# HOLISTIC WATERSHED MANAGEMENT FOR EXISTING AND FUTURE LAND USE DEVELOPMENT ACTIVITIES: OPPORTUNITIES FOR ACTION FOR LOCAL DECISION MAKERS: PHASE 1 – MODELING AND DEVELOPMENT OF FLOW DURATION CURVES (FDC 1 PROJECT)

## SUPPORT FOR SOUTHEAST NEW ENGLAND PROGRAM (SNEP) COMMUNICATIONS STRATEGY AND TECHNICAL ASSISTANCE

## TASK 5. APPENDIX B – TSC COMMENTS

1ST DRAFT APRIL 30, 2021

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# Comments received after the presentation

- We discussed trying to get a handle on groundwater withdrawals water returns. A more direct measure of groundwater storage might be found by looking at trends in groundwater elevations (water table). This would aggregate effects of withdrawals and changes in infiltration.

  Response: Agreed, unfortunately, there appears to be very limited groundwater data in the Taunton River/Wading River watersheds. Any suggestions for there to obtain data are welcome.

- In Table 2, Parks and Cemeteries are lumped into "Developed Open Space", along with Stadiums, Racetracks & Drive-Ins. Seems that they are more similar to "Participation Recreation" land uses and should be lumped into "Open Space".

  Response: The land use grouping in Table 2 was only for mapping purposes to assess changes in land use over time. The land use classifications used for HRU development were based on MassGIS 2016 Land use/ Land cover data and are discussed in section 4.1.

Table 2. Land use types for 1971-2005 datasets and revised categories

| MASS GIS Category | MASS GIS Description | Revised Category for Mapping |
|---|---|---|
| Cropland | Intensive agriculture | Agriculture |
| Pasture | Extensive agriculture | |
| Woody Perennial | Orchard; nursery; cranberry bog | |
| Forest | Forest | Forest |
| Wetland | Nonforested freshwater wetland | Wetland |
| Salt Wetland | Salt marsh | |
| Open Land | Abandoned agriculture; power lines; areas of no vegetation | Open Space |
| Participation Recreation | Golf; tennis; Playgrounds; skiing | |
| Spectator Recreation | Stadiums; racetracks; Fairgrounds; drive-ins | Developed Open Space |
| Urban Open | Parks; cemeteries; public & institutional greenspace; also vacant undeveloped land | |

- In Table 25, was “Open Space” reclassified into “Developed Open Space”, or is it absent?

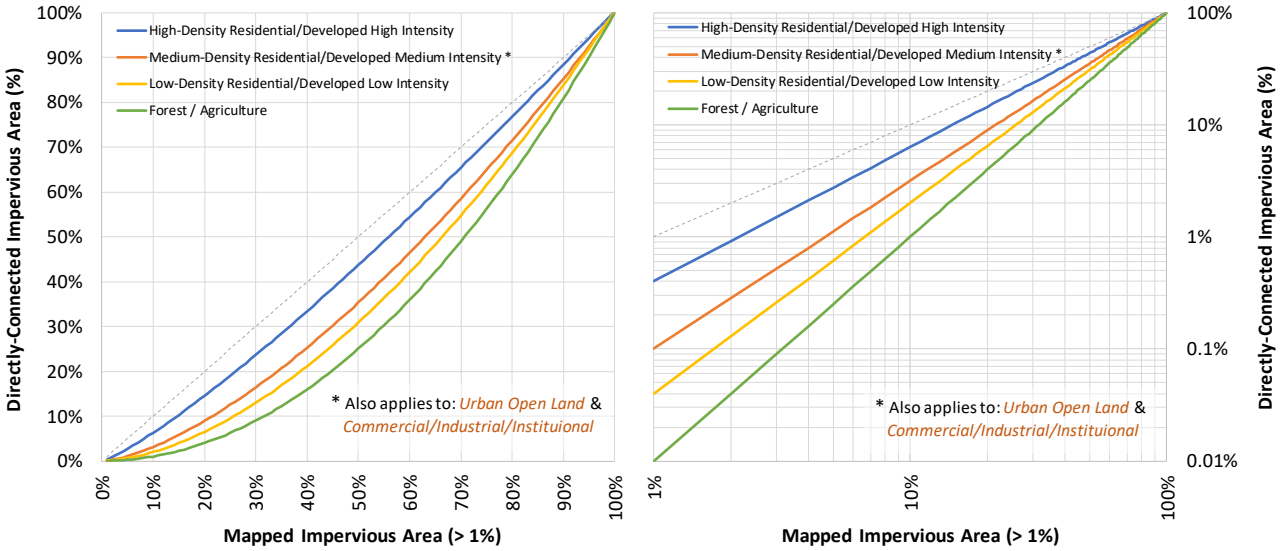
**Table 25. Final HRU categories**

| HRU Code | HRU Description | Land Use | Soil | Slope | Land Cover |
|---|---|---|---|---|---|
| 1001 | Paved Forest | Paved Forest | N/A | N/A | Impervious |
| 2001 | Paved Agriculture | Paved Agriculture | N/A | N/A | Impervious |
| 3001 | Paved Commercial | Paved Commercial | N/A | N/A | Impervious |
| 4001 | Paved Industrial | Paved Industrial | N/A | N/A | Impervious |
| 5001 | Paved Low Density Residential | Paved Low Density Residential | N/A | N/A | Impervious |
| 6001 | Paved Medium Density Residential | Paved Medium Density Residential | N/A | N/A | Impervious |
| 7001 | Paved High Density Residential | Paved High Density Residential | N/A | N/A | Impervious |
| 8001 | Paved Transportation | Paved Transportation | N/A | N/A | Impervious |
| 9001 | Paved Open Land | Paved Open Land | N/A | N/A | Impervious |
| 10110 | Developed OpenSpace-A-Low | Developed OpenSpace | A | Low | Pervious |
| 10120 | Developed OpenSpace-A-Med | Developed OpenSpace | A | Med | Pervious |
| 10210 | Developed OpenSpace-B-Low | Developed OpenSpace | B | Low | Pervious |
| 10220 | Developed OpenSpace-B-Med | Developed OpenSpace | B | Med | Pervious |
| 10310 | Developed OpenSpace-C-Low | Developed OpenSpace | C | Low | Pervious |
| 10320 | Developed OpenSpace-C-Med | Developed OpenSpace | C | Med | Pervious |
| 10410 | Developed OpenSpace-D-Low | Developed OpenSpace | D | Low | Pervious |
| 10420 | Developed OpenSpace-D-Med | Developed OpenSpace | D | Med | Pervious |
| 11000 | Forested Wetland | Forested Wetland | N/A | N/A | Pervious |
| 12000 | Non-Forested Wetland | Non-Forested Wetland | N/A | N/A | Pervious |
| 13110 | Forest-A-Low | Forest | A | Low | Pervious |
| 13120 | Forest-A-Med | Forest | A | Med | Pervious |
| 13210 | Forest-B-Low | Forest | B | Low | Pervious |
| 13220 | Forest-B-Med | Forest | B | Med | Pervious |
| 13310 | Forest-C-Low | Forest | C | Low | Pervious |
| 13320 | Forest-C-Med | Forest | C | Med | Pervious |
| 13410 | Forest-D-Low | Forest | D | Low | Pervious |
| 13420 | Forest-D-Med | Forest | D | Med | Pervious |
| 14110 | Agriculture-A-Low | Agriculture | A | Low | Pervious |
| 14120 | Agriculture-A-Med | Agriculture | A | Med | Pervious |
| 14210 | Agriculture-B-Low | Agriculture | B | Low | Pervious |
| 14220 | Agriculture-B-Med | Agriculture | B | Med | Pervious |
| 14310 | Agriculture-C-Low | Agriculture | C | Low | Pervious |
| 14320 | Agriculture-C-Med | Agriculture | C | Med | Pervious |
| 14410 | Agriculture-D-Low | Agriculture | D | Low | Pervious |
| 14420 | Agriculture-D-Med | Agriculture | D | Med | Pervious |
| 15000 | Water | Water | N/A | N/A | Pervious |

Response: Yes, (see Table 22), “Bare Land” (land cover code = 20) in MassGIS 2016 land use/land cover layer was reclassified to “Developed Open Space” to minimize the number of HRU categories and to be consistent with the number of major land use categories available in Opti-Tool.

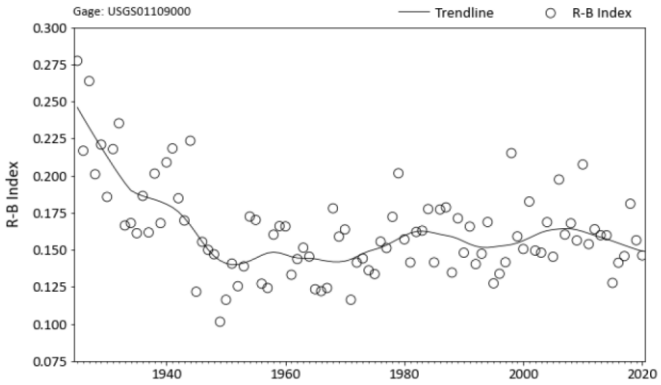
- Figure 65 refers to "Urban Open Land" – how does this relate to the above categories?

  Response: The "Urban Open Land" in the Sutherland Equations is equivalent to the "Open Land" land use category (land use code = 2) in MassGIS 2016 land use/land cover layer (see Table 22).




- Figure 32 (and others) – what type of trendlines are these (splines?). Please add to the caption.

  Response: Trendlines were created using the LOWESS function, added to the caption.




- The data for July in Table 29 is high by 19.2%, which contrasts sharply with August, which is low by 43.2%. Any explanations? The August change looks significant, but perhaps the July and September numbers are not.

Table 29. IHA parameter comparison for historical and current conditions

| Group 1. Magnitude and timing | 1972-1990 Average (cfs) | 2001-2019 Average (cfs) | % difference |
|---|---|---|---|
| January | 116.19 | 102.66 | -11.65% |
| February | 117.82 | 104.57 | -11.25% |
| March | 143.77 | 151.01 | 5.04% |
| April | 140.82 | 147.19 | 4.52% |
| May | 89.20 | 82.37 | -7.66% |
| June | 66.84 | 69.24 | 3.58% |
| July | 23.91 | 28.51 | 19.22% |
| August | 31.25 | 17.77 | -43.15% |
| September | 23.54 | 20.07 | -14.77% |
| October | 44.21 | 45.98 | 4.02% |
| November | 75.90 | 74.35 | -2.05% |
| December | 107.81 | 105.47 | -2.17% |

Response: We added a box plot graph and tested for significance. No significance among the monthly comparison (alpha = 0.1). The text has been added to the memo.

- Figure 31: There is a statistically significant increase in high flows in the winter. Could this be related to snowpack storage?

  Response: Possibly, however, we did not assess changes to the historical snowpack.

- A related question: Figure 75 refers to snowpack storage. I'm wondering if this was included in the model.

  Response: Snowpack will be modeled in LSPC. The results in the tech memo are all based on observed data.

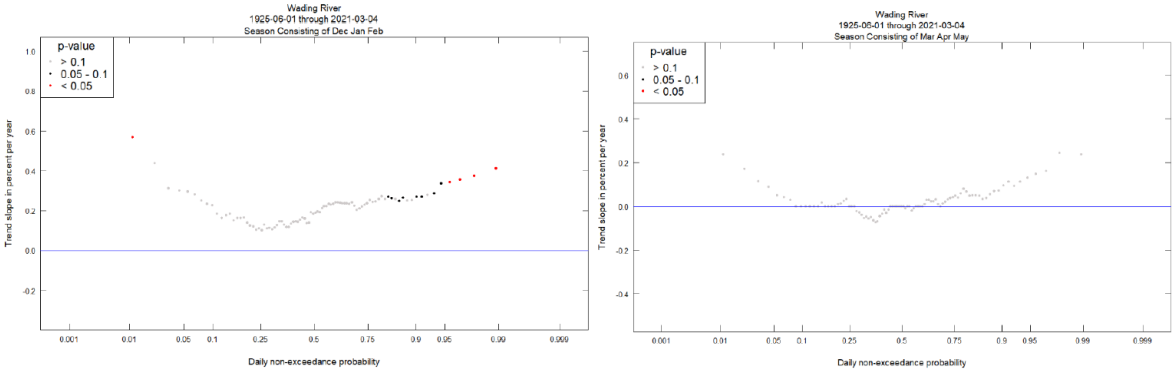



Figure 31. Quantile-Kendall plots 1925-2020 by season. Summer (top left), Fall (top right), Winter (bottom left), Spring (bottom right).

- Figures 70 and 71: please provide confidence limits on the slope; this will give us a feel for statistical significance.

  Response: Confidence limits were added

- Figure 73: We already talked bout some of the limitations here. The real differences are in a region lacking data for the 1971-1990 time period. Perhaps a less biased way to present the data would be to bin the rainfall data and use bar charts. If you look at the data for rainfall between 3 and 4 inches, I'm not sure you'd see a big effect.

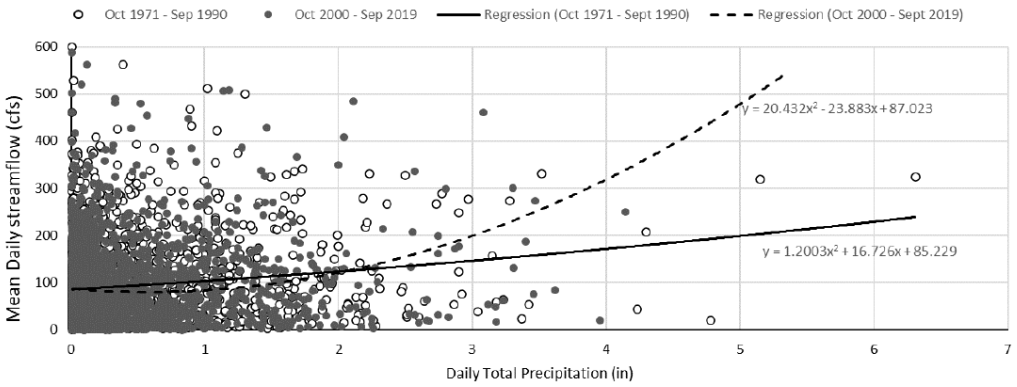



**Figure 73. Streamflow versus precipitation for days with measurable precipitation. Regression only (top), regression and data (bottom).**

Response: Agreed, we feel that based on the feedback, this is not an appropriate way to present the observed data. When comparing modeling results, we may compare this and your suggested graph.

- Figure 78: It's not clear to me how subsurface outflow in the LSPC model is estimated, or whether Managed Stormwater Runoff affects this quantity. Is the Aquifer for Infiltrated Water output from Opti-Tool basically another form of baseflow? How would long term effects of changes in infiltration on groundwater storage and baseflow be captured here?

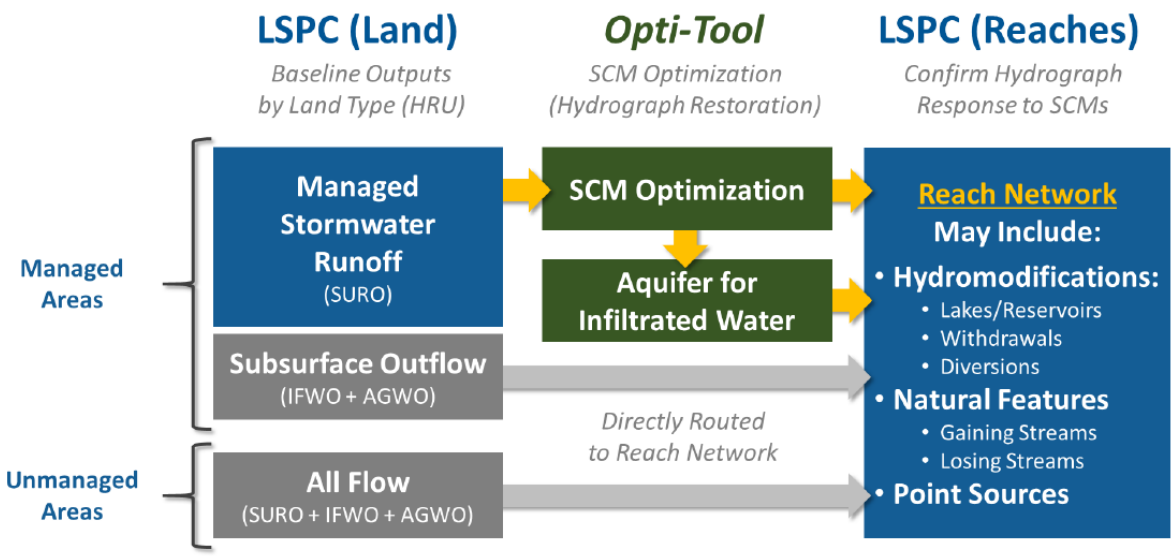



Figure 78. LSPC and Opti-Tool linkage schematic for integrated watershed-SCM hydrology modeling.

Response: The interflow and groundwater outflow from LSPC is based on the baseline condition before any planned (future) SCM implementation. When we simulating infiltrating SCMs in Opti-Tool, that infiltration (groundwater recharge) will not interact with the groundwater component in LSPC but stay on a parallel path. The parallel path from Opti-Tool tracks and accounts for a separate baseflow which is released back to the instream through user-defined recession coefficient (could be calibrated if data are available).

- I noticed that agricultural land use represented a very small percentage of the land use in the studied watersheds. This may not always be the case in basins where stormwater is being managed. In Vermont agricultural hydrologic modifications may be significant, if not currently than historically. Mentioning how agricultural tile and ditch systems may affect watershed hydrology over the period of gaged flows would be important, and, I think, deserve mention in this pilot.

  Response: We have added text to Section 2.1.3

- Table 9 - IHA parameter groupings. I appreciate the description of ecosystem impacts that addresses biological response. Wouldn't it be interesting to have another column that provides insights on the physical process responses, i.e., the effects of IHAs on the hydraulic conditions that drive erosion and deposition processes that affect how aquatic habitat is formed and maintained? I'd like to see more interface of the flow frequency data and mobilization flow data onto the same graphs.

  Response: While we have not added another column to the IHA table, we have added some new graphs that include bankfull and mobilizing flows, these include a graph of the high end of the FDC over the period of record and 3-day maximum flows between the historic and current period. We would welcome suggestions and collaboration on updating the IHA table to improve insights into the physical process responses.

- During the presentation today there's was some interesting data on sediment mobilization. This did not appear in the Task 5 memo. Will thin be in the next memo? I would like to look at this more closely. Could you make the Hawley/Vietz paper available?

  Response: We have sent the paper.

- In the Task 5 memo, page 44, there's the implication that bankfull flows may change over time due to incision. "An incised, deeper channel may have higher flows that remain confined to the channel, instead of overtopping the bank and accessing the floodplain. It is, therefore, reasonable to assume that the discharge that would be considered bankfull may have changed over time in the Wading River. No robust assessment of Wading River fluvial geomorphology was available to further investigate channel changes over time." While the flows from top-of-bank to top-of-bank may change over time due to incision. What would be considered bankfull flow and larger flows, don't necessarily change, but become contained within the stream that is becoming increasing incised. The representation of Qbkf is correct in Figure 34.

  Response: The text has been revised in the memo.

- Will modelled LIDs include wetland and floodplain restoration? These practices may not be cost-effective (i.e., feasible) in the studied watersheds, but they may be highly cost-effective in other watersheds where there are stormwater management concerns.

Response: Currently we do not plan to explicitly represent floodplain restoration, although wetlands may be simulated. However, these wetlands would be on the land, impacting runoff from HRUs and not adjacent to the stream/treating stream flows. While we have sufficient data and previous studies to help us guide our work in understanding how land use conversion and BMP implementation may impact the FDC, we are less certain of the relationship between floodplain restoration and FDC restoration. While these practices may not be modeled in the Opti-Tool, there may certainly be an opportunity to post-process data to make some conclusions. We would welcome any thoughts and suggestions on this.

- At the end of the session, there was a comment that we're perhaps only really interested in the low flows (i.e., the one-inch storm) from a water quality standpoint. I firmly believe that we will not see ecological restoration if the 5-10 storm is turning into the 25-50 yr storm due to impervious and ditching and/or climate change, and the bed sediment and organic substrates are constantly being mobilized. I hope this project looks at the high flow scenarios that will cross those critical thresholds affecting erosion and deposition processes in our urbanizing watersheds.

  Response: Agreed, we have added graphs that show these thresholds along with IHA parameters/FDCs for different periods.

# Comments during presentation

- 10:08:00 From Laura Schifman, MassDEP to Everyone: Check this paper out! They measured exactly what you are describing, Ray. https://www.pnas.org/content/116/15/7575

- 10:09:22 From mark Voorhees to Everyone: Thanks, Laura!

- 10:09:44 From Margherita Pryor to Everyone: there was also a study at the University of Wisconsin where they strapped air quality and temp sensors on a bike and investigators rode through Madison looking for areas where the air quality and temp were good. No surprise, areas with lots of tree canopy and less pavement were at the top

- 10:10:01 From rcody to Everyone: indeed, thanks!!

- 10:10:54 From Laura Schifman, MassDEP to Everyone: Thanks Margherita, that sounds cool, too! love the sampling via bike

- 10:15:20 From Tom Ballestero to Everyone: low flows are on RHS?

- 10:15:45 From Tom Ballestero to Everyone: LHS

- 10:18:26 From Chip Kilduff to Everyone: Are the lines on these plots spline fits or something else?

- 10:20:39 From Dale White (GLEC) to Everyone: What would be the return interval of the modern bankfull flows?

- 10:21:49 From James Houle to Everyone: is bankfull expected to be static over a century?

- 10:24:05 From Mike Kline, Fluvial Matters, LLC (VT) to Everyone: I think bankfull flows will change over time with changes in flow frequency but it is not a function of how incised the channel is. It's not a top-of-bank to top-of-bank measurement.

- 10:25:46 From Tom Ballestero to Everyone: 1994 - 2012 looks closer to the earlier time period

- 10:25:48 From Allison Roy to Everyone: Seems like going back a few for the current would better match that historic

- 10:26:01 From Allison Roy to Everyone: Yes, what Tom said!

- 10:27:04 From Chip Kilduff to Everyone: How about statistical significance here; July flows are 20% higher!

- 10:27:13 From Khalid Alvi to Everyone: We tried to find periods that do not overlap each other and are apart from each other to go back as far as possible.

- 10:29:06 From John Riverson to Everyone: I like the idea of investigating 1994-2012 as "current" relative to the 1972-1990 "historical" period.

- 10:31:27 From Chip Kilduff to Everyone: How high do r2 values need to be considered "good" for this type of data?

- 10:35:27 From Tom Ballestero to Everyone: Time to discuss now?

- 10:47:25 From Naomi Detenbeck to Everyone: They were looking at cumulative values.

- 10:53:56 From Kimberly Groff to Everyone: I need to jump off for another meeting.

- 10:54:31 From Allison Roy to Everyone: Water conservation is the most obvious management approach...particularly outdoor water use, which is often the big source, at least residentially

- 10:55:32 From James Houle to Everyone: or flood skimming and artificial recharge if you have sufficient aquifer storage.

- 10:58:53 From Blaine Hastings to Everyone: The 1970 period coincided with a long-term phase shift in the NAO index impacting decadal precipitation patterns

- 11:07:03 From MPRYOR to Everyone: Can you describe what a "paved" agriculture parcel would be?

- 11:10:50 From Allison Roy to Everyone: So, this EIA calculation was only done for the developed land uses and does not include soils and slope?

- 11:11:17 From MPRYOR to Everyone: Interesting about the paved ag areas. One thing to consider going into the implementation of this model is that creating surfaces to collect manure for example is one of the most popular BMPs

- 11:15:55 From Blaine Hastings to Everyone: Are specific stormwater control BMPs able to be represented in the HRU framework?

- 11:17:31 From Chip Kilduff to Everyone: Do you take into account storage provided by small dams?

- 11:18:28 From Blaine Hastings to Everyone: I suspect municipalities will have great interest in cost-benefit analysis at this scale.

- 11:19:22 From MPRYOR to Everyone: The model and observed FDCs do track really well, but it looks like the model consistently overestimates the flow. Are the differences significant?

- 11:25:41 From Laura Schifman, MassDEP to Everyone: I really like the multi-functionality aspect that you are including here.

- 11:31:16 From MPRYOR to Everyone: This may be discussed later, but when the previous slide is based on ecological impacts, where are those impacts defined? Are they built into the initial desired outcomes and hence those precipitation events are selected?

- 11:33:17 From mark Voorhees to Everyone: From a WQ perspective for retrofitting SCMs into existing developed land optimization will likely show that significantly smaller sized controls will be the most cost-effective solution and also go a long way toward significantly increasing recharging by treating IC

- 11:34:07 From mark Voorhees to Everyone: will this be reflected by choosing a smaller size event as part of the mix of design storms evaluated

- 11:34:31 From Tom Ballestero to Everyone: not really surprising that a system designed for 1-inch of rainfall is ineffective for the 100-year flood

- 11:35:15 From Khalid Alvi to Everyone: Mark: yes, we can add any storm size in the mix.

- 11:36:32 From mark Voorhees to Everyone: For future development can this approach be used to optimize the best level of control (e.g., local ordinances) to offset future impacts?

- 11:40:27 From Blaine Hastings to Everyone: Is it easy enough to run the Opti-tool with a FDC flow reduction for a given %-tile as the optimization metric?

- 11:40:36 From Blaine Hastings to Everyone: vs. design storms

- 11:43:57 From Chip Kilduff to Everyone: To what extent are detention facilities designed for infiltration? Is there a way to account for this in the model?

- 11:49:04 From Mike Kline, Fluvial Matters, LLC (VT) to Everyone: I totally agree with what Mark V. is saying to also keep an eye on the higher flows.

- 11:53:21 From mark Voorhees to Everyone: Great suggestion Allison about soil amendments. I just read in the Vermont Land Trust Newsletter that increasing soil carbon by 1% would reduce annual runoff by 23,000 gals per are per year!

- 11:54:32 From Chip Kilduff to Everyone: Wow! What are the best ways to increase soil organic carbon? Is this a biochar type of thing or something else?

- 11:54:57 From Jeff Barbaro, USGS to Everyone: I need to jump off. Thanks for the update

- 11:55:22 From Tom Ballestero to Everyone: I also need to jump off. Great effort.

- 11:55:22 From rcody to Everyone: yes, i agree. Mark, we will want to discuss this with the Team b/c my sense is that the approach is sort of like a Hawley Deitz proof where u add SCM until u achieve the Berry Brook-like UNH result. but what about ET, what about landscape architecture, green roof, and similar architectural approaches, etc. etc. . ..

- 11:55:47 From Laura Schifman, MassDEP to Everyone: Wow. and from a soil perspective, we found that urban soils had less carbon in the upper 50 cm than wildland soils, so there is lots of opportunity for more C to be added. https://iopscience.iop.org/article/10.1088/1748-9326/abbb00/pdf

- 11:56:06 From mark Voorhees to Everyone: They didn't mention specifics except to get farmers to focus on soil health. I'd like to learn more

- 11:58:38 From rcody to Everyone: if you have any questions or comments u did not have the opportunity to present here today, please feel free to submit those to me. otherwise, THANK YOU for your time today!! Talk to you all soon. ..

- 12:00:56 From mark Voorhees to Everyone: thanks Laura- I think focusing on urban soils is an amazing opportunity and also for improving IC disconnection performance

- 12:02:02 From Laura Schifman, MassDEP to Everyone: I agree, Mark - so much more to figure out.

General Response: Several of the questions were answered during the meeting, several more were also addressed based on comments received after the meeting. The memo has been updated accordingly. One of the main outstanding points concerns the choice and analysis of the 'historical' period. We have added some additional assessments, including testing for statistical significance among monthly values and adding confidence limits to select graphs. While it was discussed to change the historical period and perhaps the current period, we are not sure that this would provide much additional insight.