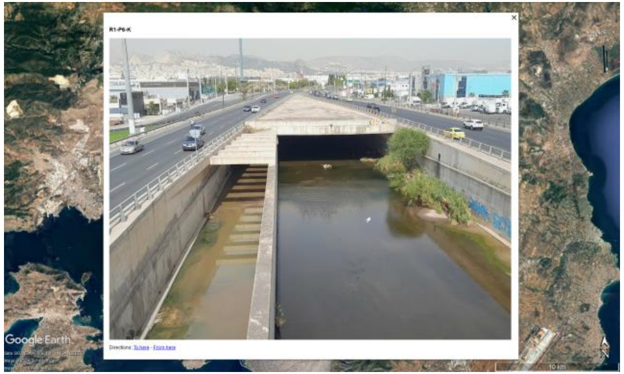


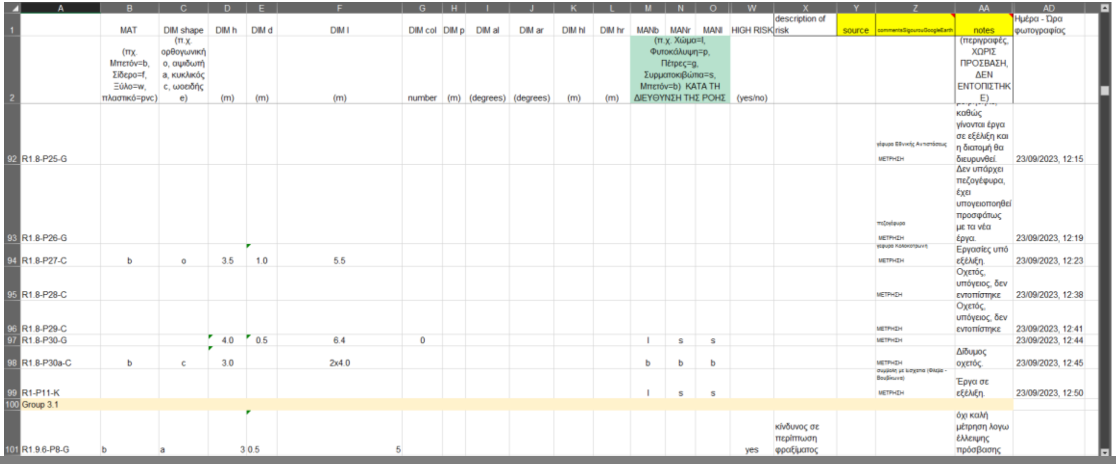






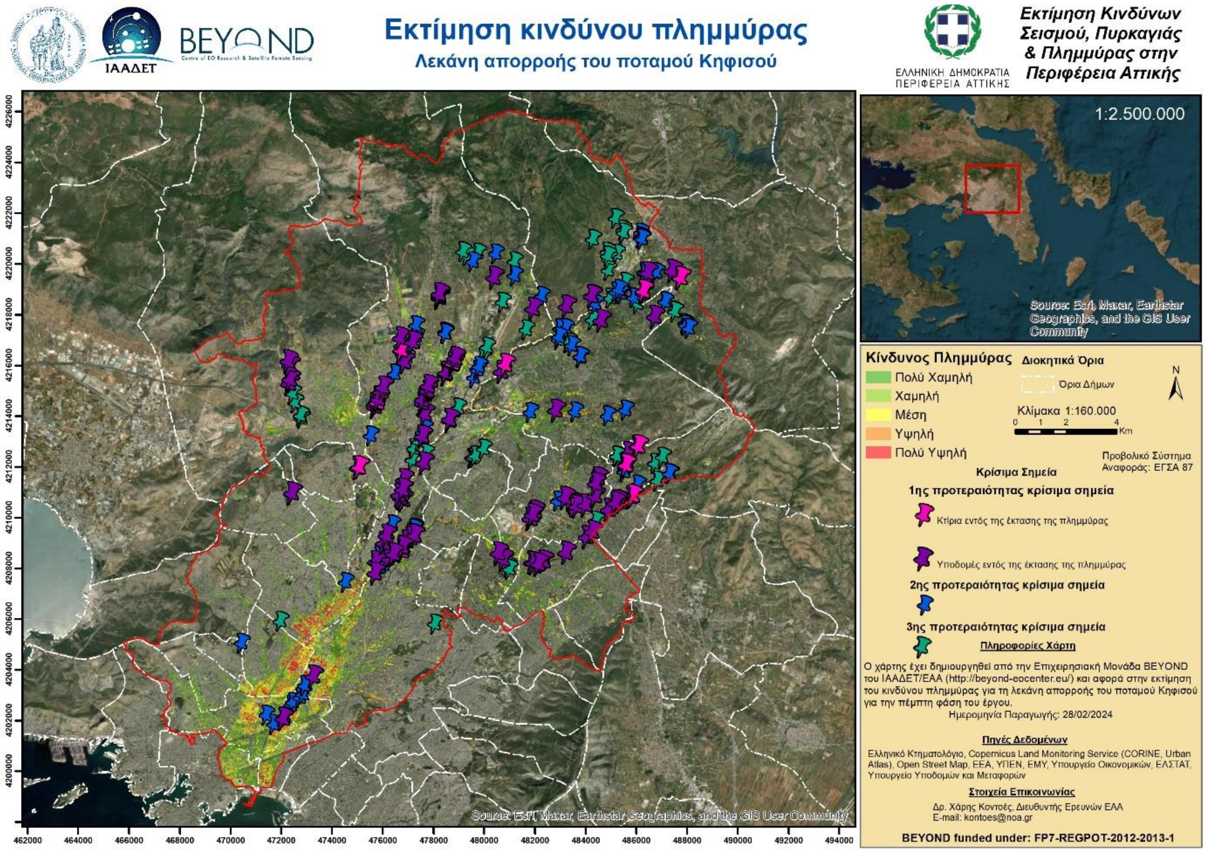
Report of flood risk study and field research





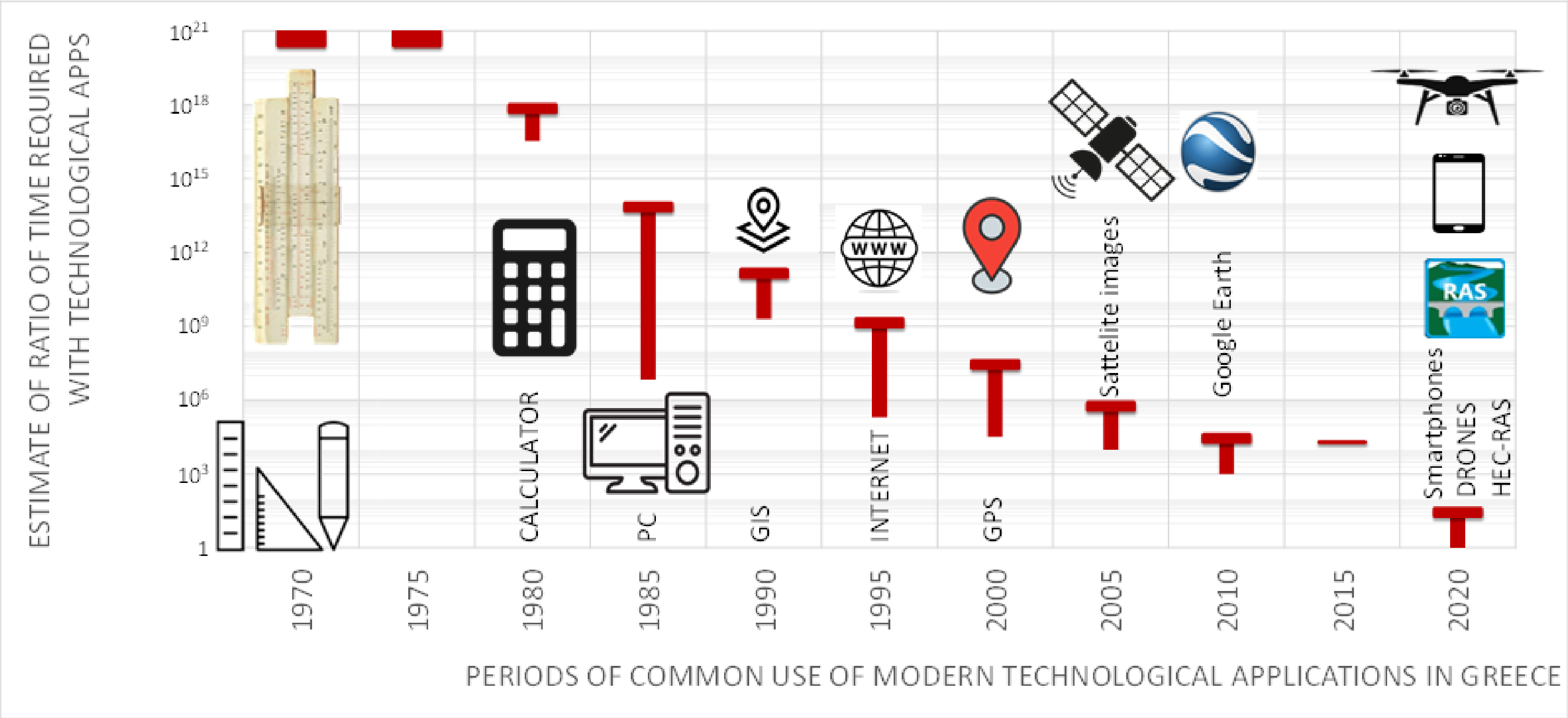
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	W	X	Y	Z	AA	AD
1		MAT	DIM shape	DIM h	DIM d	DIM l	DIM col	DIM p	DIM al	DIM ar	DIM hl	DIM hr	MANb	MANr	MANl	HIGH RISK	description of risk	source	commentsSigourouGoogleEarth	notes	Ημέρα - Ώρα φωτογραφίας
2		(πχ. Μπετόν=b, Σίδερο=f, Ξύλο=w, πλαστικό=pvc)	(π.χ. ορθογωνική o, αψιδωτή a, κυκλικός c, ωοειδής e)	(m)	(m)	(m)	number	(m)	(degrees)	(degrees)	(m)	(m)	(π.χ. Χώμα=l, Φυτοκάλυψη=p, Πέτρες=g, Συρματοκιβώτια=s, Μπετόν=b) ΚΑΤΑ ΤΗ ΔΙΕΥΘΥΝΣΗ ΤΗΣ ΡΟΗΣ			(yes/no)				(περιγραφές, ΧΩΡΙΣ ΠΡΟΣΒΑΣΗ, ΔΕΝ ΕΝΤΟΠΙΣΤΗΚΕ)	
92	R1.8-P25-G																		γέφυρα Εθνικής Αντιστάσεως ΜΕΤΡΗΣΗ	καθώς γίνονται έργα σε εξέλιξη και η διατομή θα διευρυνθεί.	23/09/2023, 12:15
93	R1.8-P26-G																		πεζογέφυρα ΜΕΤΡΗΣΗ	Δεν υπάρχει πεζογέφυρα, έχει υπογειοποιηθεί προσφάτως με τα νέα έργα.	23/09/2023, 12:19
94	R1.8-P27-C	b	o	3.5	1.0	5.5													γέφυρα Κολοκοτρώνη ΜΕΤΡΗΣΗ	Εργασίες υπό εξέλιξη.	23/09/2023, 12:23
95	R1.8-P28-C																		ΜΕΤΡΗΣΗ	Οχετός, υπόγειος, δεν εντοπίστηκε	23/09/2023, 12:38
96	R1.8-P29-C																		ΜΕΤΡΗΣΗ	Οχετός, υπόγειος, δεν εντοπίστηκε	23/09/2023, 12:41
97	R1.8-P30-G			4.0	0.5	6.4	0						l	s	s				ΜΕΤΡΗΣΗ		23/09/2023, 12:44
98	R1.8-P30a-C	b	c	3.0		2x4.0							b	b	b				ΜΕΤΡΗΣΗ	Δίδυμος οχετός.	23/09/2023, 12:45
99	R1-P11-K												l	s	s				συμβολή με [illegible] (Φλέβα - Βουβίκωνα) ΜΕΤΡΗΣΗ	Έργα σε εξέλιξη.	23/09/2023, 12:50
100	Group 3.1																				
101	R1.9.6-P8-G	b	a	3	0.5	5										yes	κίνδυνος σε περίπτωση φραξίματος			όχι καλή μέτρηση λογω έλλειψης πρόσβασης	

Modern approaches of flood risk studies



[3, 4, 5]

Timeline of the appearance of modern tools



[6]

Timeline of the appearance of modern tools used for flood risk studies in Greece in terms of an estimated ratio of time required on the task with respect to using modern tools

Conclusions

A study of flood risk in 1970s would have the following limitations:

- Calculations to 2nd digit. Even if we assume that the calculations were correct, this limitation leads to computational errors.
- Time lag of the hydrological data was monthly. In present the time lag is 10 minutes.
- No simulation process for the creation of synthetic timeseries.
- The analysis in 1970s was in 1D. 2D analysis were not referred in Greece.
- The provided blueprint maps in 1970s (scale 1:5000) refers approximately to a cell's grid in DEM 250X250. The DEM background with cell 2X2 refers approximately to a map in scale 1:100.
- The hydraulic analysis in one dimension does not provide information for the two-dimensional flow. Therefore, it loses the information about the hydraulic losses from upstream in correlation with hydraulic supply with downstream. Modern methods diminish this issue.
- The cumulative progress which is depicted in the estimation of time optimization shows that studies with similar accuracy and visualization would be impossible in 1970s.

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