National Institute of BUILDING SCIENCES™

Panel Decision and Report

SRP NJMCPT031119
Pequannock Township
Morris County, NJ

June 29, 2020

Innovative Solutions for the Built Environment

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1. Summary

Based on the submitted scientific and technical information, and within the limitations of the Scientific Resolution Panel (SRP), the Panel has determined that the data from the Federal Emergency Management Agency (FEMA) does not satisfy National Flood Insurance Program (NFIP) mapping standards defined in FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping and must be revisited.

Factors influencing this decision are complex and documented herein to show the interrelationships between decisions, recommendations and actions of all parties associated with the Pequannock Township appeal of flood risk mapping products in FEMA Region II. In general, observations, conclusions and recommendations from this Panel are based primarily on four (4) key categories:

1. Quality of FEMA mapping products
2. Technical and regulatory merit of appeal and associated evidence
3. Depth and breadth of communication between federal and local agencies
4. Opportunity to improve regulatory information enforced by state and local floodplain ordinance

It is the Panelists' sincere hope the observations, conclusions and recommendations offered in this report will offer productive guidance to FEMA so the Pequannock Township may reconcile differences of opinions with FEMA Region II on the Pompton River, West Ditch and East Ditch floodplains in New Jersey.

2. Introduction

This report serves as the recommendation to the FEMA Administrator from the NIBS Pequannock Township, MC, NJ, Scientific Resolution Panel. SRPs are independent panels of experts organized, administered, and managed by NIBS for the purpose of reviewing and resolving conflicting scientific and technical data submitted by a community challenging FEMA's proposed flood elevation. SRPs are charged with helping to efficiently resolve appeal and protest issues between FEMA and communities by acting as an independent third party in an effort to obtain the best data possible for the community's Flood Insurance Rate Maps (FIRMs).

This report presents the panel findings, the SRP process for deliberation, the justification for the panel's decision, references, and recommendations for the Community and FEMA to move forward in the process.

3. Panel

Panel ID: NJMCPT031119

Panel Name: Pequannock Township, MC, NJ

FEMA Region: II

Panel Members:

- Thomas P. Ballestero, PhD, PE, PH, PG, CGWP, University of New Hampshire, Durham, NH. Dr. Ballestero is the Director of the Stormwater Center at the University of New Hampshire. His career spans over four decades and has focused on hydrology and water resources engineering. Dr. Ballestero has taught many of the hydraulics and hydrologic models in use today, as well as their predecessors.

- Todd Cochran, PE, CFM, House Moran Consulting, Inc., Smyrna, GA. Mr. Cochran is a professional Civil Engineer with more than 20 years of experience in water resources. Todd's experience includes the analysis and design of flood mitigation/control systems, stormwater BMPs, dam hydraulics, bridges, and culverts. Todd has managed watershed-level flood studies, FEMA Letters of Map Change, stormwater/watershed master plans, and flood control master plans.

- Justin Shaw, PE, HMH Engineering, Coeur d'Alene, ID. Mr. Shaw is a professional civil engineer with over a decade of water resources experience and is the lead water resources engineer at HMH. He has worked on numerous hydrologic, hydraulic, civil, and erosion control projects across the county including Louisiana, Alaska, and Idaho. Justin has performed FEMA No-rise analyses, evaluated watersheds, developed flood mitigation measures, developed ArcGIS tools to assist with the planning and management of drainage features.

- Brian Varrella, PE, CFM, Colorado Department of Transportation, Fort Collins, CO. Mr. Varrella is a professional engineer in Colorado with 22 years of specialized experience in hydraulic analysis and floodplain management. He served 8 years in the private sector, was a local floodplain manager for 9 years, and has worked for the State of Colorado for the past 5 years at the Department of Transportation as Region Hydraulic Lead and Resident Engineer. He is a Certified Instructor for the National Highway Institute (NHI), served as Vice Chair of the Association of State Floodplain Managers (ASFPM), and is currently leading a statewide initiative at the Colorado DOT to institutionalize 2D hydraulic analyses to inform the planning and budgeting phases of infrastructure projects.

- Joseph P. Wilson, PE, PH, Wilson Hydro, LLC, Rolla, MO. Mr. Wilson has over 30 years of private consulting engineering experience working exclusively with hydrology and hydraulics related projects. These projects include floodplain mapping, floodplain map revisions, and amendments. Mr. Wilson taught Engineering Hydrology and Elementary Fluid Mechanics at the University of Missouri-Rolla for five years. He has served as an expert witness in over a dozen hydrology and hydraulics related cases. He has previously served on the Harris County, Texas, scientific resolution panel. Mr. Wilson currently works with the Missouri Department of Natural Resources Dam and Reservoir Safety Program.

4. Basis for Appeal

Pequannock Township is located in Morris County, NJ. FEMA initiated the Morris County Flood Insurance Study in 2006. Preliminary Flood Insurance Rate Maps (FIRMs) were issued in 2010. Revised Preliminary FIRMs were issued in 2011, 2015, 2016, and 2017. Consultant coordination officer (CCO) meetings were held in the following locations:

- Morristown - March 2016
- Troy Hills - March 2016
- Morristown - November 2017

The three-month appeal period began in February 2018. Pequannock Township submitted an appeal April 2018, an appeal acknowledgment letter was issued in June 2018, and an appeal resolution letter was issued in February 2019. The FEMA appeal resolution letter denied the Townships concerns as not providing sufficient scientific or technical data. The Township requested a review of the Flood Insurance Study by the Scientific Resolution Panel (SRP) on March 11, 2019.

Pequannock Township appealed the Pompton River and East Ditch FEMA mapping effort based on insufficient scientific or technical data as follows:

- Pompton River: Incorrect floodway modeling. Pequannock Township submitted floodway stations were incorrectly located within/adjacent to ineffective flow areas. The Township stated a flaw in the Hydrologic Engineering Center River Analysis System (HEC-RAS) one-dimensional (1D) hydraulic modeling floodway routine. Additionally, the Township noted insufficient cooperation and communication between FEMA and the Township. This led to confusion of the FEMA process for the Township, and the lack of coordination for floodway modeling and associated regulatory flood hazard mapping.
- East Ditch: Ineffective flow area placement and incompatibility with adjacent West Ditch Base Flood Elevations (BFEs). Pequannock Township submitted the ineffective flow areas were excessive causing artificially elevated BFEs. The Township also noted East Ditch BFEs were significantly higher than the West Ditch BFEs despite the likely hydraulic connection between to the two riverine systems. The Township appeal further stated hydraulic methodology was incorrectly applied and mathematical errors existed in analyses supporting revised flood hazard boundaries and BFEs.

5. Data Submitted by the Community and FEMA

5.1. APPELANT

The Community submitted the following documentation and data as part of the Pequannock Township's appeal:

1. Technical report titled Technical Report in Support of Pequannock Township's Appeal of Revised Preliminary Flood Insurance Studies and Revised Preliminary Flood Insurance Rate Maps for Morris County, New Jersey dated April 27, 2018, prepared by SWM.
2. Cover letter to FEMA Region II from the Township of Pequannock for the SRP request form dated March 11, 2019.
3. The SRP Request Form dated March 11, 2019.
4. The National Institute of Building Sciences SRP Community Submittal Agreement dated March 11, 2019.
5. Appeal of Revised Preliminary Pompton River Floodway and East Ditch Special Flood Hazard Area, Pequannock Township, Morris County, New Jersey, SRP Presentation, April 30, 2020.
6. SWM – East Ditch FEMA Appeal Model, HEC-RAS Model, 4/25/2018.
7. SWM – Pompton River Floodway to FEMA, HEC-RAS model, undated.

5.2. FEMA

FEMA submitted the following data and documentation in response to the Pequannock Township's appeal:

1. Preliminary Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) report for the Township of Pequannock, Morris County, New Jersey, August 22, 2017.
2. Letter to Mr. Adam Brewer, Township of Pequannock, dated February 12, 2019, appeal resolution denying the appeal.
3. Hydraulic Analysis of the East Ditch Floodplain, Morris County, New Jersey, RAMPP Fairfax, Virginia, August 2017.
4. Hydraulics_Summary_NJDEP.DOCX, undated.
5. Appeal Start Submittal Acknowledgement for the Township of Pequannock, Morris County, New Jersey, letter from FEMA Region II dated June 4, 2018.
6. Scientific Resolution Panel, Morris County, NJ, Township of Pequannock, FEMA RiskMAP presentation, April 30, 2020.
7. East Ditch, HEC-RAS model, April 21, 2017.
8. Pompton River Detailed Study, HEC-RAS model, undated.
9. West Ditch compressed by East Ditch, HEC-RAS model, undated.

10. Final Hydrology Report, Riverine Flood Insurance Studies in FEMA Region II, New Jersey, Natural and Technological Hazards Management Consulting, Inc., Montvale, New Jersey, February 3, 2009.
11. 200430_Pequannock_SRP_wirtten responses_FEMA_final.DOCX, the file name has a date in it, however the document is undated.

6. Summary of Panel Procedures

6.1. TIMELINE

Key dates for the Pequannock Township SRP are listed below:

- 4/03/2020, Panel kickoff meeting
- 4/16/2020, Initial meeting
- 4/30/2020, Oral Presentations
- 5/07/2020, Oral Presentations debrief and discussion
- 5/26/2020, Panel discussion and vote
- 6/16/2020, Panel discussion of report
- 6/23/2020, Panel discussion of report
- 6/29/2020, Submission of final report

6.2. REVIEW OF COMMUNITY APPEAL AND SUPPORTING DATA

The SRP reviewed all the data provided by the Township that was included in their appeal request. This included the report and revised HEC-RAS models prepared by Storm Water Management Consulting, LLC (SWM 2018). The model and floodplain/floodway mapping revisions were found to NOT meet FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping.

The Pompton River HEC-RAS model submitted by Pequannock Township revised the floodway encroachment stations from the FEMA model. This re-delineation of the floodway appears to meet FEMA and New Jersey's maximum allowable surcharge limits of 0.2 feet. Additionally, the Township-delineated floodway meets the development objectives of the community outlined in local floodplain ordinance, state floodplain standards, and Title 44 of the Code of Federal Regulations (44 CFR) without unduly shifting conveyance to or allowable rises on adjacent properties.

The East Ditch HEC-RAS model submitted by Pequannock Township revised the FEMA model by adjusting the encroachment stations. The Township noted FEMA ineffective areas were excessive and caused the East Ditch BFEs to be substantially higher than the West Ditch. The Township HEC-RAS model reduced the ineffective flow areas by percentages (0 to 60%.) to calibrate water surface elevations to the West Ditch BFEs. This method of reducing ineffective flow areas is unique and not a typical modeling technique documented in FEMA guidance or in the HEC-RAS Hydraulic Reference Manual (HEC 2016) or User's Manual (HEC 2016). Ineffective flow areas should be placed as needed based on topographic or human-made features obstructing flow.

6.3. REVIEW OF FEMA RESPONSE AND SUPPORTING DATA

FEMA failed to review the modeling submitted by the Community. The review was therefore incomplete and did not adequately address or resolve the appeal.

FEMA submitted a Microsoft Word document named, "Hydraulic_Summary_NJDEP.docx." This document provides a basic description of the hydraulic analysis that was conducted on many streams in and around the Appellant Community, including the Pompton River. This document does not include details of how the floodway encroachments were determined, except that floodway calculations were run on the calibrated models using a target maximum allowable surcharge value of 0.2 foot.

FEMA provided additional details on the HEC-RAS model on the Pompton River in the Appeal Resolution letter, dated February 12, 2019. The Appeal Resolution letter states the Revised Preliminary hydraulic modeling for the Pompton River is based on a one-dimensional (1-D) unsteady HEC-RAS model. The letter explains the difference in how ineffective flow areas are computed in an unsteady vs steady HEC-RAS model. The letter also explains the typical process of developing a floodway with an unsteady flow HEC-RAS model. However, as discussed previously, the HEC-RAS model provided by FEMA is a steady-state model.

6.4. ORAL PRESENTATIONS AND Q&A SESSION

The SRP attended (remotely) presentations by both the community and FEMA on April 30, 2020. The community presented their justification for the appeal on both the Pompton River and the East/West Ditch and FEMA offered their conclusions and opinions on the same.

6.5. DISCUSSION OF ORAL PRESENTATIONS

FEMA's conclusion that "Appellant did not provide sufficient data to demonstrate that the preliminary hydraulic methodology was inappropriate or incorrect and has not provided alternative methods or applications that are more correct" was rendered without reviewing the Community data in its entirety.

6.6. VOTE ON DETERMINATION

The SRP voted on May 26, 2020. The decision was unanimous to recommend that FEMA's data does not satisfy National Flood Insurance Program (NFIP) mapping standards defined in FEMA's Guidelines and Standards for Flood Risk Analysis and Mapping and must be revisited.

6.7. REPORT PREPARATION

The Panel Decision and Report for SRP NJMCPT031119, Pequannock Township, Morris County, NJ, was submitted to the National Institute of Building Sciences on June 29, 2020.

7. Recommendation

Based on SRP findings it is recommended FEMA revisit the Pompton River analysis and coordinate with the community to establish floodway limits.

The SRP recommends FEMA revisit the distribution of flow and definition of ineffective flow areas for the common conveyance of the East Ditch and West Ditch floodplain.

8. Rationale for Findings

8.1. POMPTON RIVER

The HEC-RAS modeling for the Pompton River floodway was reviewed in detail. The following discussion describes modeling assumptions and potential impacts on the resulting special flood hazard area.

8.1.1. Discussion of FEMA Modeling

The FEMA Pompton River modeling included floodway boundary stations located inside ineffective flow areas. This does not appear to be a typical modeling practice. The floodway does comply with New Jersey standards of 0.2 feet as the maximum allowable surcharge.

A 1D HEC-RAS version 4.1 model of the Pompton River was provided by FEMA. The model included both multi-profile and floodway simulations. The ineffective flow stations and floodway encroachment stations were reviewed for each cross-section to evaluate the appellant's claim of an incorrect floodway model. The model provided by FEMA was a steady flow HEC-RAS model. Therefore, the explanation provided in the FEMA Appeal Resolution letter, which described the process of using an unsteady HEC-RAS model to establish ineffective flow areas and base water surface elevations, was invalid.

Due to the incorrect placement of the ineffective flow areas, the floodway encroachment stations may need to be revised after the model is updated. The differences between the FEMA floodways and community floodways should be resolved via closer communications between the two parties and abiding by state and federal criteria.

8.1.2. Discussion of Community Modeling

The Community submitted a revised HEC-RAS model of the Pompton River that refined the floodway stations to more clearly meet community needs without exacerbating flood risks on adjacent communities. However, the submitted model and documentation did not meet all of FEMA's requirements for a floodway revision. Coordination with the Community during the development of the floodway boundaries would have provided the opportunity to remove the floodway mapping from contention by technical and regulatory means.

The SWM (2018) report suggested coincident stations for ineffective flow areas and floodway boundaries, or floodway boundary stations inside ineffective flow areas, would eliminate floodway encroachment computations at six cross sections. This opinion is incorrect; coincident stationing for ineffective flow areas and floodways doesn't negate, skip or otherwise cancel surcharging calculations, but rather causes negligible surcharging. A sensitivity analysis would show the differences between an encroachment boundary that introduces a vertical wetted perimeter with resistance to conveyance, and an ineffective

flow boundary which introduces a smooth water-on-water boundary with no added wetted perimeter, is nearly imperceptible in the Pompton River model. The claim that no floodway encroachments were computed by HEC-RAS simulations at six cross sections (SWM 2018, Sec. 4.1, Page 10, 5th paragraph) is incorrect as it has no technical merit.

The SWM Report (2018) suggested placing a floodway station at or near an ineffective flow boundary is contrary to the definition and regulatory intent of a floodway (Sec. 4.1, Page 11, 1st paragraph). It is common practice for floodway boundaries to be calculated coincident with other stations, including flood fringe limits, ineffective flow areas, and physical features blocking conveyance. This can occur from any combination of standards of practice for calculating floodway encroachment stations which require line smoothing, negative surcharge mitigation, engineering judgement and a number of other necessary modifications resulting in floodway boundaries that do not fully encroach to the allowable surcharge at every cross section. This statement has no regulatory or practical merit based on established standards and guidelines for mapping floodways.

Section 4.1 of the SWM Report (2018) suggested there is an existing "bug" in the HEC-RAS software that ignores the presence of ineffective flow area when computing allowable floodway surcharge (Page 19, 1st paragraph). This is false based on the technical information provided in preceding paragraphs in this report where ineffective flow adds no vertical wetted perimeter and floodway encroachment does; a sensitivity analysis would likely show a difference of 0.01 ft or less if these boundaries were separated from one another, but such an analysis was never prepared. HEC reports known software errors or "bugs" with every update to HEC-RAS and the problem identified by SWM was neither catalogued nor indicated, nor proven with technical analysis, and is an unsubstantiated false claim. An opportunity does exist, however, to optimize the allowable surcharge to the 0.2-ft standard for the state of New Jersey; if the ineffective flow areas are re-evaluated, then a re-calculation of floodway encroachment stationing and associated surcharge optimization becomes a technical opportunity that promotes technical accuracy, regulatory equity, and due consideration for community land use needs consistent with NFIP standards

8.1.3. FEMA and Community Coordination Challenges

The FEMA Guidance for Stakeholder Engagement clearly states "To achieve these goals, stakeholder coordination and engagement is necessary throughout the Risk MAP project lifecycle. Engagement is important during the Preliminary NFIP Map Release Phase to minimize problems and controversy before FEMA and the community make the Preliminary versions of the FIRM(s), FIS report(s), FIRM database, and SOMA(s) available to the public."

Section 6.0 of FEMA's Guidance for Flood Risk Analysis and Mapping (November 2019) lists several reasons why the community may choose to have the floodway boundaries adjusted to account for existing and future planned development.

Coordination with the Community was clearly not initiated or executed with respect to the development of the floodway boundaries on the Pompton River or their impacts to community land use planning efforts permissible under NFIP standards and state and local floodplain ordinance. In addition, failure to review the Community modeling for the Pompton River for the appeal constitutes an incomplete review.

It is therefore recommended that FEMA revisit the floodway delineation of the Pompton River.

8.2. EAST DITCH AND WEST DITCH

8.2.1. Discussion of FEMA Modeling

A hydrology report was submitted, titled, "Final Hydrology Report – Riverine Flood Insurance Studies in FEMA Region II New Jersey FY-07 – Morris County, New Jersey" and is dated February 3, 2009 (NTHMC 2009). This report includes calculations of peak flows for West Ditch using the procedures in the U.S. Geological Survey publication Special Report 38 (SR38).

The report titled, "Hydraulic Analysis of East Ditch Floodplain – Morris County, New Jersey" (RAMPP 2017), was also provided for this SRP. This report states that the hydrology was not updated for the appeal resolution and that the peak flows were taken from the effective FIS for the Township of Pequannock, Morris County (1992). The report also summarizes the hydraulic analysis revisions completed in response to an appeal by the NJDEP.

Two 1D HEC-RAS models were provided for the East and West Ditch reaches. Both models were created using HEC-RAS version 4.1 and include both multi-profile and floodway simulations.

The method of estimating flows (Special Report 38) in the East Ditch and West Ditch utilized an empirical method developed in 1974. More modern methods should be employed especially since the 1974 report had extremely limited long-term data for watersheds this size, and standards of practice of and technical tools associated with hydrologic analysis and hydraulic engineering have evolved significantly over the past four decades. The FEMA analysis fails to take into consideration that the systems become one 'diverted' flow (per regulations) where the shared floodplain becomes one system.

The FEMA analysis assumed coincident flood peaks for the East Ditch and West Ditch, based upon the assumption the watershed area ratios were between 0.6 and 1.4. The basis for this rationale is when modeling main stem and tributary systems, specifically when considering the boundary condition for the tributary. In reality, the East Ditch and West Ditch systems are parallel systems that share a common floodplain. Their watershed area ratios do not fall between 0.6 and 1.4 from their confluences with Beaver Brook, upstream through most of the study reaches. By estimating flood peaks independently for the East Ditch and West Ditch and then assuming that 100-year storm events occurred on the two watersheds simultaneously, the condition reflects a return period greater than 100 years, or an annual probability of exceedance less than 1-percent annual chance (1% a-c). The empirical method to compute flows (Special

Report 38) will compute a smaller flood flow for the entire watershed than when computing floods on tributaries and then adding them together. If the concurrent flood approach is to be used, the flood for the entire watershed should be estimated and then apportioned between the East and West Ditch.

Overall, the East Ditch and the West Ditch share a common floodplain. These two streams were modeled independently, and in order not to double-count floodplain conveyance between them and to model two separate floodways, model lateral limits were established at common ineffective flow area stations. This parallel stream system more appropriately could have employed a two-dimensional (2D) modeling approach to calculate flow convergence and divergence between both waterways using two fundamental equations of fluid dynamics, or at the very least a 1D approach with two reaches converging to one, hydraulically communicating over their shared overbank lateral weirs oriented parallel to channel alignments. The 2D approach would be most accurate, would avoid the ineffective flow area issues, and would allow water to move freely and naturally between the two waterways based on allowable conveyance, existing obstructions (natural and human-made), and conditions as they exist on the ground at the time of remapping. The method of delineating floodways in models is of course non-unique. The differences between the FEMA floodways and community floodways should be resolved via closer communications between the two parties and abiding by state and federal criteria.

FEMA's selection of stations for the ineffective flow areas does not reasonably reflect the impact of the conveyance of the shared floodplain between the East and West Ditch. The decision to utilize West Ditch left overbank conveyance as the only contributing discharge to an area overlapping the East Ditch right overbank is not based on any technical evidence, and is arbitrary. This shared overbank receives contributions from both Ditches during a 100-year storm by this logic, and should be hydraulically connected by either a series of 1D lateral weirs or (better yet) a 2D conveyance area. If both of these waterways flood at the same time, as indicated by RAMPP (2017) and FEMA Region II, then the overbanks for both simulations should hydraulically communicate with one another in 1D or 2D simulations.

The East Ditch flood risk mapping was revised with updated topography in some locations and new cross sections to create a more numerically robust simulation than the West Ditch. The West Ditch did not converge on an accurate solution during the HEC-RAS simulations as indicated in the Summary of Errors, Warnings and Notes, especially from Cross Section 7092 and points upstream. The HEC-RAS simulation from Square Place Road Bridge to points upstream should not be trusted as accurate and should be updated by FEMA at the same time the East Ditch is updated. To indicate the East Ditch and West Ditch are hydraulically connected and allow numerical errors to promulgate in one watershed but not the other is an error in judgement and arbitrary in practice. If the West Ditch hydraulic model received the same updates as the East Ditch, and their shared overlapping overbank was analyzed with 1D lateral weirs or 2D conveyance (especially from Jacksonville Road to the downstream limit of both waterways) then both models would calculate flood risks with comparable accuracy.

The FEMA HEC-RAS model ineffective flow areas were established in large portions of the floodplain that would appear to exhibit conveyance, for example, areas south of the airport at Jacksonville Road, rather than using topographic or roughness element or human-made obstruction cues recommended in Chapter 5 of the HEC-RAS Hydraulic Reference Manual (Brunner 2016). In many instances, the floodplain areas considered ineffective are expansive and hydraulically contiguous with upstream and downstream conveyance areas. Additionally, the ineffective flow areas at bridge structures were set to elevations much higher than the computed 100-year flood elevation, thereby negating the opportunity for calculating weir overtopping of roadways and artificially raising BFEs in the vicinity of these crossings. In totality, the FEMA HEC-RAS model ineffective flow areas unreasonably affected computational model results.

8.2.2. Discussion of Community Modeling

The Township indicated ineffective flow areas in the East Ditch are unreasonably narrow (SWM 2018, Sec. 4.2, Pg. 36, 2nd paragraph); the logic has merit but there are two concerns worthy of consideration. First, the East Ditch HEC-RAS model appears to be overly-constrained by ineffective flow stations that do not reflect topographical features, human-made obstructions, or hydraulic structures and roadways that would obstruct flows. Second, the overbank elevations in the shared overbank south of Jacksonville Road (at the airport and locations to the south) do not align in the East Ditch and West Ditch 1D simulations. When combined with the numerical errors created by outdated topography and limited cross sections in the West Ditch simulation identified in Section 8.2.1 of this report, it is reasonable to suggest ineffective flow stations require re-evaluation in both the East and West Ditch HEC-RAS models.

Community efforts led by SWM (2018) to widen ineffective flow stations to match BFEs were interesting but do not follow standards of practice, and amount to little more than input manipulation to achieve desired output (Section 4.2, Page 38, 4th through 6th paragraphs). The East Ditch and West Ditch ineffective flow areas must be adjusted to reflect obstructions to flow created by natural topographic features, infrastructure (roads, bridges and culverts), and human-made features (buildings, non-floatable stockpiles, fencing, etc.). When coupled with the necessary improvements to the West Ditch quality suggestions and the combined overbank hydraulic connectivity suggestions in this report, the East Ditch flood hazard mapping will be more accurate and may garner the trust of the adopting local communities, including the Pequannock Township, which will improve consensus with state and federal partners.

8.2.3. FEMA and Community Coordination Challenges

Again, there was little to no coordination between FEMA, study contractors, and the community during the development of the SFHA for the East and West Ditches.

The community listed their models as part of the appeal. It is common practice to transmit models electronically. To rely on "it wasn't included in the submittal" as a reason to dismiss the appeal is

disingenuous at best. Failure to review the available community modeling as part of the appeal constitutes an inadequate review for the appeal.

It is therefore recommended that FEMA revisit the flow distribution and ineffective flow areas of both the East and West Ditch.

9. References

Brunner, G.W. and CEIWR-HEC, 2016. "HEC-RAS; River Analysis System User's Manual," U.S. Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC), Report No. CPD-68, Version 5.0, Davis, CA.

Brunner, G.W., 2016. "HEC-RAS; River Analysis System Hydraulic Reference Manual," U.S. Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC), Report No. CPD-69, Version 5.0, Davis, CA.

Guidance for Flood Risk Analysis and Mapping, Floodway Analysis and Mapping, FEMA, November 2016.

Guidance for Flood Risk Analysis and Mapping, General Hydrologic Considerations, FEMA February 2019.

Guidance for Flood Risk Analysis and Mapping, Hydrology: Rainfall-Runoff Analysis, FEMA, February 2018.

Guidance for Flood Risk Analysis and Mapping, Post-Preliminary Due Process, FEMA, May 2017.

Guidance for Flood Risk Analysis and Mapping, Riverine Mapping and floodplain Boundaries Guidance, FEMA, November 2015.

Guidance for Stakeholder Engagement, Preliminary National Flood Insurance Program Map Release Phase, FEMA, May 2016.

Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization, Special Report 38, State of New Jersey, Department of Environmental Protection, Division of Water Resources; United States Department of the Interior, Geological Survey, 1974.

Natural and Technological Hazards Management Consulting (NTHMC), Inc., 2009. "Final Hydrology Report; Riverine Flood Insurance Studies in FEMA Region II, New Jersey, FY-07, Morris County, New Jersey," prepared for the Federal Emergency Management Agency (FEMA) Region II, Department of Homeland Security, Contract No. EMN-2003-5006, Task Order No. HSFE02-07-J-0001, February 2009, Montvale, NJ.

Risk Assessment, Mapping, and Planning Partners (RAMPP), 2017. "Hydraulic Analysis of East Ditch Floodplain; Morris County, New Jersey," prepared for the Federal Emergency Management Agency (FEMA) Region II, Department of Homeland Security, Contract No. HSPFEHQ-09-0369, Task Order No. HSFE02-13-J-0090, August 2017, New York, NY.

Skupien J.J., 2018. "Technical Report in Support of Pequannock Township's Appeal of Revised Preliminary Flood Insurance Studies and Revised Preliminary Flood Insurance Rate Maps for Morris County, New Jersey," prepared for Township of Pequannock by SWM Consulting, April 2018, Pompton Plains, NJ.

Urban Drainage Design Manual, Hydraulic Engineering Circular 22, Federal Highway Administration, Washington, D.C., September 2009.