HYDROLOGY IN THE WEEDS

OR… HOW TO CARRY ON FROM, OR WITH, PRIOR EFFORTS

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ACKNOWLEDGEMENTS

- V3 Companies – Thank you for a place to practice the science and art of Engineering
- IAFSM – Thank you for the opportunity to present a few thoughts…

IAFSM
Illinois Association for Floodplain and Stormwater Management

INTRODUCTION

- "In the Weeds" is a way of saying there are challenges to following prior engineering efforts
- For example, consider Manning's 'n'

Table 15–1 Manning's roughness coefficients for sheet flow (flow depth generally ≤ 0.1 ft)

Surface description	n [1/]
Smooth surface (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short-grass prairie	0.15
Dense grasses [2/]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3/]	
Light underbrush	0.40
Dense underbrush	0.80

1 The Manning's n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

PROCESS

HYDROLOGIC CONSIDERATIONS

BACK TO BASICS – HYDROLOGIC PARAMETERS

- Rainfall – What comes down
- Soils – What it lands on
- Land Use – How it infiltrates (Impervious vs. Vegetation or lack thereof)
- Watershed – How much is involved, especially considering an ungauged situation
  - Size, Shape, Slope and Situation among perhaps numerous other characteristics

ADDITIONAL CONSIDERATIONS & CONSTRAINTS

- Rainfall – What comes down
- Soils – What it lands on
- Land Use – How it infiltrates (Impervious vs. Vegetation or lack thereof)
- Watershed – How much is involved
- Observations – What actually happens when it rains (our best understanding)?
- Context – How should I think about prior efforts (the Why – intent or scope)?
- Relevance – How should I value prior efforts?
- Application – What should I do about prior and future efforts?

HYDROLOGIC PARAMETERS & CONSTRAINTS

- Rainfall – What comes down
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ILLUSTRATION

CAP-HAITIEN WATERSHED – LARGELY UNGAUGED

CONTEXT

- Watershed prone to flooding – examples: Nov 2012

CONTEXT

- Watershed prone to flooding – examples: Nov 2012, Nov 2014

Severe flooding hits Haiti, Republic

Associated Press / 04:03 PM November 07, 2014

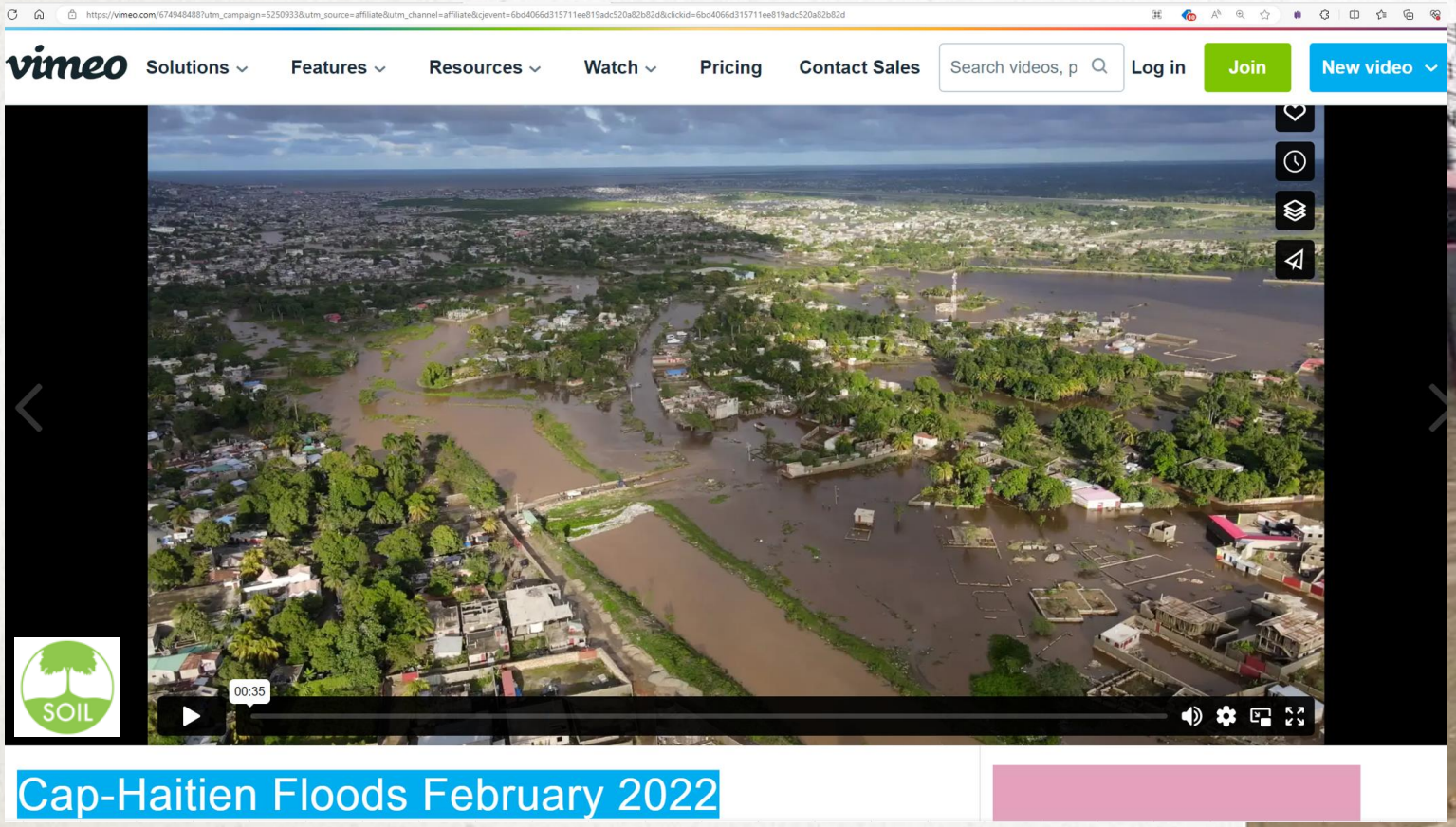
CONTEXT

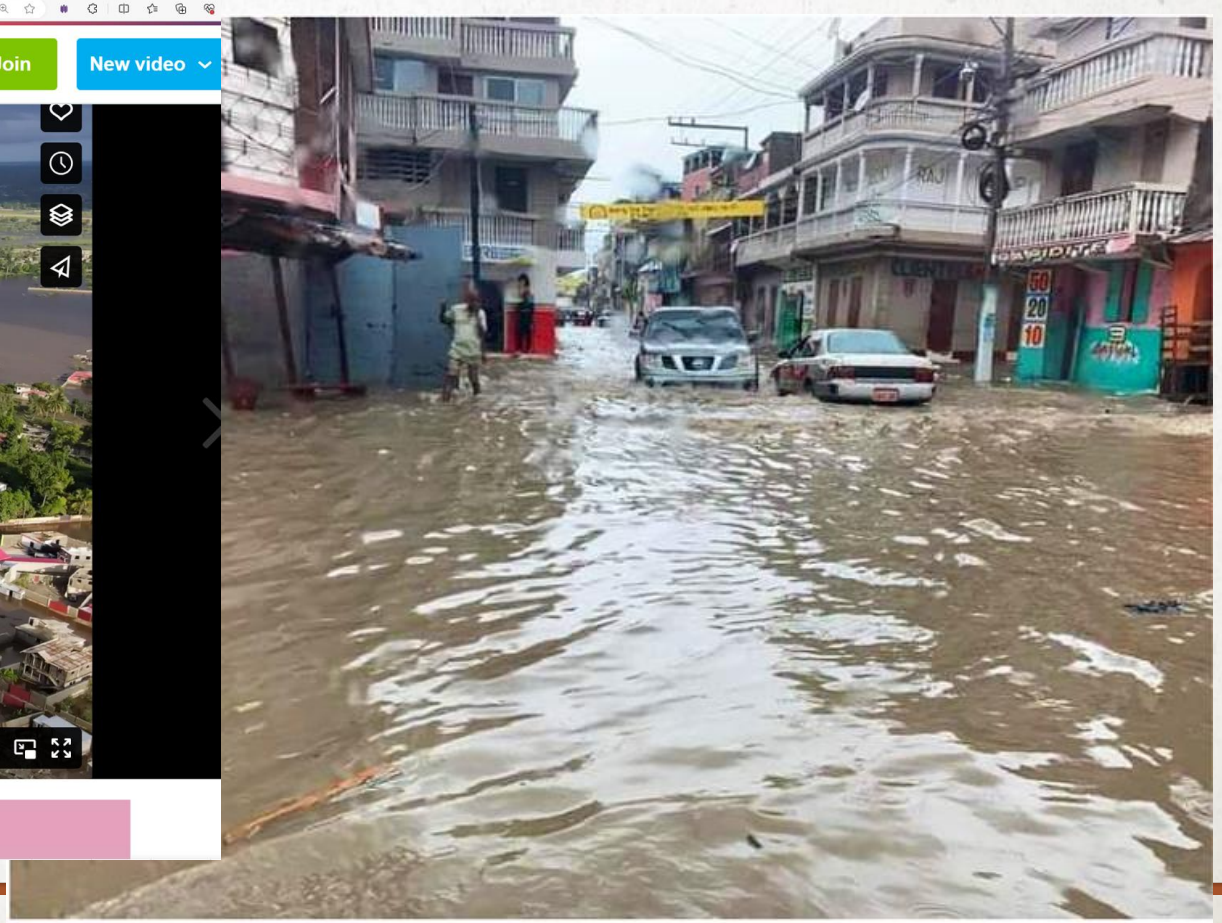
- Watershed prone to flooding – examples: Nov 2012, Nov 2014, Nov 2016

Published: November 13, 2016 ~ 0

CONTEXT

- Watershed prone to flooding – examples: Nov 2012, Nov 2014, Nov 2016 and Jan 2022

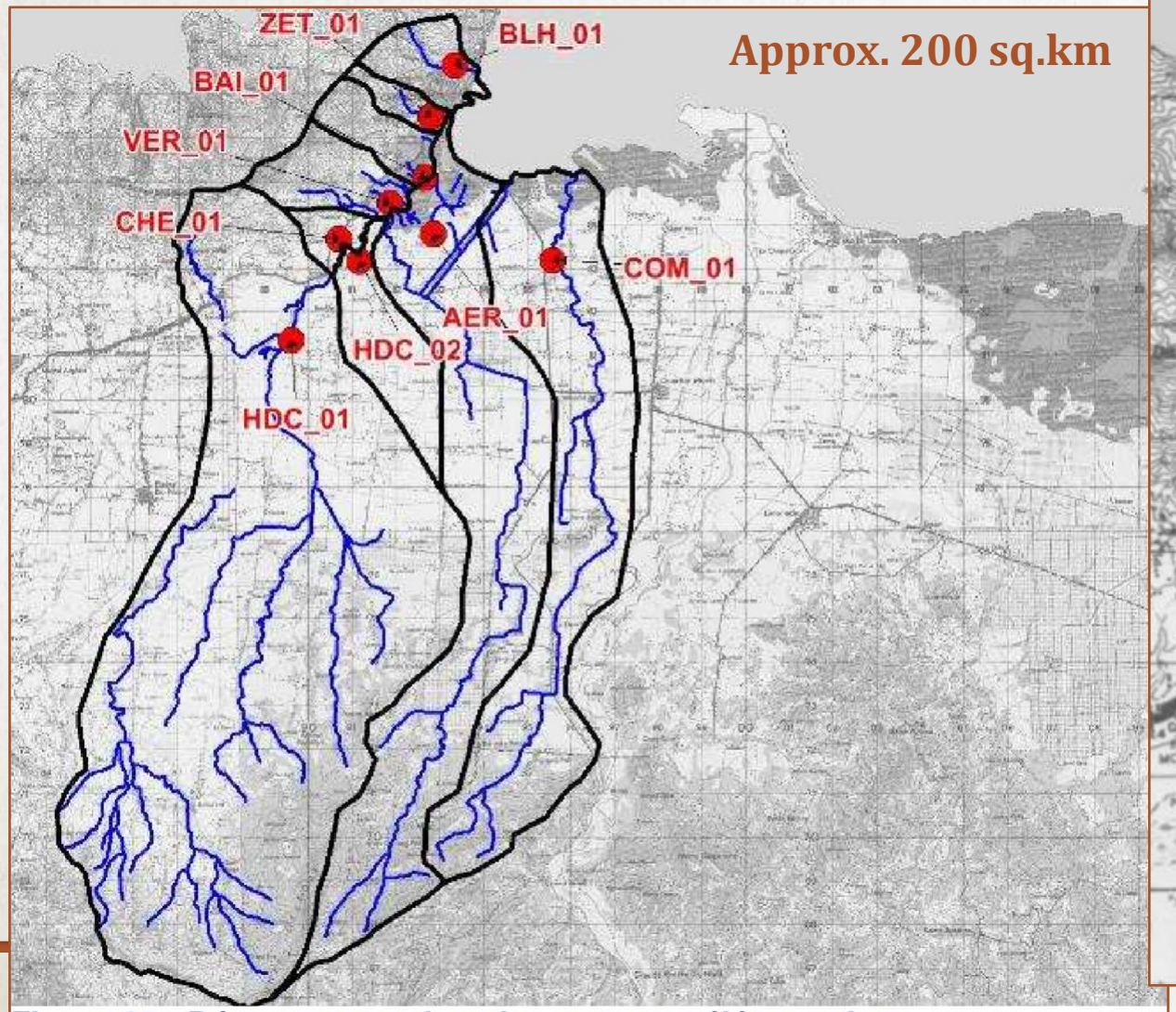




Floods Haiti Late January 2022. Photo:Pwoteksyon sivil Haiti

WATERSHED

Approx. 200 sq.km



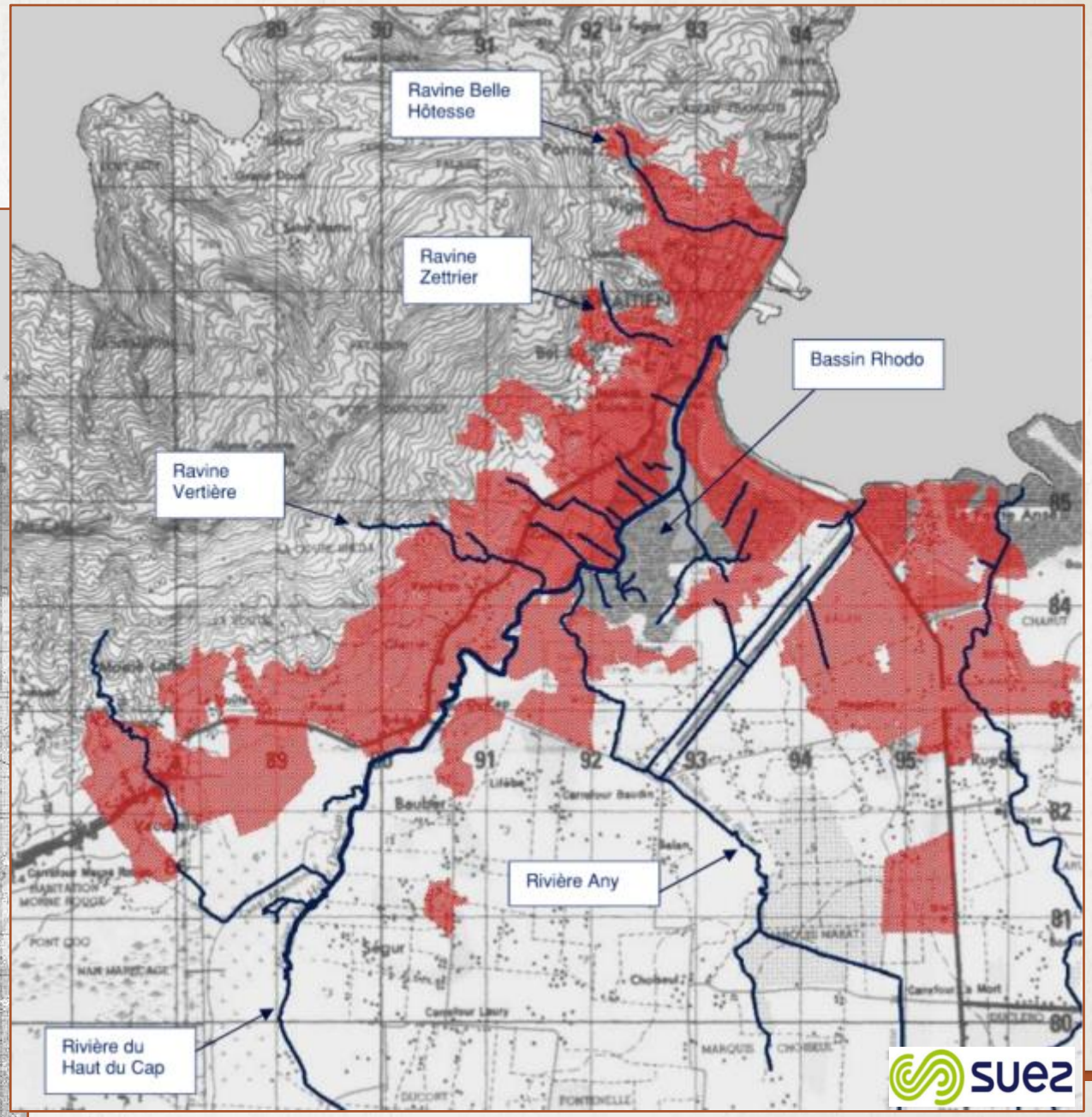


Figure 25 : Découpage en bassins versants élémentaires

PRIOR EFFORTS – SOILS

- Complete watershed study, but perhaps "larger scale" in character?

Tableau 3 : Caractéristiques générales des bassins versants

Identifiant du bassin versant	Nom du bassin versant	Surface du bassin versant (km2)	Longueur du chemin hydraulique (km)	Altitude du point haut (m)	Altitude du point bas (m)	Pente moyenne (m/m)	Occupation du sol	% de surfaces imperméabilisées	Contexte géologique
BV_HDC_01	Rivière du Haut du Cap, amont	98.1	20	600	1	0.030	Zone verte non aménagée ou à dominante agricole	0.16	Alluvions, matériaux détritiques
BV_HDC_02	Rivière du Haut du Cap, aval	6.8	5.66	20	1	0.003	Zone verte non aménagée ou à dominante agricole	9.47	Alluvions, matériaux détritiques
BV_CHE_01	Bassin ravine urbaine	1.7	1.7	320	0	0.188	Urbanisation dense	64.96	Alluvions, matériaux détritiques
BV_VER_01	Ravine Vertière	4.9	3.3	760	1	0.230	Urbanisation dense	18.91	Andésites et rhyodacites
BV_BAI_01	Bassin ravine urbaine	3.4	2.9	660	0	0.228	Urbanisation dense	28.40	Andésites et rhyodacites
BV_ZET_01	Bassin ravine Zettrier	1.5	2.6	620	0	0.238	Urbanisation dense	33.69	Andésites et rhyodacites
BV_BLH_01	Bassin ravine Belle Hôtesse	3.6	3	560	0	0.187	Urbanisation dense	31.30	Andésites et rhyodacites
BV_AER_01	Bassin rivière Any	39.3	23	500	0	0.022	Zone verte non aménagée ou à dominante agricole	5.48	Alluvions, matériaux détritiques
BV_COM_01	Bassin rivière du Commerce	34.0	18.5	400	0	0.022	Zone verte non aménagée ou à dominante agricole	8.98	Alluvions, matériaux détritiques

PRIOR EFFORTS – SOILS

- Soils per Runoff Curve Number (RCN)

Avg. Watershed RCN = 62.8

Tableau 5 : Curve number et capacité d'infiltration des sols des bassins versants

Identifiant du bassin versant	Nom du bassin versant	Curve number	Capacité d'infiltration des sols (en mm)
BV_HDC_01	Rivière du Haut du Cap, amont	62	158
BV_HDC_02	Rivière du Haut du Cap, aval	57	188
BV_CHE_01	Bassin ravine urbaine	83	50
BV_VER_01	Ravine Vertière	75	86
BV_BAI_01	Bassin ravine urbaine	75	83
BV_ZET_01	Bassin ravine Zettrier	77	77
BV_BLH_01	Bassin ravine Belle Hôtesse	78	71
BV_AER_01	Bassin rivière Any	62	159
BV_COM_01	Bassin rivière du Commerce	61	161

Occupation du sol	Curve Number (CN) selon la classe de perméabilité du sol			
	A	B	C	D
Urbanisation dense	95	95	95	95
Urbanisation peu dense	56	75	87	92
Zone d'activité, industrielle ou clôturée	98	98	98	98
Zone verte non aménagée ou à dominante agricole	39	61	74	80
Mangrove, lit mineur, zone estuarienne, lac, zone humide	100	100	100	100
Friche	76	85	89	91

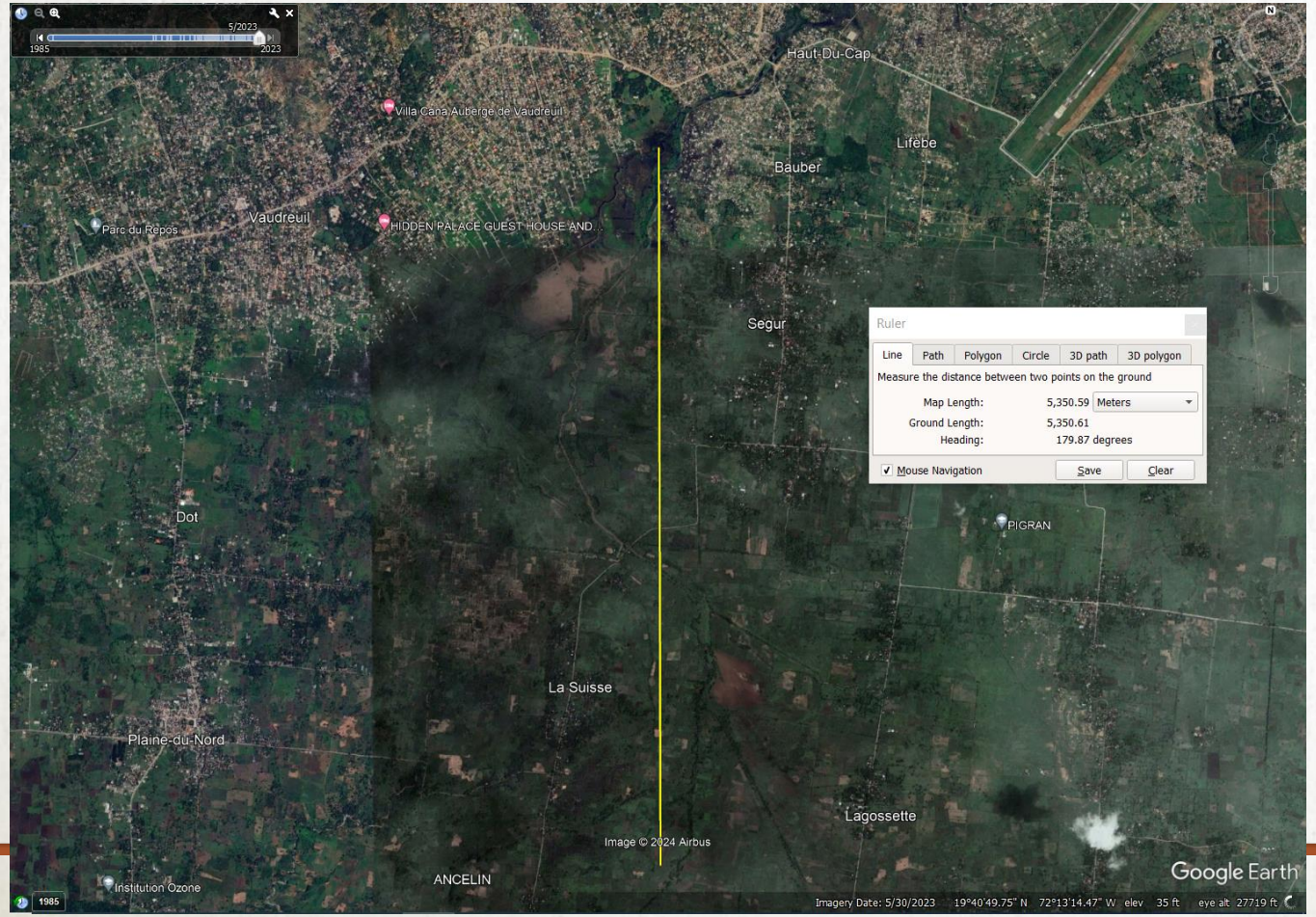
Cover description: cover type	treatment [2]	hydrologic condition [3]	CN for hydrologic soil group: A	B	C	D
Fallow	Bare Soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90

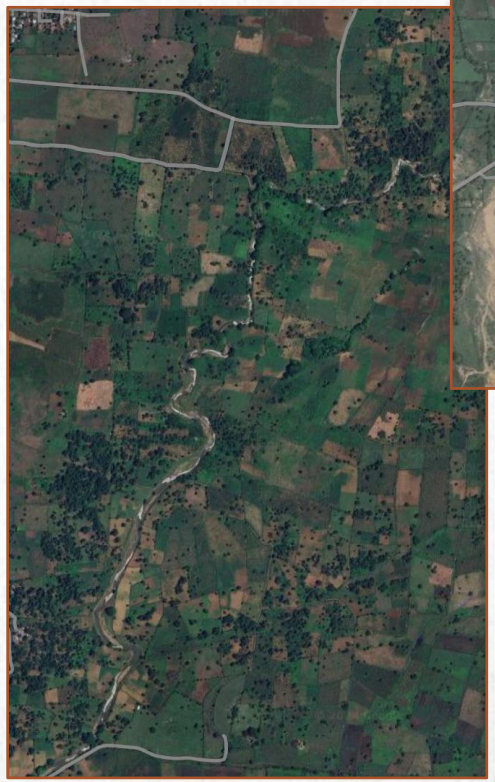
Table 9–5 Runoff curve numbers for urban areas [1]

Cover description: cover type and hydrologic condition	Average percent impervious area [2]	CN for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

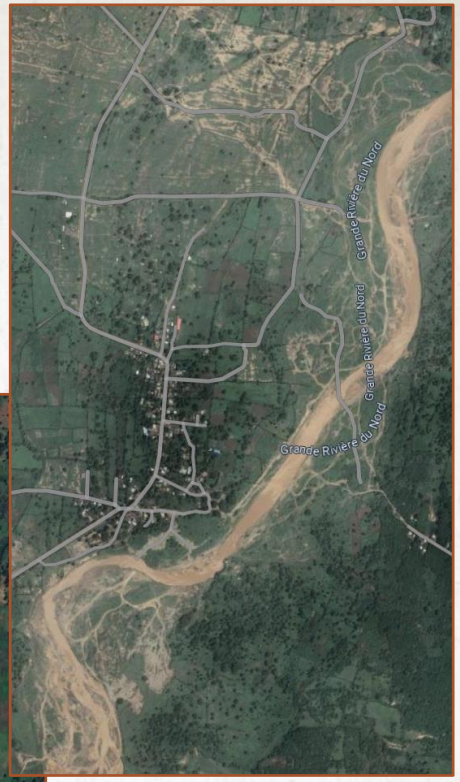
FOLLOW-ON EFFORTS – SOILS

- Review watershed soil considerations – saturation, character





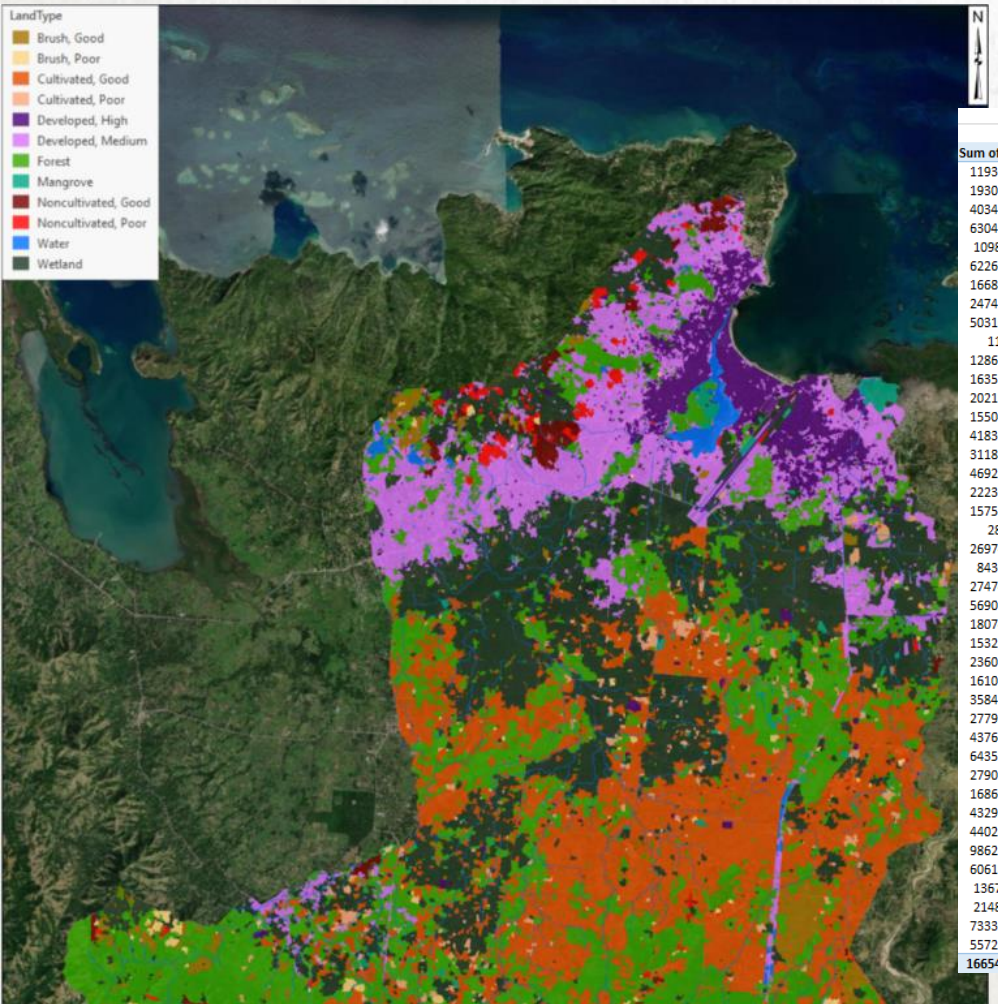
Haut du Cap



Grand Riviere

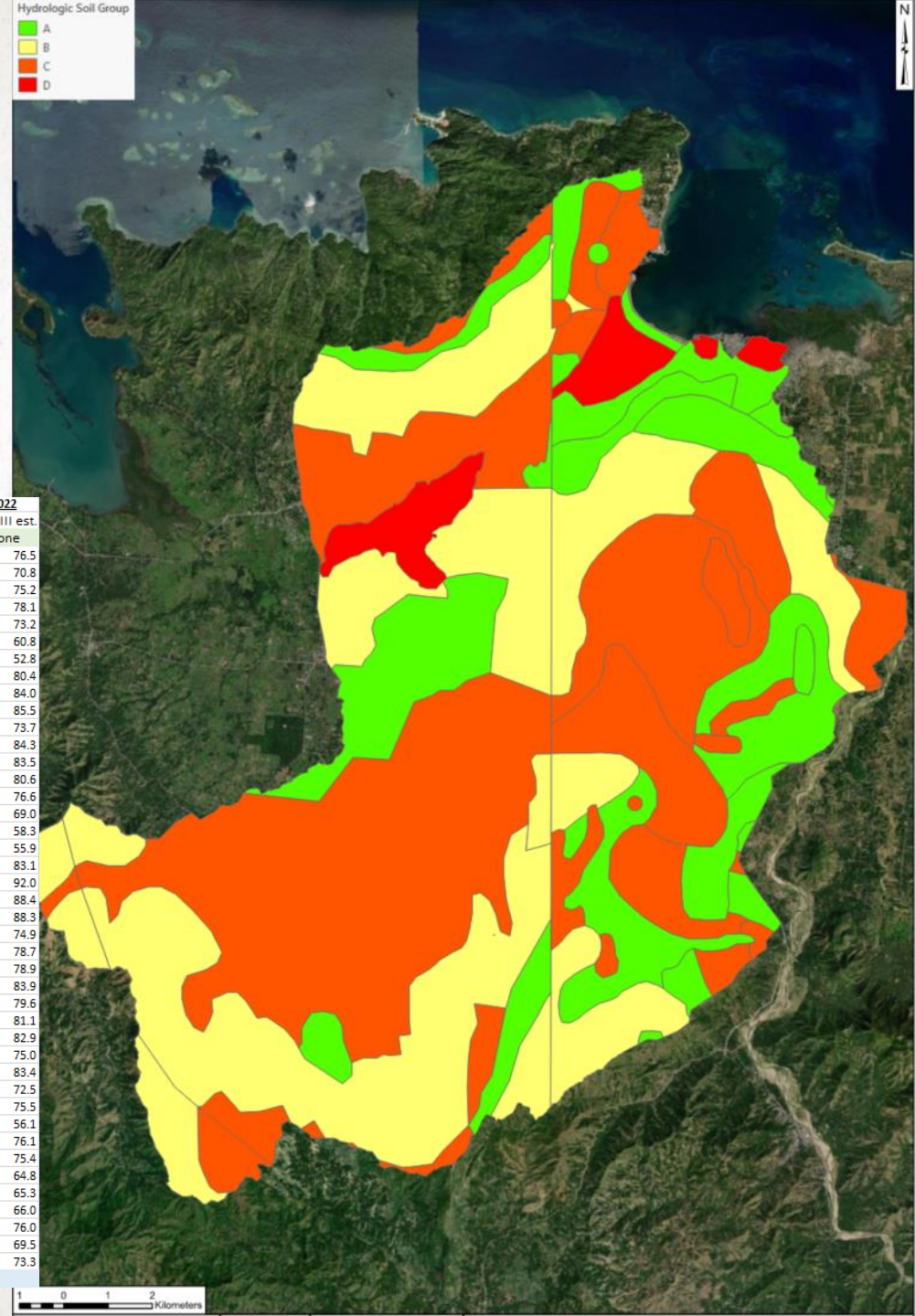
FOLLOW-ON EFFORTS – SOILS

- Review and revise RCN values per improved data



Avg. Watershed RCN = 72

		AMC II		AMC III	2012	2016	2022
					AMC III est.	AMC III est.	AMC III est.
Sum of A*CN	Sum of microArea	Comp CN			North + SE	South Only	None
119366160.8	1559992.515	76.5	A11	86.7	86.7	76.5	76.5
193067291.6	2725292.817	70.8	A12	83.3	83.3	70.8	70.8
403409737.4	5364868.748	75.2	A121	86.0	86.0	75.2	75.2
630401655.6	8074872.697	78.1	A13	88.0	88.0	83.0	78.1
1098930665	15021303.6	73.2	A14	84.5	78.8	84.5	73.2
622651918.6	10234134.23	60.8	A15	78.0	60.8	78.0	60.8
166899752.1	3161899.946	52.8	A151	71.8	52.8	71.8	52.8
247425099.9	3077665.954	80.4	B01	89.0	89.0	80.4	80.4
50316381.22	598752.1374	84.0	B02	91.0	91.0	84.0	84.0
11413106	133481.622	85.5	B03	92.0	92.0	85.5	85.5
128673743.1	1745672.532	73.7	B04	85.0	85.0	73.7	73.7
163512798.9	1938540.508	84.3	B05	91.1	91.1	84.3	84.3
202138863.1	2420959.323	83.5	C11	91.0	91.0	91.0	83.5
155048159.4	1923943.196	80.6	C12	89.0	89.0	89.0	80.6
418328809.4	5461812.684	76.6	C13	86.8	86.8	86.8	76.6
311858815.9	4519962.257	69.0	C14	82.0	82.0	82.0	69.0
469275715.8	8055665.851	58.3	C15	76.3	67.3	76.3	58.3
222395568.5	3978642.173	55.9	C16	74.9	55.9	55.9	55.9
157544184.7	1895477.094	83.1	HD11	91.0	91.0	83.1	83.1
28417675	308886.7172	92.0	HD12	95.0	95.0	92.0	92.0
269744127.1	3051420.346	88.4	HD13	93.0	93.0	88.4	88.4
84303414.4	954944.2542	88.3	HD14	93.0	93.0	88.3	88.3
274744649.3	3667662.41	74.9	HD15	86.0	86.0	74.9	74.9
56903932.09	723384.5818	78.7	HD16	88.0	88.0	78.7	78.7
180741180.4	2289862.218	78.9	HD17	88.0	88.0	78.9	78.9
153220193.3	1826815.459	83.9	HD20	91.0	91.0	83.9	83.9
236039867.1	2963620.155	79.6	HD21	88.7	88.7	79.6	79.6
161004301.6	1986075.425	81.1	HD22	89.0	89.0	81.1	81.1
358438509.2	4325515.681	82.9	HD23	90.7	90.7	82.9	82.9
277923029.2	3705948.51	75.0	HD24	86.0	86.0	75.0	75.0
437641966.4	5248062.572	83.4	HD25	91.0	91.0	83.4	83.4
643527961.6	8871506.533	72.5	HD26	84.0	78.3	78.3	72.5
279052137.9	3693645.955	75.5	HD261	86.0	86.0	75.5	75.5
168605032.8	3004872.87	56.1	HU11	75.0	65.6	75.0	56.1
432924839.5	5692289.57	76.1	HU111	86.3	76.1	86.3	76.1
440284886.4	5836773.457	75.4	HU1111	86.0	75.4	86.0	75.4
986232789.4	15228387.1	64.8	HU11111	81.8	64.8	81.8	64.8
606181599.5	9279829.025	65.3	HU1112	79.1	65.3	79.1	65.3
1367030430	20722716.38	66.0	HU1117	79.7	66.0	79.7	66.0
2148699604	28255753.25	76.0	HU12	86.2	81.1	86.2	76.0
733354768.3	10552971.96	69.5	HU122	82.0	69.5	82.0	69.5
557221287.3	7601467.032	73.3	HU125	84.6	73.3	84.6	73.3
16654896608	231685351.3	72	Grand Total				



PRIOR EFFORTS – RAINFALL

- Complete watershed study, but perhaps “larger scale” in character?

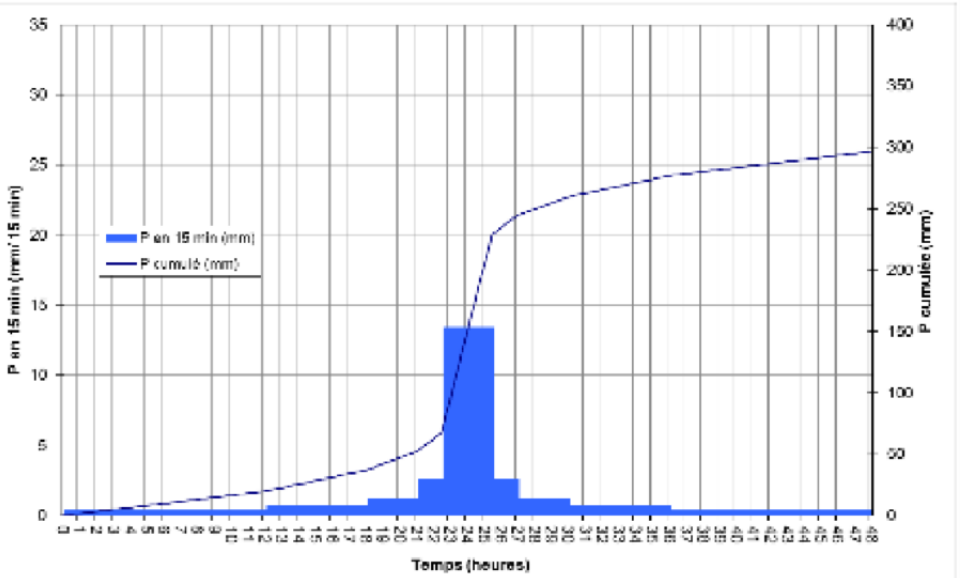
- Results appeared to be lower than we expected by calculation

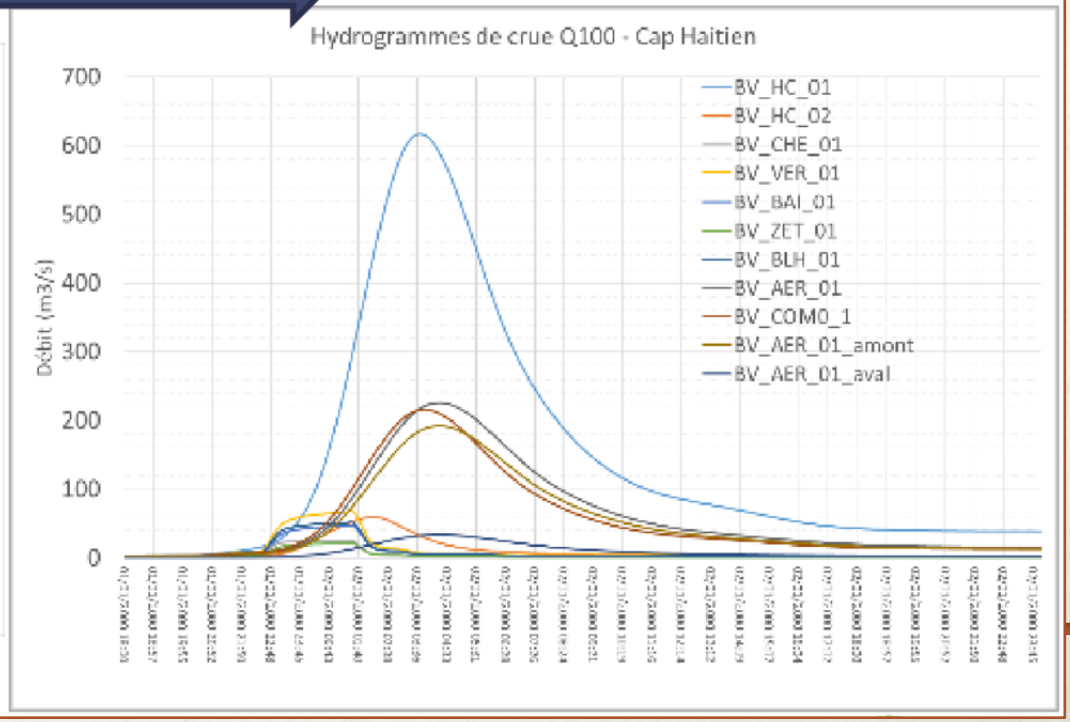
  (SCS Type III Duration vs Depth?)

  Need for Sub-daily rainfall data characteristics

Modélisation hydrologique (HEC HMS)

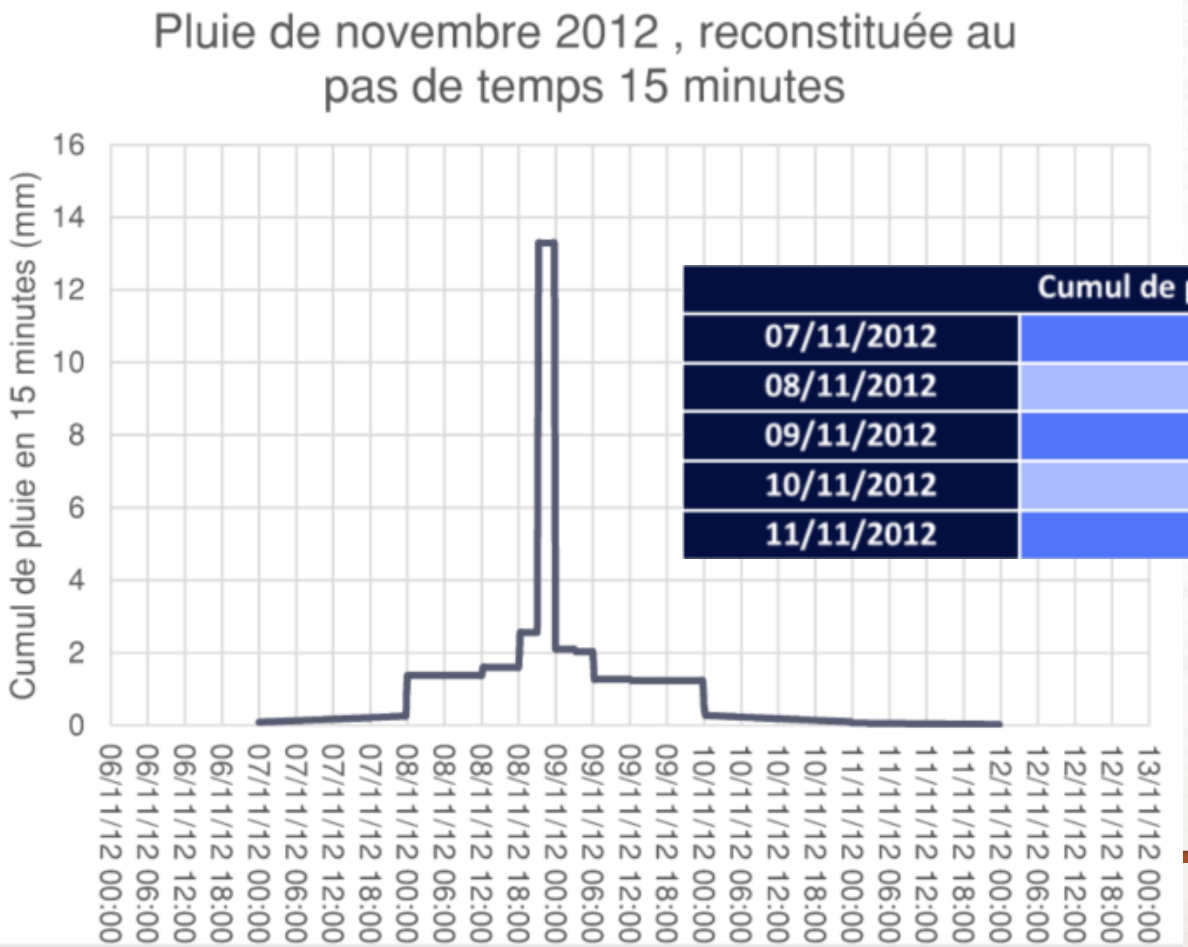
Pluie → ***Bassin versant*** → **Débits et volumes**



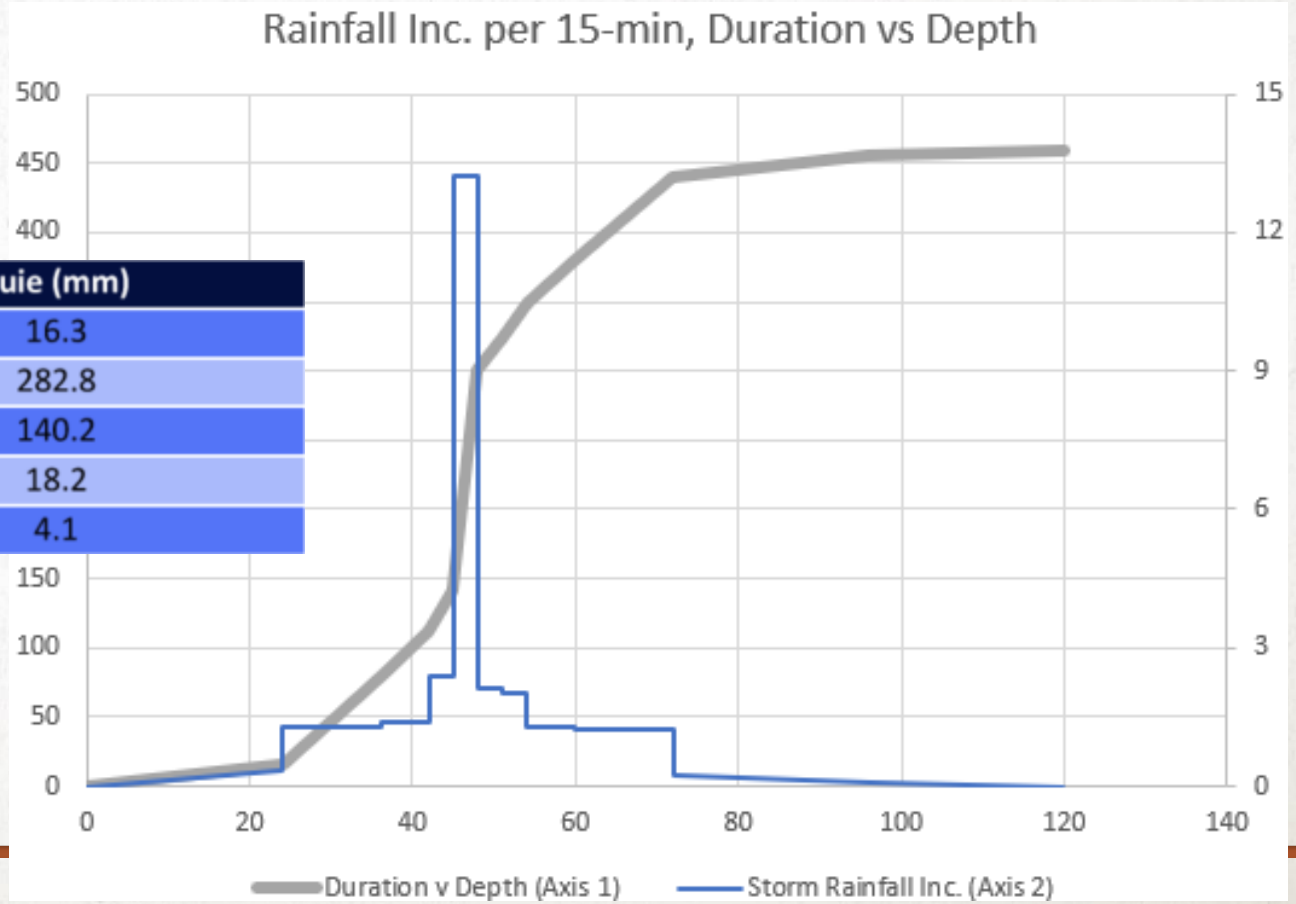


PRIOR EFFORTS – RAINFALL RECONSTRUCTION

- November 2012 Storm Event – Sub-daily rainfall Duration vs Depth curve development



	Cumul de pluie (mm)
07/11/2012	16.3
08/11/2012	282.8
09/11/2012	140.2
10/11/2012	18.2
11/11/2012	4.1



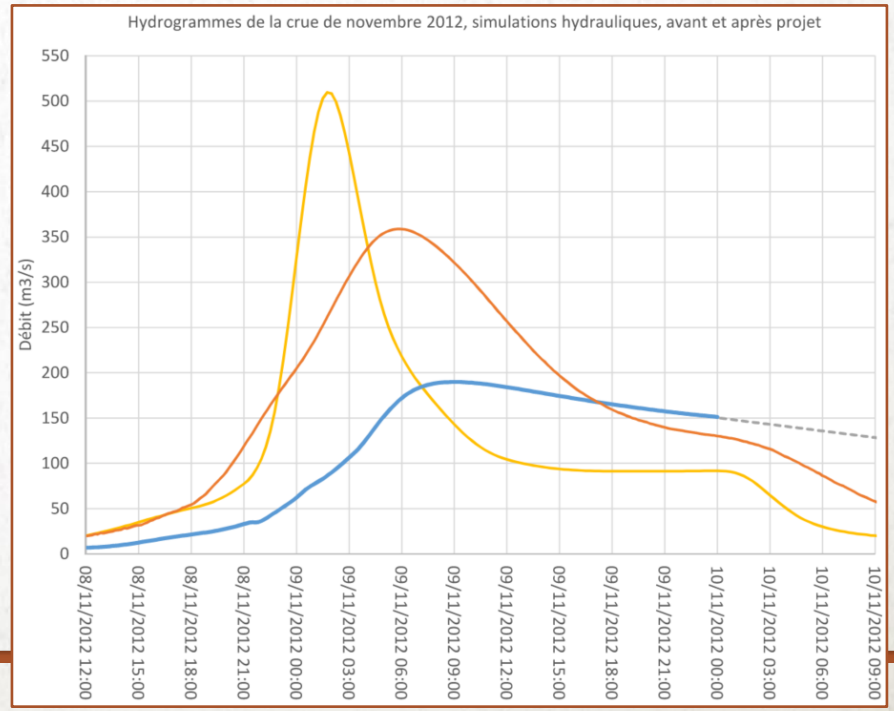
PRIOR EFFORTS – RAINFALL RESULTS

- November 2012 Storm Event flows compared to Design Storm flows

Tableau 7 : Débits de pointe estimés à l'exutoire des bassins versants

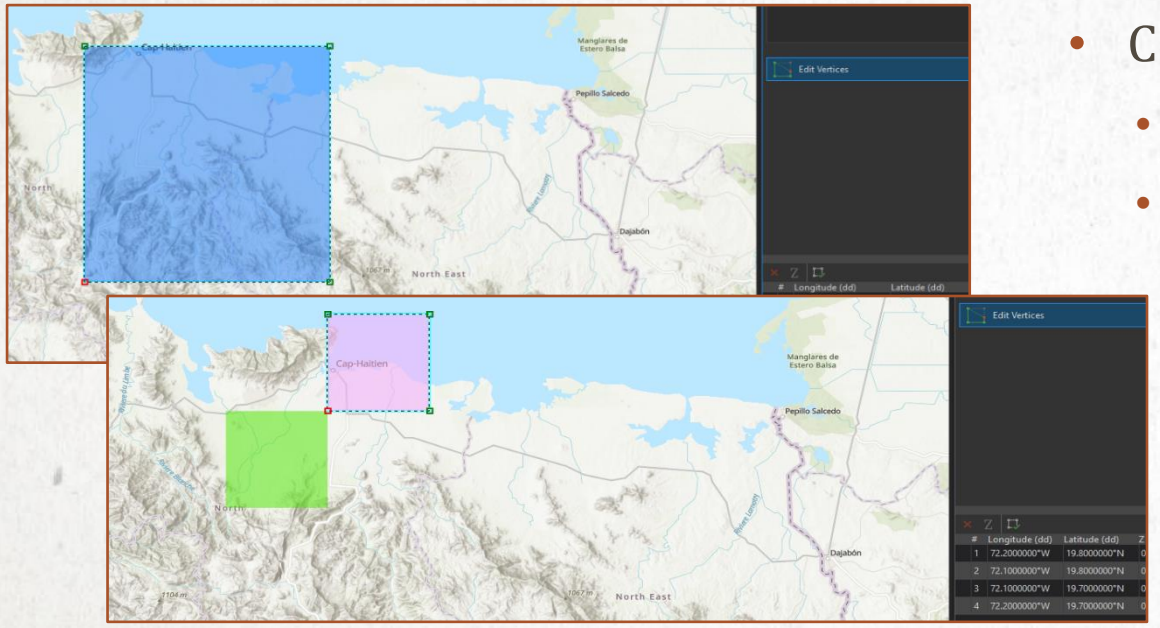
Bassin versant		Superficie du bassin versant (km^2)	Débits de pointe (m^3/s)					
			Période de retour					
			2 ans	5 ans	10 ans	20 ans	50 ans	nov-12
BV_HC_01	Rivière du Haut du Cap, amont	98	73	145	224	320	487	510
BV_HC_02	Rivière du Haut du Cap, aval	7	8	15	22	32	47	48
BV_CHE_01	Bassin ravine urbaine	2	8	11	14	17	21	19
BV_VER_01	Ravine Vertière	5	17	26	34	43	57	52
BV_BAI_01	Bassin ravine urbaine	3	13	19	24	30	40	36
BV_ZET_01	Bassin ravine Zettrier	1	6	9	11	13	18	16
BV_BLH_01	Bassin ravine Belle Hôtesse	4	15	21	27	33	44	40
BV_COM0_1	Bassin rivière du Commerce	34	31	56	83	116	172	177
BV_AER_01_amont	Rivière Any, amont	33	26	48	73	102	153	159
BV_AER_01_aval	Rivière Any, aval	5	5	8	13	18	27	28

- Results appeared to be lower than we expected by calculation (Type III Duration vs Depth?)

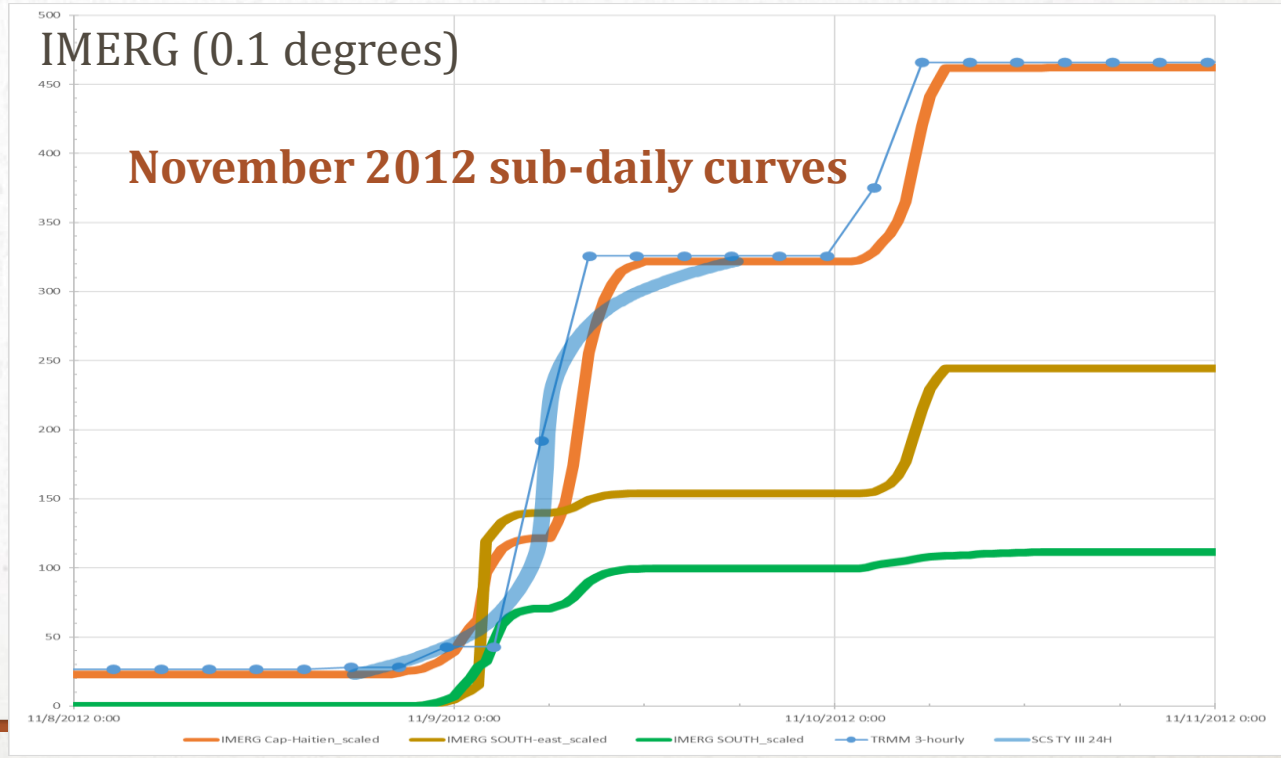


FOLLOW-ON EFFORTS – RAINFALL

- Establish sub-daily data based on TRMM (3-hr) and IMERG (30-min) real time satellite data



- Coverage squares
  - TRMM (0.25 degrees)
  - IMERG (0.1 degrees)



FOLLOW-ON EFFORTS – RAINFALL STATISTICS

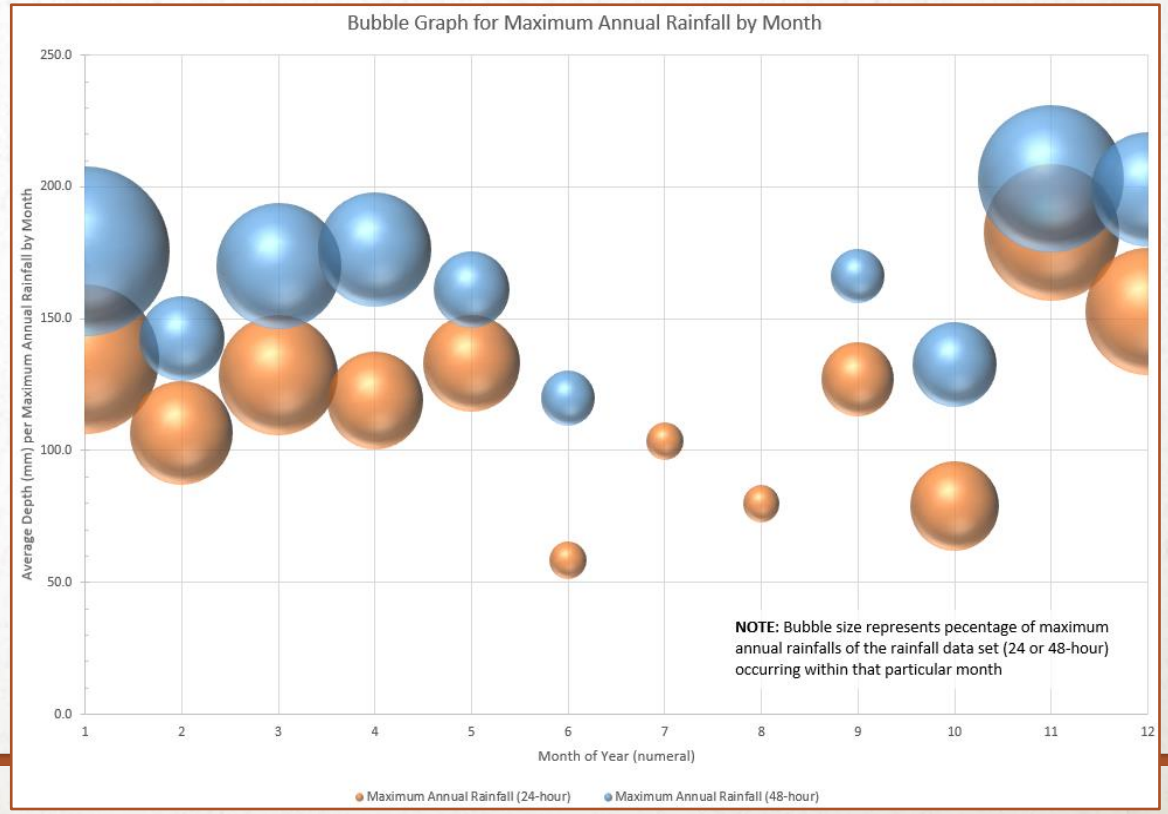
- Establish "typical" conditions for the watershed (48-hr), include orographic influences
- Bubble Graph for average storm percentage occurrence and rainfall depth per month

Annual rainfall averages for gages within or near the Cap-Haitien watershed

Characterisitc	Cap-Haitien	Soufriere	Aitz	Citadelle	Grand Riviere
Distance to Citadelle (km)		11.1	13.1		8.7
15-year avg (mm)		1878	1798	2411	1835
Delta 15-yr to 53-yr (mm)		109	-224	-124	-241
53-year avg (mm)	**1498**	**1987**	**1574**	**2287**	1593
Ratio to Cap-Haitien (mm/mm)	*1*	*1.326*	*1.051*	*1.526*	*1.063*

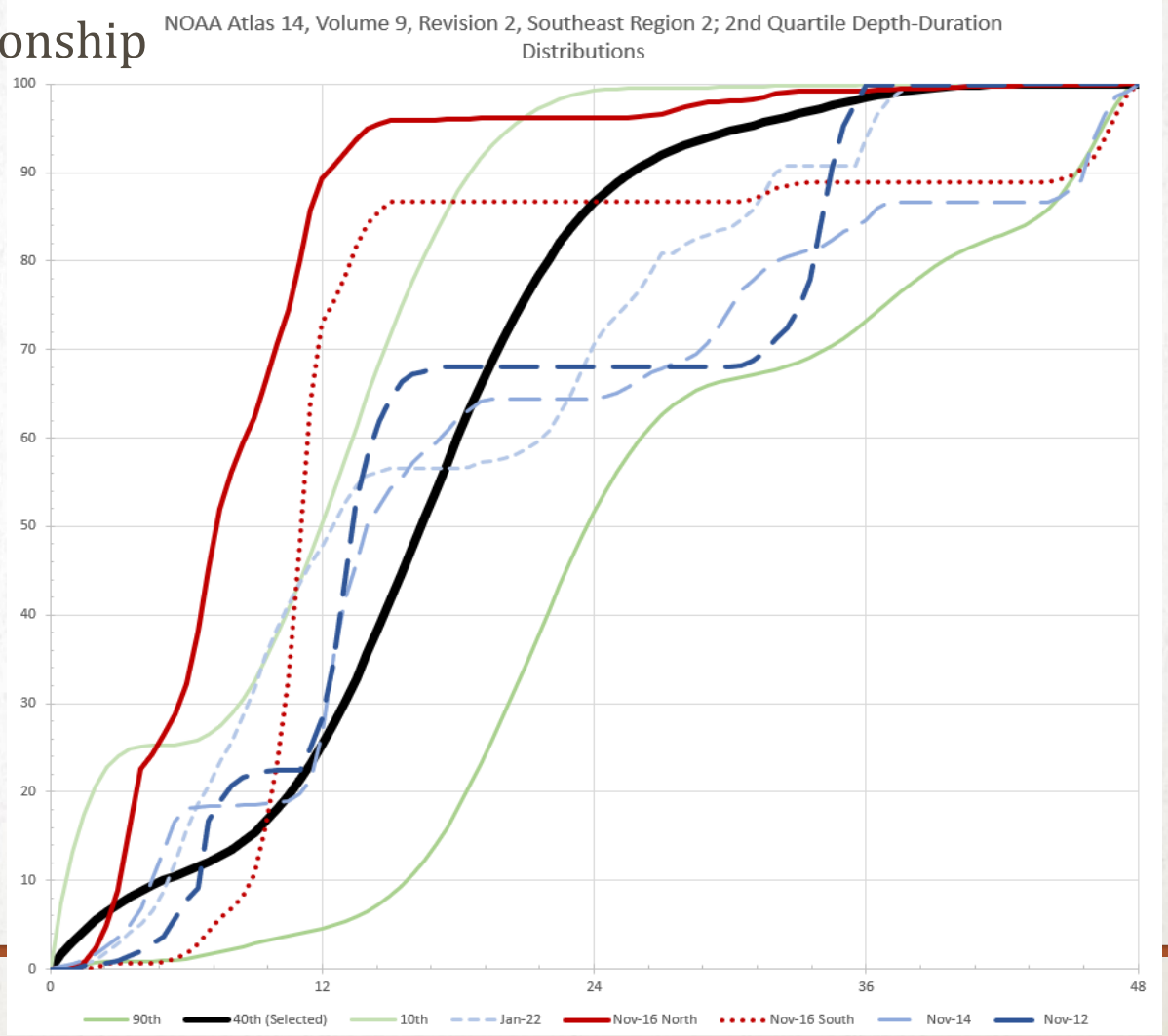
Monthly Triad (~50-Percent) rainfall averages for gages within or near the Cap-Haitien watershed

Characterisitc	Cap-Haitien	Soufriere	Aitz	Citadelle	Grand Riviere
Distance to Citadelle (km)		11.1	13.1		8.7
15-year avg (mm)		182	146	214	148
Delta 15-yr to 53-yr (mm)		15	-14	-6	-17
53-year avg (mm)	**185**	**197**	**132**	**208**	132
Ratio to Cap-Haitien (mm/mm)	*1*	*1.078*	*0.721*	*1.134*	*0.718*

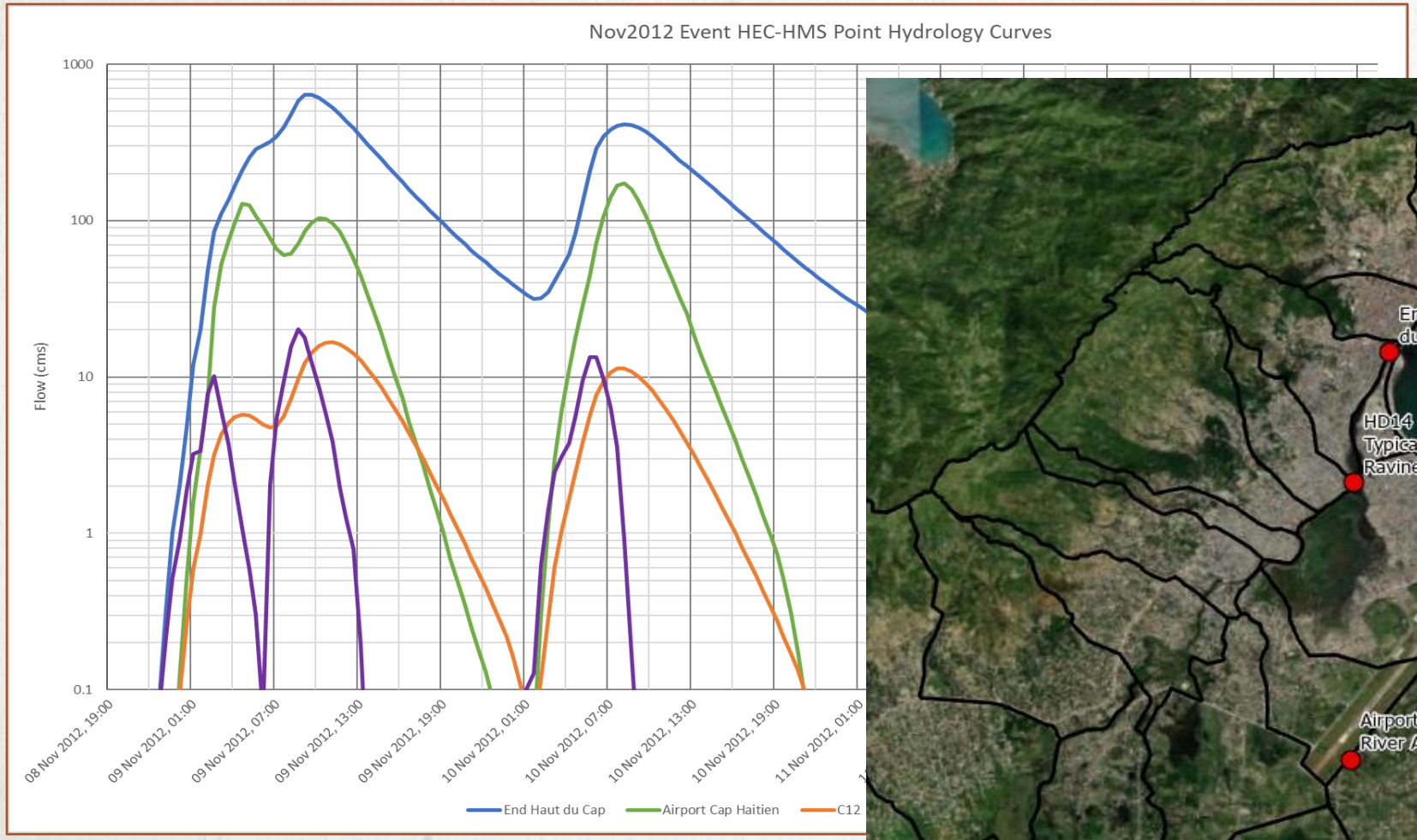


FOLLOW-ON EFFORTS – RAINFALL

- Design Storm Duration vs Depth Relationship
- Potentially similar conditions - Miami



FOLLOW-ON EFFORTS – RAINFALL RESULTS



CLOSURE

REMAINING ITEMS, COMMENTS, CONCLUSIONS

REMAINING ITEMS AND COMMENTS

- Peak Rate Factor (PRF) – 300 (flat), 484 (5 percent or so), 600 (Steep)
- Areal Considerations (orographic, Thiessen polygons, intra-annual patterns)
- Tc's – Similar to prior efforts
- Modeling – Basin assignments
- Sub-daily rainfall record would result in better statistics (future study)
- Application – Study Goal is proposed flood mitigation solutions ($$$$)

CONCLUSIONS

- GIS is an important tool for data manipulation and calculation
- Review soils in light of watershed character if soils data limited (adjacent watersheds)
- TRMM and IMERG may help with ungauged watersheds
- We do the best we can – prior or follow-on
  - Understand context of prior efforts
  - Respect prior efforts

QUESTIONS

ENJOY THE REST OF THE CONFERENCE…

IAFSM

Illinois Association for Floodplain and Stormwater Management