Climate Modeling and Stakeholder Engagement to Support Adaptation in the Iowa-Cedar Watershed

An FY12 Responses to Climate Change Pilot Study

DRAFT FINAL REPORT
MARCH 2013

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Executive Summary

Responsible planning today must incorporate the impacts of climate change. Fortunately, climate change does not require a *separate* process, but can and should be incorporated into the existing Corps Planning process. In this pilot study, we demonstrated how technical information about climate change could be effectively used to support watershed planning.

This pilot supported on-going efforts toward developing a Comprehensive Watershed Plan for the Iowa-Cedar Basin, which supports the development of an Upper Mississippi River Basin Comprehensive Plan. The purpose of this effort was to increase understanding of the contribution of land use and climate conditions on watershed processes, to engage stakeholders in a dialogue on adapting to changing conditions, and to support risk-informed decision making with uncertainty.

The Iowa-Cedar Rivers Basin's large area made engaging stakeholders from across the basin challenging, so the team agreed to focus on the basin's Indian Creek Watershed for both the technical modeling and the stakeholder engagement. Indian Creek's mix of both urban and agricultural land use allow the results of this study to apply across the larger basin.

This pilot study applied the decision scaling methodology [Brown, 2010] within the Shared Vision Planning [Cardwell et al. 2009] framework in order have stakeholders and decision makers define their level of acceptable risk and then compare potential climate scenarios to identify if the acceptable risk threshold is likely to be exceeded. The pilot effort engaged stakeholders and decision makers in a series of five workshops which followed a modified USACE planning process with a focus on accounting for hydrologic uncertainties associated with land use and climate changes. The steps included: 1) Clarify goals, objectives, and perceived problems; 2) Describe existing conditions; 3) Describe future hydrologic conditions under a range of land use and climate change scenarios; 4) Identify and evaluate actions towards achieving goals under future conditions. The stakeholder dialogue sessions helped the group to organize their thinking within a decision making framework and to help frame what steps the group could take to prepare for the future, to reduce risk of damages from future flood events, and to increase awareness and support among the community.

As a result of this effort, the Indian Creek Watershed stakeholders are now more informed that the extreme precipitation events they have been experiencing are highly variable and likely to continue. This effort identified that both land use and climate changes may have a significant influence on the severity of flood impacts. The stakeholders who participated in the workshops have a better understanding that actions will likely require a combination of structural and non-structural solutions, including moving out of the floodplain where possible and appropriate. The participants are generally supportive of floodplain zoning regulations and moving current structures out of the floodplain, but also now appreciate the uncertainties regarding defining the current and future boundaries of the "floodplain."

A comparison of modeling techniques was evaluated which explored the benefits, limitations and appropriate uses of differing hydrologic models and climate downscaling methods for presenting hydrologic impacts at a local scale to inform the stakeholder dialogue sessions. This effort uncovered that event based models have major limitations in their ability to capture initial conditions. This effort also uncovered that a "counterfactual analysis" technique for downscaling climate date may be favorable for overcoming bias' and expressing climate change impacts at a specific gauge location.

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1. Purpose & Scope

The purpose of this pilot study is to test the appropriate integration of climate information to support Corps integrated watershed planning for the purposes of improved understanding and adaptation. The effort in this pilot contributes to an on-going study to develop a comprehensive watershed management plan for the Iowa-Cedar Rivers Watershed. The pilot contains three primary components:

(1) Public Outreach Component: Engaging stakeholders in a dialogue about watershed goals and how to adapt to hydrologic changes and the potential impacts on land and water resources.

(2) Collaborative Risk Informed Decision Making: Development of an integrated model to present a technical analysis to stakeholders as part of the stakeholder dialogue process.

(3) Comparative Analysis: Compare hydrologic models and three climate downscaling methods for generating climate data at the regional scale.

Central Questions Addressed and Methods Used

The public outreach component of this study was designed to collaboratively develop and select implementable climate change adaptation strategies with stakeholders, decision-makers, and the public through a Shared Vision Planning (SVP) approach for the Iowa-Cedar Rivers Basin. A collaborative process supported the risk informed decision making process by testing two central questions: (1) how climate change considerations can be incorporated into watershed planning so that policies and watershed investments result in a watershed that is robust and adaptive to potential climate changes; and (2) how complex technical information about climate change may be presented to stakeholders in a format that is both understandable and relevant to the decision at hand.

The comparative analysis of hydrologic tools component was designed to support the SVP effort by providing output from a suite of models for communicating technical information, and associated uncertainties, assumptions, and limitations. The analysis compared outputs from three hydrologic tools:

(1) Physically-based, fully-distributed continuous hydrologic model Gridded Surface Subsurface Hydrologic Analysis (GSSHA),

(2) Physical-empirical, quasi-distributed continuous hydrologic model Soil and Water Assessment Tool (SWAT), and

(3) Empirical, lumped parameter event hydrologic model Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS).

Models were intended to be compared against one another based on the central questions:

- *How do we incorporate climate data in a highly tiled agricultural landscape?*
- *How do we incorporate climate data to evaluate structural and non-structural measures for flood damage reduction?*

Previous Work

This study builds on the results of the Coralville Lake climate change pilot study, which was also led by Rock Island District. The Coralville project site is also located within the Iowa-Cedar watershed, on the Iowa River, so many of the lessons learned are directly relevant to nearby Indian Creek watershed. The Coralville study evaluated the potential impacts of climate change on the operation of a flood control reservoir. Downscaled climate data were used in conjunction with a calibrated hydrologic model to perform a quantitative analysis of the effects of selected climate change scenarios. Two problems arose in the quantitative analysis that made evaluating extreme events difficult. The first came from the hydrologic model which was well calibrated to total flow volumes and floods of moderate severity, but was unable to re-create large historical flood events as well as the general amount of variability in daily streamflow. The second problem was due to the climate data. The downscaled climate data were only available for short (30 years or less) periods, so due to sampling alone the occurrence of rare, extreme events in the data was unlikely, making those events difficult to test. In general the data represented relatively small variability and few events toward the extremes. The dynamically-downscaled climate data are still considered experimental, and so results of any study using them need to consider their provisional and experimental nature.

The key message from the climate data is that there is no solid answer to what the future climate will look like and that planning with uncertainty is the new normal. A method that is not constrained by irreducible uncertainty in climate projections is a positive alternative in these planning efforts. A project that can be tested for vulnerabilities to a changing climate and specific other vulnerabilities can be addressed with adaptation strategies. Brown et al. [Brown et al, 2011] uses this approach to investigate climate risks in the management of the Great Lakes. The Coralville study originally took this approach by analyzing the assumptions that were made in the dam's design and evaluating if during historical operation of the reservoir these assumptions were violated, and if they were likely to be violated in the future based on trends. In light of a lack of accepted practice in using

downscaled climate data for adaptation planning and impacts analysis, an approach such as this was determined to be favorable in Indian Creek.

2. Background

Study Area

The Iowa-Cedar Rivers Basin is a tributary to the Mississippi River which includes some of the most fertile agricultural land in the nation and debatably in the world. In recent years high commodity prices and ethanol demand has contributed to landscape changes, including conversion from pasture and other agricultural crops to cultivated row crops, primarily corn and soy beans. Landscape conversion has increased stress on fresh water sustainability and contributed to both Gulf hypoxia and epic flooding. The Iowa-Cedar Rivers Basin contains three large urban areas which all have experienced monumental flood events in recent years, most notably 1993, 2002, and 2008.

The Indian Creek Watershed, which was the primary focus of this study, is a mixed use basin with increasing urban growth and expansion from the City of Cedar Rapids. The eastern portion of the City of Cedar Rapids and the City of Marian are the cities in Indian Creek most impacted by this development. Other cities in the basin include: Alburnett, Hiawatha, and Robins. The urban areas constitute 26 percent of the landuse. Other land uses are as follows: forest and grassland compose 10 percent, pasture accounts for 6 percent and the remaining 58 percent of the basin is predominantly row crop agriculture.

Problems, Issues of Concern and Opportunities

The primary problem is that flood risk in Indian Creek has increased in recent decades along with water quality degradation that is contributing to Gulf hypoxia. There are concerns that as urban areas continue to expand and market prices increase for corn and soybeans that land use changes within the basin may have dramatic impacts on the basin's hydrology. Similarly, there is concern that the changing climate may also have dramatic impacts on the basin's hydrology. This pilot provides an opportunity to bring stakeholders together to develop common goals, develop an understanding of the economic, environmental and social benefits and consequences to land use decisions and how the uncertainty surrounding climate change scenarios may impact these potential benefits and consequences.

Current Climate

In Iowa, the average annual temperature, total annual precipitation, and the number of days per year with precipitation have been increasing from the early 20th to the early 21st century. The biggest changes in temperature are due to wintertime and nighttime temperature increases. This resulted in more frost-free days per year (about 5 more at the start of the 21st century than in the mid 20th century, and about 8-9 more than beginning of the 20th century), which increased the length of the

growing season, due to fewer days of frost. Warmer temperatures also result in earlier seasonal snowmelt, and lakes and streams remaining frozen for less time. A decrease in the number of extreme high temperature events (days above 100°F) has been observed due to an increase in summer precipitation and soil moisture that have suppressed surface heating and reduced daytime summer maximum daytime temperatures. From the Climate Change Impacts on Iowa 2010 report:

> *If Iowa were to experience a severe drought, as has occurred frequently in the past, the slow and steady rise in statewide annual mean temperature, now masked in summer by moist surface conditions, could lead to an abrupt switch to extreme summer heat comparable to the summers of 1983 or 1988.* [Iowa Climate Change Impacts Committee 2011 - Report to the Governor p. 9]

Cedar Rapids, Iowa is the nearest long record gauge to the Indian Creek basin. At that gauge, the average annual temperature, total annual precipitation, and the number of days per year with precipitation have been increasing from the early 20th to the early 21st century with positive trends that are statistically significant at 95 percent confidence.

Cedar Rapids has an annual mean temperature of 10 °C (50 °F) and averages about 850 mm (33.6 in) of precipitation per year [cumulative data since 1893 from IEM Climodat].

Since 1893, mean annual temperature at the Cedar Rapids gauge has been rising at an average rate of 0.06°C (0.11°F) per decade. Figure A-1 in Appendix A, *Climate Data and Information*, shows mean annual temperature since 1893 at Cedar Rapids as well as a 30-year average and a linear trend line. Prior to 1960, 10 years out of 67 (15 percent) measured a mean annual temperature at or over 50 °F (10 °C), but from 1960 and later, 13 of 52 years (25 percent) have met or exceeded that threshold.

On average, annual total precipitation has been rising by 23.1 mm (0.91 in) per decade. Figure A-2 shows annual total precipitation since 1893 at Cedar Rapids, as well as the 30-year average and linear trend for those totals. Of note is the year 1993, which was an anomalously wet year across the whole Midwest (culminating in the Flood of 1993) and remains the wettest year on record by almost 250 mm (almost 10 in). Also notable is that there has been an increase in year-to-year variation in annual total precipitation as well. Visually this is represented by increasing noise in the annual total precipitation timeseries, and quantitatively it is an increase in 30-year coefficient of variation (CV) in annual precipitation from around 0.13-0.19 in the early 20th century to around 0.20-0.23 in the early 21st century (Figure A-3).

On average there has been one more rainy day per year every 2.8 years. Figure A-4 shows the number of days per year with greater than trace precipitation at the Cedar Rapids gauge. Since 1990 there have been on average 120 days of rain a year, a total number that prior to 1990 had only been observed twice. A considerable portion of the additional annual rainfall observed at Cedar Rapids is due to the increased frequency of rainfall. Some of the increase in annual total rainfall can be

attributed to an increase in the intensity of rainfall, as shown by the slight increase in annual maximum precipitation since 1893 in Figure A-5. While the trend shows a moderate increase over time, the year-to-year variability in annual maximum precipitation has increased since 1960, much like the variability in annual total precipitation.

The increase in average and variance of precipitation over time has been visible in the two large floods that have occurred on Indian Creek in the past 10 years, and more broadly the 1993 and 2008 floods across the Midwest. 2008 was an especially devastating year in the Iowa-Cedar watershed which experienced the largest flows on record. While there is not a long-record streamflow gauge on Indian Creek with which to illustrate trends; downstream on the Cedar River the gauge at Conesville shows the trend in peak annual discharge mirroring the increase in annual precipitation (Figure A-6.)

3. Stakeholder Dialogue Initiative

The goal of engaging stakeholders was to incorporate climate uncertainty (along with the range of other uncertainties) into watershed planning and local decision making. To accomplish this, we invited a diverse group of stakeholders from local government officials, planners, water managers, residents, NGO's, agricultural representatives, representatives of disadvantaged populations, technical experts, consultants, academics, teachers, and state agency representatives. The pilot team's approach to engaging stakeholders was to coach them through planning steps so they identify a desired future and then discuss how climate change projections may affect their desired future and their potential adaptation strategies [Brown et al (2011)]. The pilot team decided early on not to focus the engagement on collaborative development of a computer model during this phase of the engagement process because (1) stakeholders with weak understanding of watershed fundamentals may not have been ready for this more sophisticated exercise; (2) the hydrologic modeling team was still calibrating the models, the results of which were needed to support a broad collaborative model; and (3) resources were not available to support model development within the limits of this pilot effort.

When engaging the stakeholders in dialogue sessions, we encouraged discussion on a wide variety of watershed issues; however, flood risk immediately stood out as the dominant concern for nearly everyone. Additional objectives related to improving water quality and ecosystem habitat, and increasing recreational opportunities. The dialogue sessions helped the group to organize their thinking within a decision making framework and to help frame what steps the group could take to prepare for the future, to reduce risk of damages from future flood events, and to increase awareness and support among the community. The sessions also provided the opportunity to share hydrologic and climate change modeling results, information on land use (particularly in the floodplain), water quality data and success stories for organizing stakeholders.

A key focal area was discussing the role of climate change and land use on future flood risk. We presented information about the extreme conditions as well as uncertainty and discussed their role in local land use and other adaptation decisions.

Overview of the Stakeholder Dialogue Effort

- Stakeholder Assessment (December 2011)
- Workshop 1 – Objectives and Visions, 53 participants (Jan 26, 2012)
- Workshop 2 – Challenges and Enabling Factors, 36 participants (March 29, 2012)
- Workshop 3 – Performance Metrics, 29 participants (May 22, 2012)
- Workshop 4 – Watershed Assessment, Floodplain Mgt, Public Outreach, and Climate Change, 21 participants (August 9, 2012)
- Workshop 5 – Transitions to next steps, Action Planning (September 25, 2012)

Full documentation of each workshop is available at <http://iowacedarbasin.org/community/indian-creek-pilot-project>.

Stakeholder Assessment

In December 2011, conducting a Stakeholder Assessment of semi-structured interviews helped the team identify stakeholders to invite, to gauge the current level of understanding and issues of concern, as well as to be informed of any tensions or distrust among stakeholders or the multiple jurisdictions. Through this exercise, a list of contacts was developed that included federal, state, and local agency representatives, elected officials, teachers and academics, consultants, agricultural landowners and representatives, urban residents, environmental NGO's, conservationists. During this stakeholder assessment the pilot team learned that residents most affected by the recent extreme events are frustrated by the lack of change. These individuals expressed that they believe it will take a team effort with everyone involved to make any meaningful changes. During calls, we also promoted the first workshop and gathered schedule availability information.

Workshop 1

On January 26, 2012, over 50 stakeholders from the Indian Creek watershed convened at the Marion City Council Chambers to kick off a focused dialogue and planning process for the watershed. The day started off with brief presentations about the Indian Creek Watershed and with introductions from the Iowa Cedar Watershed Interagency Team, who co-facilitated the process. Through a series of interactive exercises using the Appreciative Inquiry method Doug Davis (USACE-MVR) led the group through an Appreciative Inquiry approach to generate vision statements and goals for the watershed. Participants worked as partners and in small groups of six to eight people in order to establish their vision statement and goals which guided the remainder of the dialogue process. The group identified vision statements and goals related to the management of water quantity and quality, agricultural land management, urban development, recreation, ecosystem health, as well as a number of social behavior goals related to getting the whole community to understand the

watershed and their impact, to feel a sense of urgency, to be accountable for their actions, and to all work together.

Workshop 2

On March 29, 2012, 36 stakeholders participated and six team members conducted the workshop, with Stacy Langsdale serving as the primary facilitator. Dr. Marty St. Clair, Professor of Chemistry, Coe College, presented water sampling data for the watershed, noting that nitrogen concentrations peak after significant rainfall events and that *E. coli* levels are often high. Toby Hunemuller, Chief Hydrologist, USACE-MVR, presented on development and precipitation trends, noting that precipitation seems to be occurring more frequently and with greater variability of intensity. Next, because many of the participants expressed impatience with the lack of change since the 2002 and 2008 floods, the pilot team led groups in brainstorming the challenges and drivers to implementing change. Again, major concerns were raised associated with a need for public education. The group's perception is that the majority of watershed residents lack appreciation for the creeks and don't recreate there, and thus, lack motivation to protect the resource or take action to manage flood risk.

Workshop 3

On May 22, 2012, 29 stakeholders participated in the development of performance metrics for the watershed. Dr. Stacy Langsdale, Public Participation Specialist, Institute for Water Resources, facilitated the session, where participants worked on developing metrics for each of their objectives. The group reviewed and revised a draft set of *Effectiveness Metrics* to measure physical changes, and then brainstormed *Acceptability Metrics* to determine if an action would be socially acceptable or feasible with current laws and regulations. Economic metrics were also included.

Table 1 shows water quantity/flood management objectives. The complete table of metrics is located in Appendix B, *Stakeholder Engagement: Goals, Objectives, and Performance Methods*, and currently posted at <http://iowacedarbasin.org/community/indian-creek-pilot-project>.

Table 1: Water Quantity/Flood Management Objectives

Objective (from Workshop 1)	Refined, More Specific Objective	Draft Performance Metrics That the Stakeholders Agreed Were Reasonable
Reduce flood volume flows	Reduce extent and duration of large flood events.	Stage of 500-yr storm; stream "flashiness."
	Reduce extent and duration of frequent flood events.	Highest stage of a 5-yr storm.
A watershed with a very low risk of flood damages	Reduce damages affiliated with large flood events.	• Estimated damages from a 100-yr equivalent storm • No. of vulnerable structures in the 100-yr floodplain. • No. of structures within the 100-yr floodplain +/- # feet.
Achieve clean, unpolluted, safe, healthy water through the watershed	Reduce Sediment	• Concentration of suspended sediment • Rate of bank erosion
Lots of recreational opportunities	Increase access to creek for fishing, wading, canoes/kayaks	Miles of creek banks that are accessible to public for use (i.e., not private land)
Healthy ecosystem	Increase biodiversity through diverse habitats	• Acres of woodland • Acres of open meadow • Acres of wetland
The community supports watershed improvements because they understand the urgency of the problem, understand how their actions impact others, and are held accountable.	The general public (both urban and rural) support the measure	• Are residents and landowners willing to pay now? Would they vote for it? • Are people willing to support/implement/maintain over time? • Is it culturally acceptable? • Are policy makers able to implement policies? • Are they able to pay? Are costs and benefits to different members of society distributed fairly?

Workshop 4

On August 9, 2012, 21 stakeholders participated as Stacy Langsdale facilitated plenary and working group dialogue regarding steps they can take to reduce flood risk and improve the watershed. In the breakout group's participants explored resources for developing a comprehensive watershed plan, considered land use in the floodplain as well as factors that change "the floodplain", and explored opportunities for building public awareness of watershed issues. The pilot team presented new information on the influence of land use change and Rock Island District Hydrologic Engineer Greg Karlovits presented information related to potential climate change impacts on hydrologic response for moderately large precipitation events. The group considered what this means for watershed management. Details on the information presented and discussed are described in the following section *How Technical Information Supported Stakeholder Dialogue*.

Workshop 5

On September 25, 2012, 19 stakeholders participated as Stacy Langsdale facilitated the discussions centered on the next steps required for this group to take the lead and continue efforts to improve the watershed. A guest speaker from a nearby watershed shared their experience of leading an Advisory Board, presented the steps they took, and resources utilized. The group was also updated on the status of the formation of a Watershed Management Authority, and how they can support it in the future, including building public awareness and support. Finally, in order to tie the group from initial goals to tangible actions on the ground the pilot team displayed aerial imagery of urban and rural areas with resource concerns and presented recommendations for actions at the various sites, identifying how certain actions would achieve certain goals that were defined in the first three workshops. At closing, the participants expressed great appreciation for the increased understanding of the hydrology especially with regard to possible future conditions of the watershed. The participants also appreciated having greater clarity in realistic options for improvement and improved access to the resources and agency contacts that are needed to facilitate action.

How Technical Information Supported Stakeholder Dialogue

Throughout the series, members of the pilot team along with other subject matter experts presented existing conditions data and information related to flood risk, water quality, streambank stability, climate, landuse, and hydrologic changes. Here, we highlight how information related to land use and climate scenarios contributed to better understanding of flood risk and how it may increase over time as a function of one or both of these factors.

Identifying Risk Thresholds and Testing Sensitivity

Presentation of local temperature and precipitation trends in early stages of the dialogue helped to frame the significance of climate change on hydrologic response. Figure A-3 which displays the coefficient of variation was meaningful to stakeholders as discussion of the high variability of precipitation in recent years confirmed what many residents believed through experience.

Other graphics presented to stakeholders were used to communicate flood risk based simply on the distribution of land use types located within and outside of the 1 percent annual exceedance probability floodplain boundary (Figure C-1). Discussion focused on:

- *Who defines the floodplain boundary?*
- *Can a floodplain boundary change?*
- *What are appropriate uses of the floodplain?*
- *What is an acceptable level of flood risk in Indian Creek?*

Participants identified that a floodplain boundary is defined by both physical parameters and political influence, and that the floodplain boundary can change by either influence. Participants offered that appropriate land uses within the floodplain are natural areas, agriculture (minus CAFOs), recreational trails, campgrounds and sports fields. Participants indicated that there is an acceptable level of risk for flooding of structures like vending buildings at stadiums and similar low-damage type structures.

After the participants described an acceptable level of flood risk, the pilot team presented a comparison of the current and future land use in the 1 percent annual exceedance probability floodplain boundary. Flood risk of future land use was based on Linn County's published land use plan. See Appendix C, *Stakeholder Engagement: Technical Information Presented*, Figure C-2 and http://www. linncounty.org/content.asp?Page_Id=783&Dept_Id=25). The rural land use plan was cross-referenced to the NLCD 2006 land use types to allow for direct comparison between existing and future conditions (Figure C-3). Participants were surprised that given the number of residences impacted in the 2002 and 2010 flood events that Linn County's land use plan allowed residential or commercial development within the defined floodplain to increase from 22 to 40 percent (Figure C-4). The participants were relieved to learn that Linn County is revisiting this future land use plan and hopeful that it will better reflect their values to not have additional people bear the consequences of flooding in their homes.

The pilot team next presented graphics to communicate the impact that land use and climate change may have on hydrologic response. Hydrologic responses for historical, current, and future land uses based on HEC-HMS model results (developed for another Corps study effort in Indian Creek - model under review at time of stakeholder workshops so shown as unofficial) were displayed on a hydrograph to help frame how much land use changes contribute to peak discharges. The hydrograph results were based on one moderately large (approximately 4 percent annual exceedance probability (25-yr return period)) storm in August 2009, which many people remember and could relate to easily (Figure C-5). The future land use condition (shown as "future build out 2020") was based on Linn County's future land use plan. In Figure C-5 the team decided to include a hypothetical 100 percent impervious scenario as a sensitivity analysis. When participants questioned the validity of a 100 percent impervious scenario, one agricultural grower noted that frozen soils can perform as completely impervious to rain and thus this scenario may not be as extreme as some may think.

After the group was provided a sense of the hydrologic response to land use changes, the next step was to add a climate change scenario, CRCM-CGCM3 (the reason for selecting this climate change scenario is documented in detail in the following section). Figure 1 displays combinations of land use and climate change scenarios together on the same hydrograph. When looking at land use scenarios only, peak flows were on the order of roughly half of the flow resulting for the 100 percent impervious watershed scenario. However, the 2020 land use combined with the revised 25-year return interval flood event results in peak flows of around 80 percent of the peak flow resulting from the 100 percent impervious scenario.

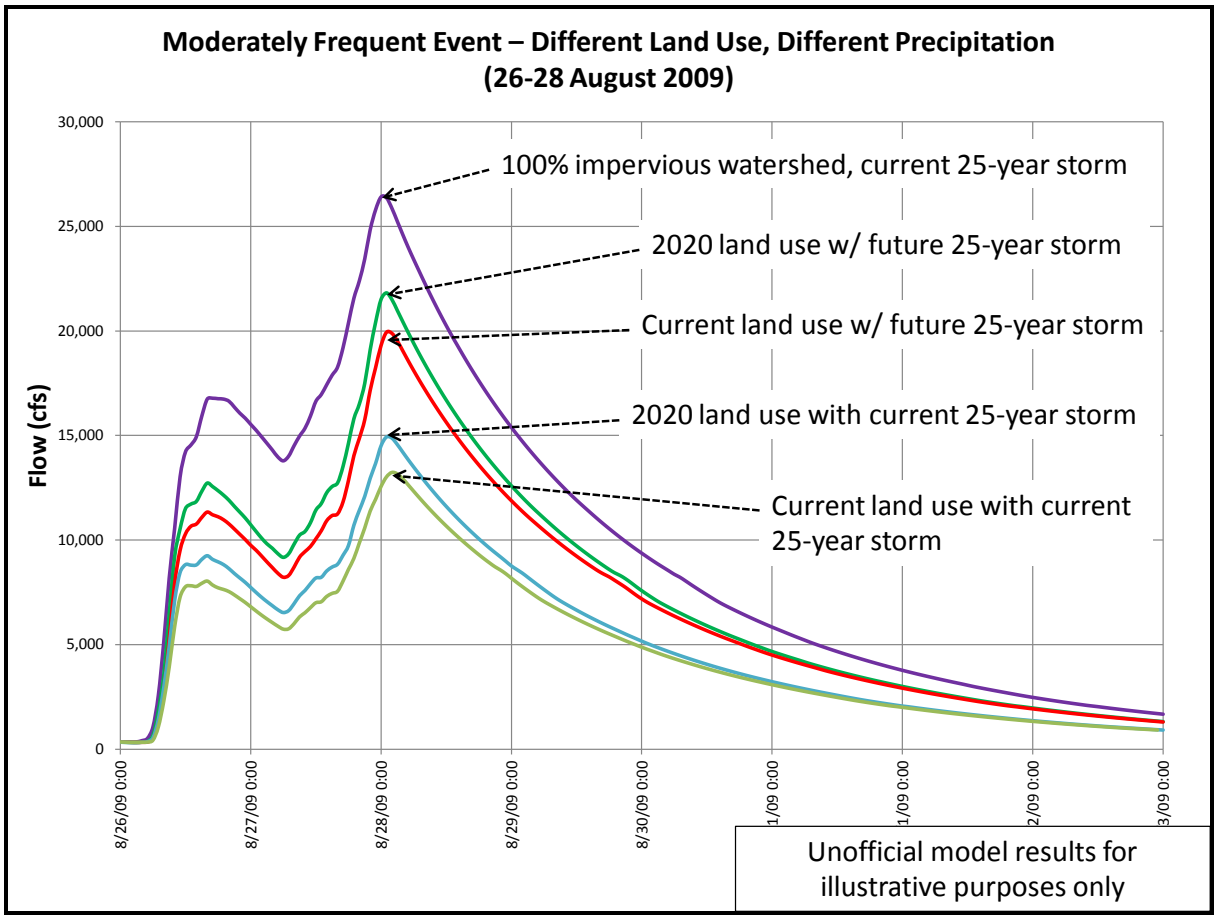

Figure 1: Combined Land Use and Climate Change Scenarios

Landscape Inundation, Aerial Imagery Analysis to Evaluate Impacts

The hydrographs provided stakeholders with a sense of the order of magnitude of change of the scenarios; however, participants were most interested in knowing what these changes looks like on the landscape. The pilot team selected an area in the watershed to display the inundation extent using a recently developed HEC-RAS model (developed for another Corps study in Indian Creek – model under review at time of stakeholder workshops so shown as unofficial). Figures 2 and 3

display the change in inundation resulting from a future 25-year return interval storm under climate change and if the watershed was 100 percent impervious, respectively.

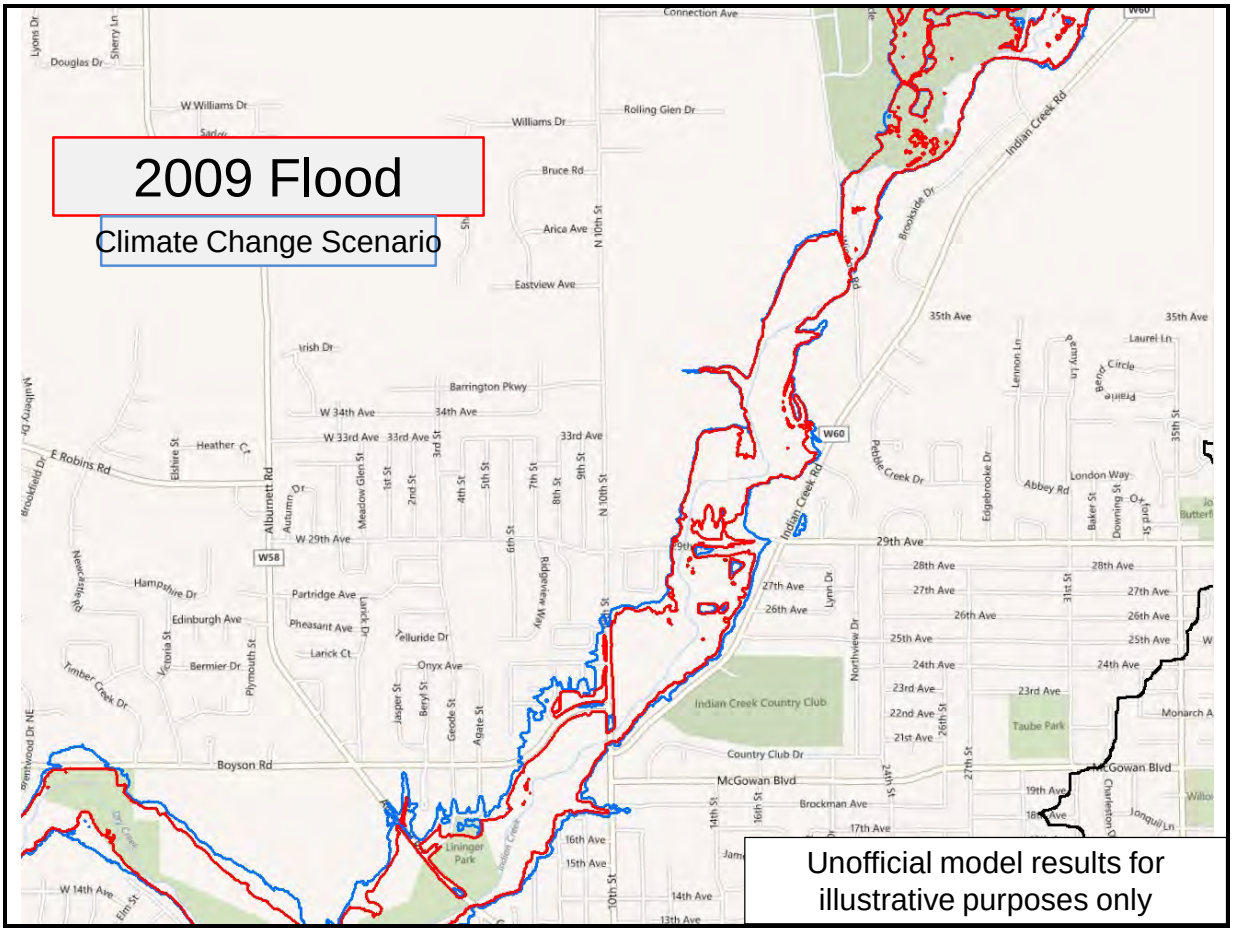

Figure 2: Inundation Extent of Current Land Use With Climate Change Scenario

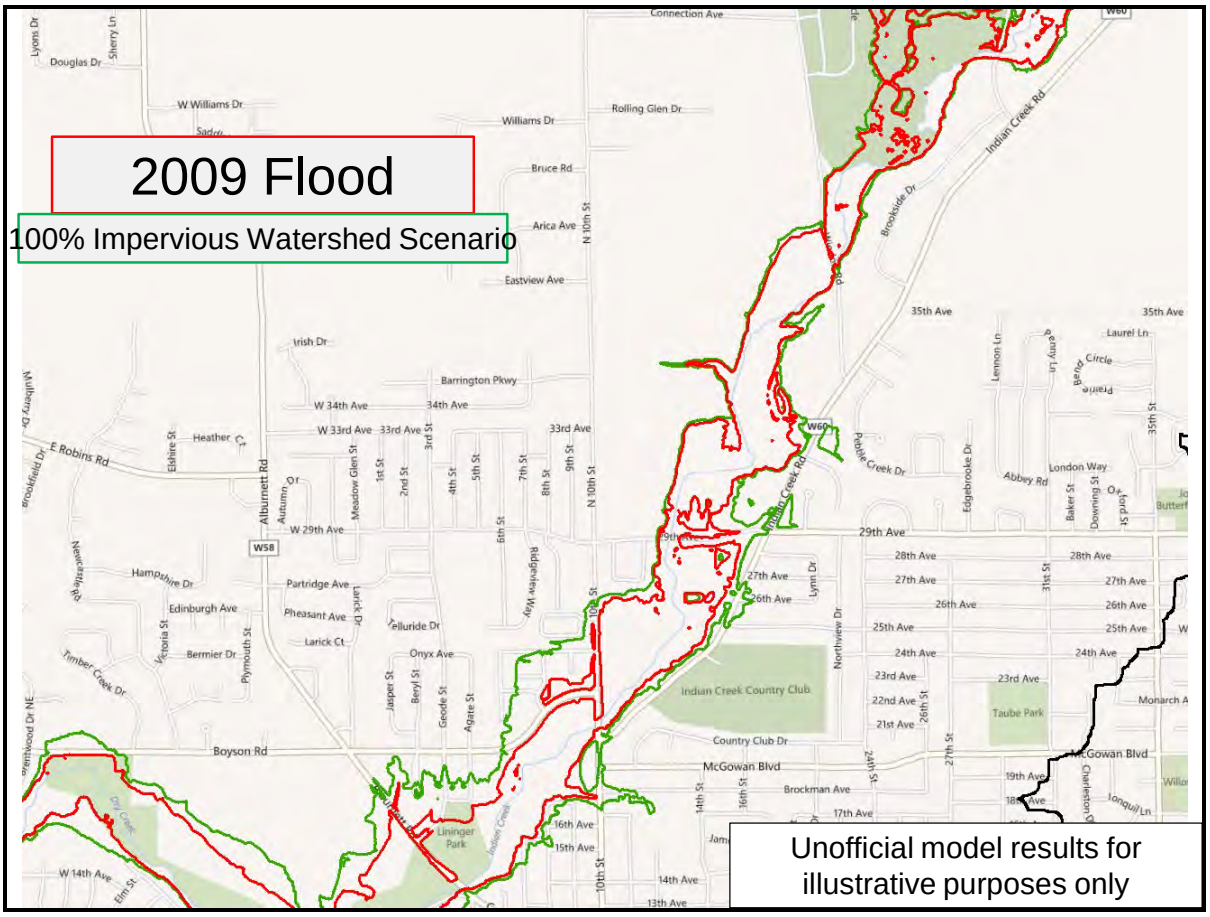

Figure 3: Inundation Extent of 100% Impervious Watershed Scenario

The participants noted that uncertainties surrounding land use and climate change seem daunting when viewing the data on a hydrograph but that seeing the inundation extent puts in perspective where to leave room for the river.

Next, the pilot team utilized aerial imagery and GIS data layers to locate rural and urban locations of concern and identified potential actions that could improve conditions and help the stakeholders meet their defined goals and objectives. Figure 4 displays a rural wetland complex site where hydrologic reconnection may help achieve water quantity, water quality, habitat, and recreation goals. Figure 5 displays an urban residential site where structural and non-structural measures may achieve water quantity, economics and public support goals.

Figure 4: Potential Rural Wetland Reconnection Project

Figure 5: Potential Flood Risk Management Project

As a result of this effort, the Indian Creek Watershed stakeholders are now more informed that the extreme precipitation events they have been experiencing are highly variable and likely to continue; thus they need to take action to manage their risk to future flood damages. This effort identified that land use does have a significant influence over infiltration rates and thus flood flow characteristics which determines the severity of flood impact. In the worst case scenario, land would act as 100 percent impervious, which sounds extreme; however, frozen ground creates this condition annually. The stakeholders who participated have a better understanding that actions will likely require a combination of structural and non-structural solutions, including moving out of the floodplain where possible and appropriate. The participants are generally supportive of changing floodplain zoning regulations and moving current structures out of the floodplain, but also now appreciate the uncertainties regarding defining the current and future boundaries of the "floodplain." There is still a lot of work yet to be done in communicating these messages out to the wider community of residents and decision-makers.

4. Comparative Analysis

This section describes the quantitative analysis that was conducted to address the central pilot questions surrounding how certain technical methods compare in terms of their relative

uncertainties. Specifically, this section compares how outputs from three hydrologic models compare in terms of the message they communicate about risk. This section also includes details on climate science and how the method of downscaling impacts the scale at which you can communicate risks associated with climate changes.

The analysis compares outputs from three hydrologic tools:

(1) GSSHA, a physically-based, fully-distributed continuous hydrologic model,

(2) SWAT, a physical-empirical, quasi-distributed continuous hydrologic model, and

(3) HEC-HMS, an empirical, lumped parameter event hydrologic model.

The analysis also compares three different climate downscaling methods:

(1) Statistical downscaling versus dynamic downscaling using regional climate models. In particular, the range of projected changes from the Bias Corrected and Downscaled WCRP CMIP3 Climate Projections archive (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/dcpInterface.html) and North American Climate Change Assessment Project (www.narccap.ucar.edu);

(2) North American Regional Climate Change Assessment Project (NARCCAP) data covering the IA-Cedar watershed formatted for direct use in a SWAT model; and

(3) Counterfactual time series adjustment coefficients applied to historical weather observations.

The comparative analysis of hydrologic tools was designed to support the SVP effort by providing output from this suite of models to communicate technical information, associated uncertainties, assumptions, and limitations. However, due to workshop timelines and funding constraints the only hydrologic model that was determined to be ready for display to stakeholders was the HEC-HMS model. Therefore this section explains how the HEC-HMS model was used specifically to communicate risk in the SVP process and then later provides comparison of the full suite of models.

Indian Creek Tools for Public Dialogue

Land Use Analysis Hydrologic Modeling

Two HEC-HMS models of the Indian Creek basin were developed in order to demonstrate the magnitude of change in peak discharges of Indian Creek that could be caused by changing land use relative to the risk posed by a changing climate. One model was developed for more frequent, low-flow events and the other for less frequent, high-flow events. Both models were initially calibrated to 2011 watershed conditions for the following historic precipitation events—May 24-26, 2011 (low flow), August 26-28, 2009 (moderate to high flow), and June 3-4, 2002 (record flow event). Inputs

utilized to derive model parameters and run the model included elevation, land use, aerial photographs, and precipitation data as summarized in Table 2.

Table 2. HMS Model Data Sources

Input	Source
DEM	Linn County LiDAR (~5 m resolution)
Land use/land cover	NLCD 1992 & 2006 (MRLC)
Aerial Photographs	USDA (NAIP) & Iowa Geographic Map Server
Precipitation	NEXRAD (NCDC), CID ASOS rain gauge (NCDC)

The models were run for the historical flood events mentioned previously while varying the land use for the watershed to represent "past" and "future" conditions in order to test the sensitivity of the hydrologic response of the watershed to land use. A summary of basin parameter values and assumptions made when developing the HEC-HMS model and adjusting for "past" and "future" conditions can be found in Appendix D.

The resulting flows from the HMS model were run through a calibrated HEC-RAS (Hydrologic Engineering Center - River Analysis System) hydraulic model for Indian Creek in order to calculate approximate inundation extents caused by these floods. This allows for better communication of the potential increase in flood risk caused exclusively by land use change.

Climate Analysis Using a Counterfactual Time Series Method

In order to frame the discussion of climate change in a more familiar way, the presentation of more tangible local impacts was preferred to global or broad regional climate simulations. Discussion at the stakeholder workshops was primarily centered on flood risk, especially recent and thus familiar events such as the floods of record on Indian Creek and the Iowa and Cedar Rivers in 2002 and 2008, respectively. This familiarity provided a useful baseline for communicating how the climate may change in the future and how that change would affect stakeholders in a tangible way.

The Coralville Lake climate change pilot study made available for use data from the North American Regional Climate Change Assessment Program (NARCCAP) simulation results, so these were used for the climate change analysis. When this analysis was being performed the only hydrologic model available for use in simulating climate change scenarios on Indian Creek was the HEC-HMS model, which was formulated for simulating the peak discharge of a single event. Ordinarily the dynamically-downscaled data from the NARCCAP simulations would be used in a continuous simulation hydrologic model. However, without the availability of a continuous model at the time of the public dialogue workshop a "counterfactual" methodology to apply the simulated changes in climate to an individual event was determined to be necessary.

A "counterfactual" analysis was performed as an attempt to make "what if" scenarios out of a known, observed event by perturbing the event using a hypothetical or probable change in the system. In this case, the change in the system is the simulated change in rainfall intensities in the

mid-21st century using an assumed greenhouse gas (GHG) emissions scenario, a general circulation model (GCM) and a regional climate model (RCM). GCM simulations are often performed not only for future climate scenarios based on potential future GHG emissions, but also for historical time periods with known atmospheric GHG concentrations. This analysis helps frame the performance of the GCM in terms of its ability to replicate historical climatic conditions. This is useful for the analysis done in this study, because comparing the results of the future simulations and historical simulations isolates the effect of GHG emissions when holding the GCM constant. Ideally this bypasses limitations of the GCM. The GCM simulations are then increased in spatial and temporal resolution by use of an RCM, which produces downscaled climate simulations useful on a more local scale for impacts analysis.

The local scale event that was simulated for impacts analysis was a relatively recent storm in August 2009, which caused flooding throughout Indian Creek. Observed data regarding the severity of the flood was available for use in validating model results. The average return interval of the 2-day storm event was roughly a 25 year storm (4 percent annual chance exceedance), which is a moderately rare event and has a return interval shorter than the normal simulation length of a GCM, about 30 years.

A statistical analysis of rainfall intensities was performed in order to establish the frequency-intensity relationship of historical observed rainfall, historical rainfall simulated by the GCM, and future rainfall simulated by the GCM. This frequency-intensity function defines the probability of occurrence of a range of rainfall intensities. The GCM results were used to compute how rainfall with a given probability of occurrence was forecasted to change in the future. The change in intensity for a whole range of probabilities was computed for two different GCMs. These changes in intensity were used as scale factors and were applied to the August 2009 rainfall event by scaling daily rainfall according to the computed event probability of occurrence.

This procedure, detailed further in the following “Climate Data Downscaling Method Comparison” section, accomplished the creation of a new rainfall timeseries that demonstrates the potential change in precipitation due to climate change but is referenced to a historical event. The resulting perturbed historical rainfall events (Figure 6) were run in the HMS model for Indian Creek. The resulting outlet hydrograph is shown in Figure 7 for two GCM-RCM pairs. These pairs are the low and high scenarios for this event out of a pool of four that were evaluated in an effort to bracket a probable range of changes in precipitation. Figure 8 shows the difference between historical inundation due to the 2009 event and the higher climate change scenario for a selected area.

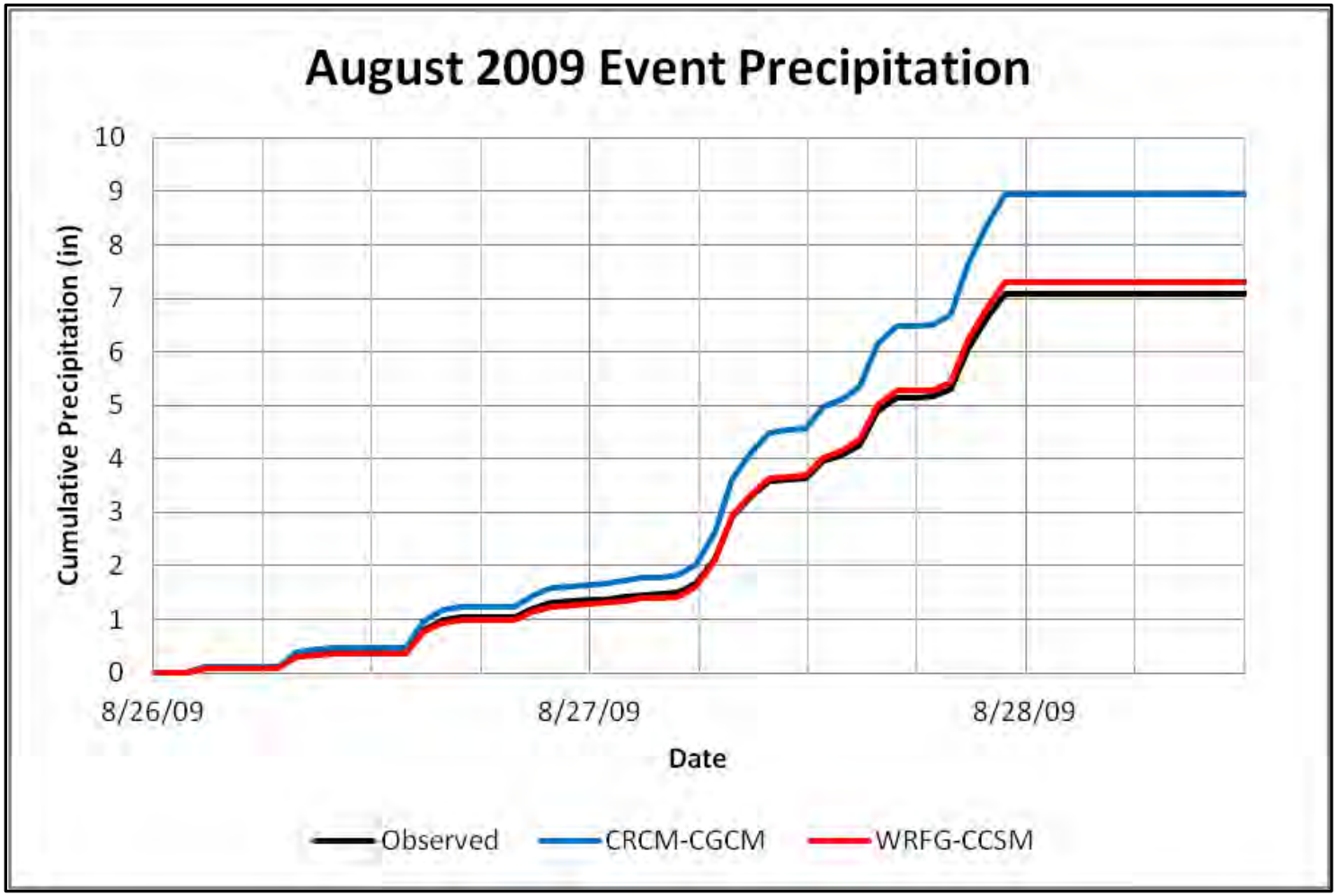

Figure 6: Climate Change Scenarios with Counterfactual Statistical Adjustment of August 2009 Storm Event – Cumulative Precipitation

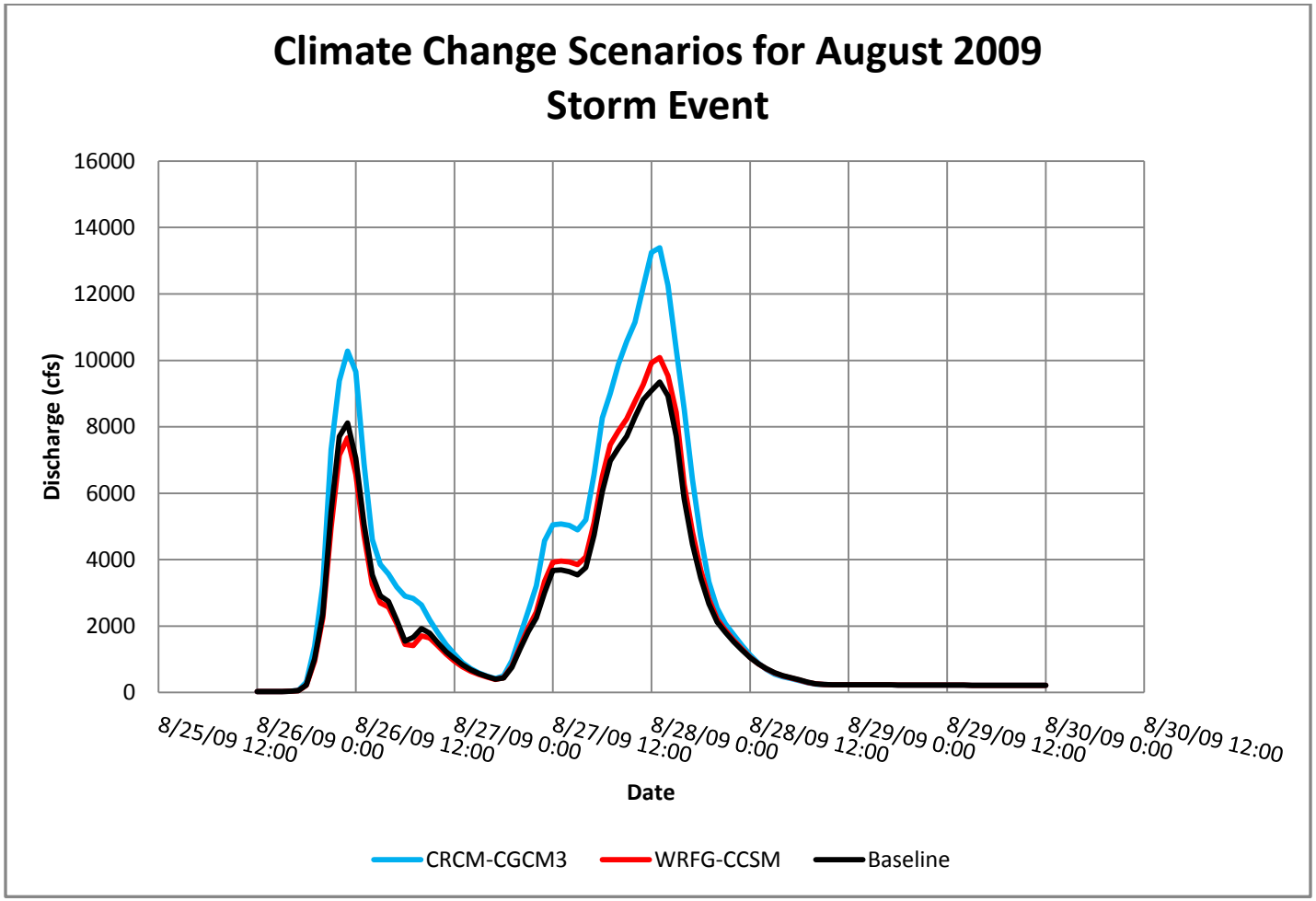

Figure 7: Climate Change Scenarios with Counterfactual Statistical Adjustment of August 2009 Storm Event – Discharge

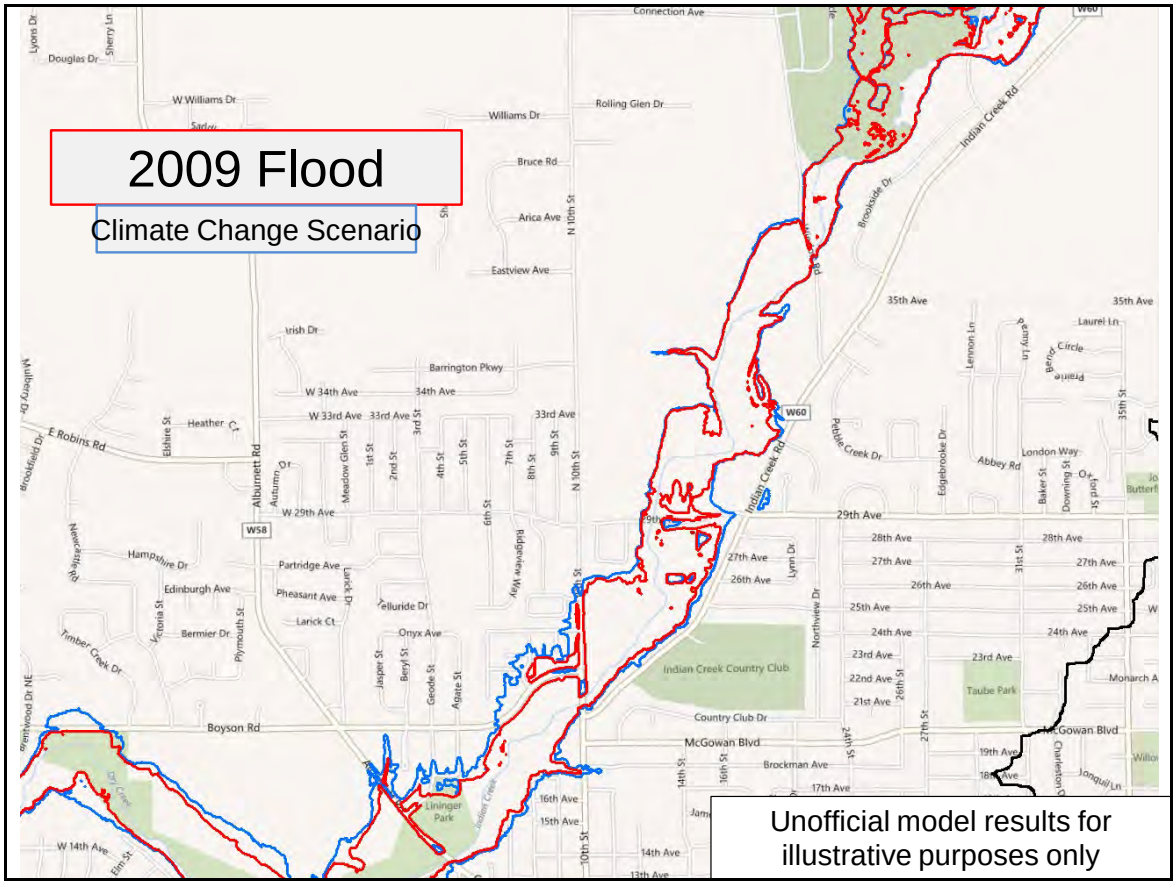

Figure 8: Historical Simulated Inundation (Red) and Future Scenario Flooding (Blue) for the August 2009 Storm Event

The model sets used for the analysis in this study were the CRCM and WRFG-downscaled CGCM3 and CCSM model runs. Because the CGCM3 and CCSM GCM runs were downscaled with the same two RCMs, these results were selected for use so that the effect of changing downscaling RCM (holding GCM result constant) on the resulting meteorology could be determined, as well as the effect of using a different forcing GCM (holding RCM downscaling constant). At the time of the public dialogue workshop these were the only model pairs with available data for running such an analysis.

Model Comparisons

Hydrologic Model Comparison

Hydrologic models differ by formulation and purpose. There are a large variety of models to choose from to simulate a watershed. Therefore, it is important to select the correct tool for the analysis being performed. An important difference between models is the amount of time, effort and data it takes in order to properly set it up and obtain simulation results. This study evaluated the use of

three hydrologic models for simulation of the Indian Creek watershed. The three models used have different levels of complexity and different methodologies for simulating the hydrologic cycle.

HEC-HMS. The Indian Creek HEC-HMS model was built for use in a Corps Section 205 study for the watershed. This model is a single-event lumped parameter empirical model. Its only meteorological input is rainfall, and infiltration and runoff parameters are lumped to a sub-basin level. The precipitation input is a rainfall average for each sub-basin, and was derived from grid averages of NEXRAD RADAR rainfall data and from rainfall gauges. The model is a single-event model so antecedent condition parameters are calibrated for an individual rainfall-runoff event. The HMS model was run at a 1-hour timestep.

SWAT. A portion of the Cedar River SWAT model, developed by the USGS, was extracted for the sub-basins that comprise the Indian Creek watershed, and run separately from the rest of the Cedar River model. This model is a continuous, quasi-distributed and quasi-physically based hydrologic model. The primary infiltration calculation method is the SCS Curve Number method which is empirical, but the curve numbers are adjusted by a number of physically-based simulations for soil moisture and evapotranspiration at each timestep. Parameters are distributed within sub-basins by hydrologically homogeneous regions called "hydrologic response units" (HRU). Several or many HRUs, depending on how they were defined in the model, make up each sub-basin. These HRUs are a non-geographically continuous area within the sub-basin with the same land use, slope classification and soil type. SWAT is a continuous model, and for comparing hydrologic events the model is run for a long period of time before the event of interest in order to equilibrate initial conditions such as soil moisture. The model is run at a daily timestep and thus the results are average daily outputs. The model assumes a uniform distribution of each day's rainfall throughout the day. The SWAT model used in this study was not calibrated specifically to Indian Creek flows, as observed discharges were not available. The entire Cedar River model was calibrated to a number of gauges on the mainstem and tributaries, and the sub-basins used in this model were calibrated to that end. No further calibration was performed on the extracted portion of the Indian Creek model.

GSSHA. A GSSHA model was built for the Indian Creek watershed. GSSHA is an event or continuous model that is fully-distributed and physically based. It simulates fully coupled overland flow and groundwater flow in two dimensions, as well as one-dimensional channel flow and infiltration. It is capable of being run with NEXRAD RADAR rainfall and gauge data as inputs and requires a full suite of meteorological data in order to calculate the full energy and water balance. This GSSHA model was run at a 10 second timestep with hourly output. The Indian Creek GSSHA model was calibrated using observed stage data from the Iowa Flood Center bridge sensors that was converted into flows using derived rating curves.

Direct Model Comparison

Performing a direct comparison of the results from the three models proved difficult, as there are significant differences between the models that affected the resulting comparison:

- The HMS model is an event model, while GSSHA and SWAT are continuous. There are only HMS results for the flood event of interest, and the model does not have a spin-up period to equilibrate parameters. Instead it is calibrated using parameters to estimate initial conditions.
- The SWAT model runs and outputs results at a daily timestep, while HMS and GSSHA run and output at a sub-daily timestep. Rapidly rising and falling peaks occur commonly in small watersheds such as Indian Creek, and capturing the peak discharge of such an event is difficult with a daily timestep model. The model may be adequate for simulating average volumes during a storm event but will not capture the peak discharge which is often of more interest.

Depending on the intent of simulating watershed processes, one or more of these models may be appropriate. The three evaluated models differ in complexity and the amount of data necessary to run them. An important consideration is whether or not the additional complexity of the model will answer key questions any better than a simpler model, since the more complex model will require more labor and data to build. A more complicated model is not necessarily better than a simple model (Occam's razor), and in fact overfitting may occur if an excessively parameterized model is calibrated to observed data. A model should only be as complicated as is necessary to accurately model the system.

The complexity point is important when considering the three models in this study. The HMS model is much simpler than the SWAT and especially the GSSHA model, however when comparing the results of the three models it is apparent that although the models have different levels of complexity they can produce similar results. Figure 9 shows the results of simulating the August 2009 flood event in Indian Creek using the HMS and GSSHA models. Both models show hourly output using hourly rainfall input. The peak discharge difference between the two models is about 13.5 percent, which considering the fact that neither model was calibrated to this event (and considering the sparse calibration data for this watershed), is a small percentage. However, the HMS model is made of five sub-basins with lumped parameters, requires only precipitation as an input to run and takes less than a minute to compute the August 2009 flood event simulation. In contrast, the GSSHA model has almost 25,000 100 m grid cells and requires complete meteorology, land use, soil and terrain data to run. Simulating an event plus 6-month model equilibration period may take 4-8 hours to run on a normal PC.

However, the difference between the model results is more than the difference in the discharge peaks. There are large differences in the volume of flow simulated by the two models. The HMS

model, which simulates individual events, does not represent the initial conditions via any physical process. Thus if the model is not calibrated to represent initial conditions of a storm event, then it may over- or underestimate the initial rainfall infiltration and in large events, the time until soil saturation and Hortonian overland flow. In the model results shown in Figure 9, it is likely that the model is largely underestimating the amount of infiltration occurring due to the rainfall early in the event and thus producing a large volume of runoff. In the GSSHA simulation the near soil surface is dry and requires a sizeable volume of rainfall to become saturated, reducing the volume of runoff produced.

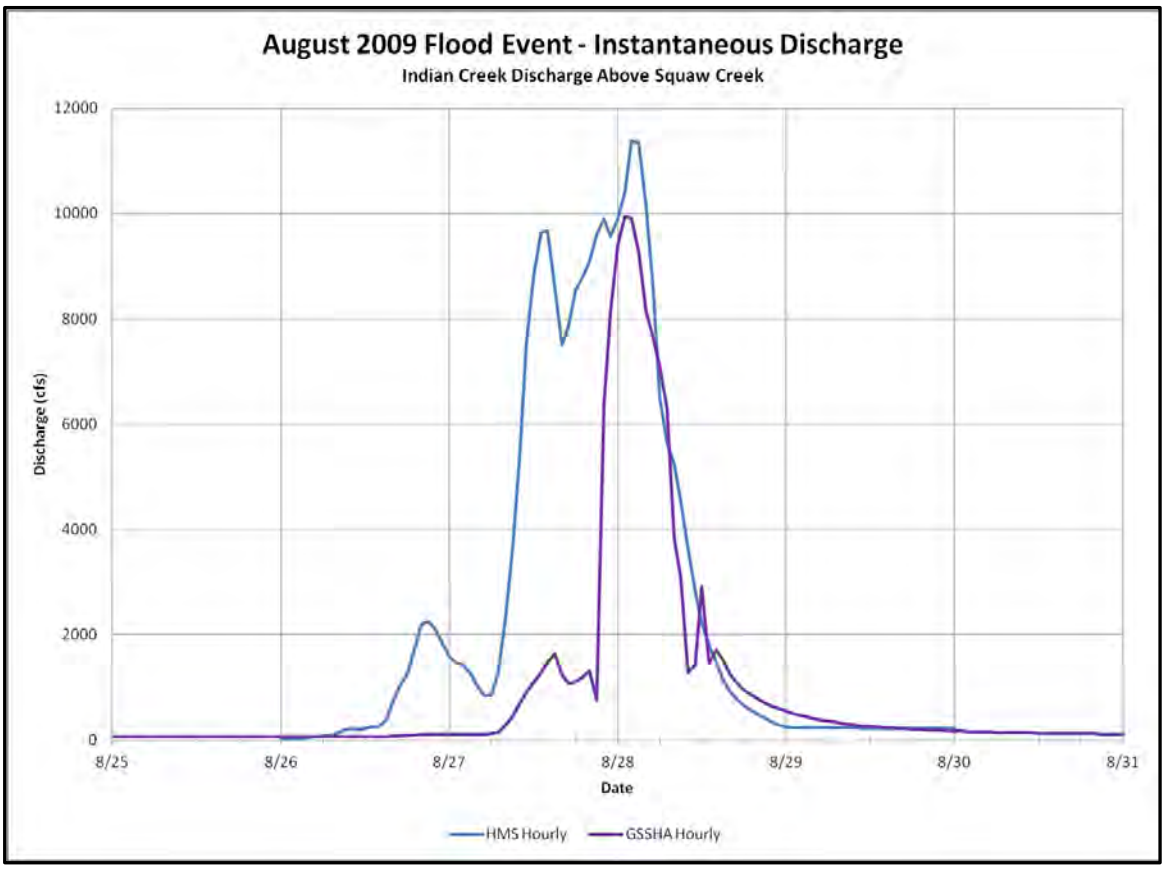

Figure 9: Comparison of Instantaneous Discharge for the HMS and GSSHA Models for the August 2009 Flood Event in Indian Creek

Comparing the averaged daily results for the GSSHA and HMS results to the SWAT model makes apparent the importance of accurately representing antecedent conditions. Figure 10 displays a plot where the continuous models show a similar shape on the flood hydrograph, with SWAT producing higher flows. The HMS results show a large peak on August 27, while the other two models show a more mild increase in discharge, as SWAT and GSSHA are producing much less runoff than infiltration for the same volume of rainfall due to antecedent conditions. Correspondingly, the increase in soil

moisture in the SWAT and GSSHA models on the August 27th leads to an increase in runoff for the 28th, showing a 2 to 3 fold increase in discharge for that date. Because the HMS model was not calibrated specifically for this event, the infiltration method being used (initial and constant loss) does not accurately portray the hydrologic conditions of the watershed prior to the storm event. Thus the peak on the 27th is not an accurate representation of the actual hydrologic response for the watershed to this precipitation event. However, the peak on the 28th is more in line with the other models, showing that the HMS model can produce similar flows once the initial conditions are ironed out. The results are acceptable for illustrative purposes, which was the intent of using the model for the public engagement sessions. Calibration of the model for this specific event would be necessary for use of the model if the actual (and not relative) magnitude of the flood peak were being computed.

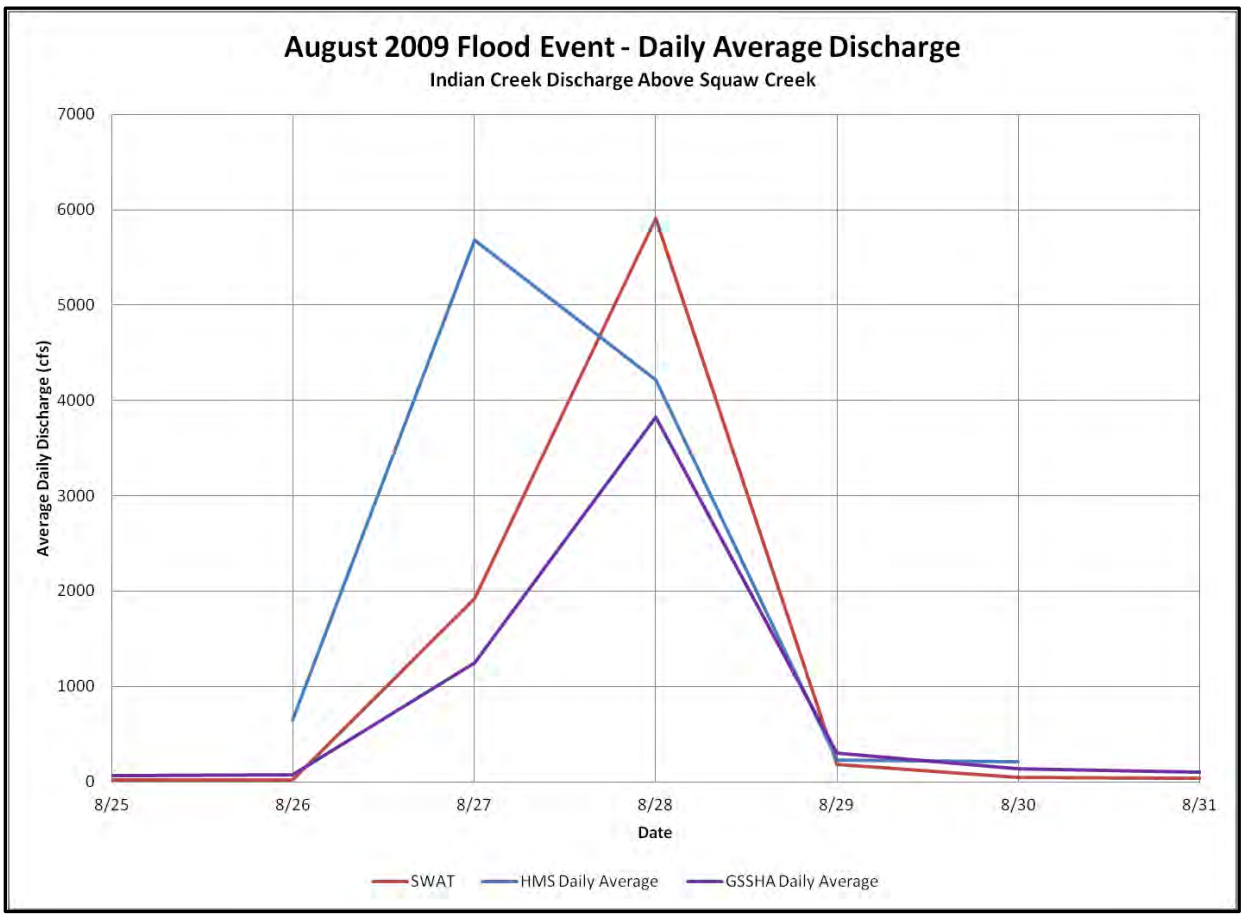

Figure 10: Comparison of Daily Average Discharge for the HMS, GSSHA, and SWAT Models for the August 2009 Flood Event in Indian Creek

Climate Data Downscaling Method Comparison

This section describes the three different climate data downscaling methods and compares their various levels of uncertainty and how that may impact how they may be used for the purpose of communication with stakeholders.

1. Empirical Adjustments Versus Regional Dynamical Models. This method accounts for the range of projected changes from the Bias Corrected and Spatially Downscaled (BCSD) WCRP CMIP3 Climate Projections archive (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/dcpInterface.html) and North American Climate Change Assessment Project (www.narccap.ucar.edu).

This analysis, performed by Chris Anderson (Iowa State University Agronomy Department) was provided in the form of a scatter plot of the 112 BCSD results and selected NARCCAP results showing projected average annual and seasonal changes in temperature and precipitation. From this an idea of what general direction the climate is headed for the mid 21st century can be gathered. For example, Figure 11 shows how mid-century annual temperature is projected to be between 1.5 and 3.5 °C warmer and generally wetter on the order of 5-15 percent more precipitation per year according to the densest part of the cloud of projections, but there are also warmer projections than that range which are also drier. Some very warm projections (greater than 2.5 °C warmer) show a marked decrease in precipitation. The annual plot shows relatively small variance and somewhat clear correlation with increasing temperature decreasing precipitation. While a good deal of attention has been given to increased flood risk due to higher precipitation volumes and storm intensification, the warmer-drier scenarios pose a significant risk for drought intensification. All the NARCCAP projections shown in the annual plot are in the "warm-wet" region of the graph. Generally, the models forecasting larger increases in average temperature are also forecasting the lowest precipitation increases (or even small decreases). Further, a minority of the BCSD results forecast that the warmest average temperatures are also consistently forecasting a decrease in precipitation in the future.

Seasonal averages demonstrate a less clear correlation and especially summer is highly uncertain (Figure 12.) Observationally, summer conditions have large variance in temperature and precipitation so it makes sense that forecasting the future of summer conditions is highly uncertain. The NARCCAP results plot within the cloud of BCSD results and are not extreme in any comparison yet do a good job of representing some of the variance in the projections.

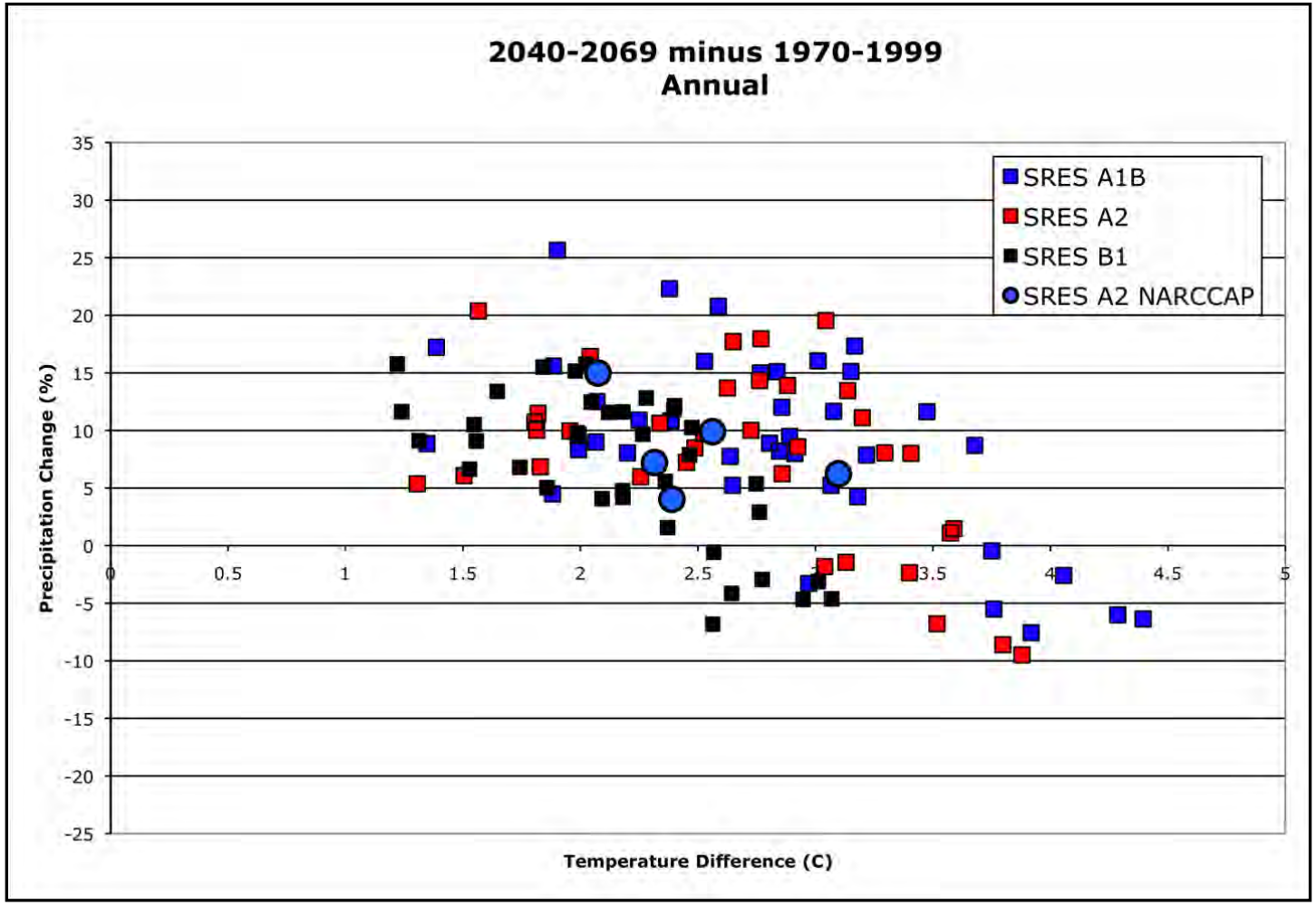

Figure 11: Comparison of NARCCAP & BCSD Projections for Changes in Annual Average Temperature and Precipitation

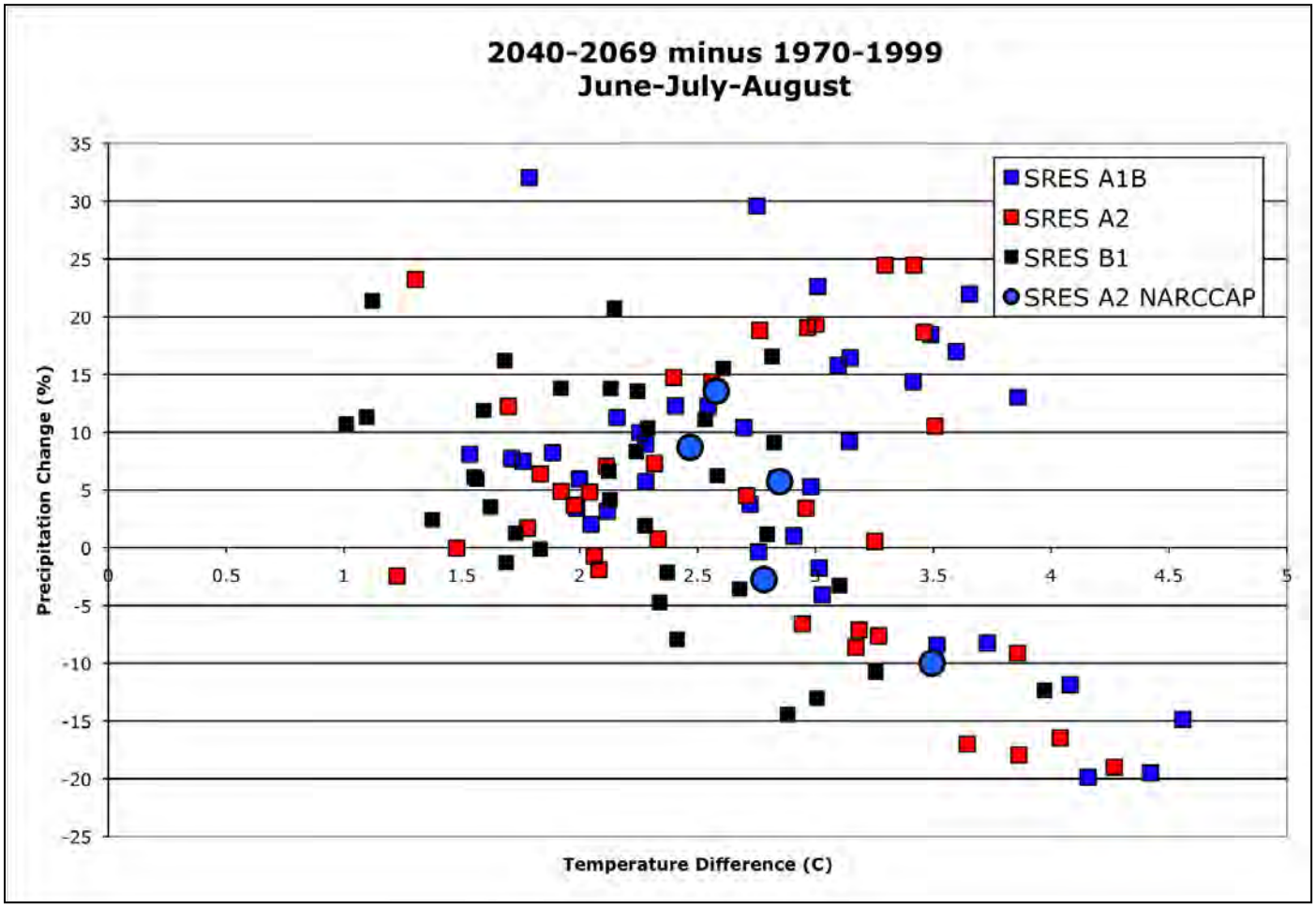

Figure 12: Comparison of NARCCAP & BCSD Projections for Changes in Summer Average Temperature and Precipitation

The cloud of projections paints in broad brushstrokes an image of potential future climate. What the figures emphasize is the uncertainty associated in forecasting climate for the 21st century. This uncertainty makes meaningful decision making about the future very challenging. However, techniques being developed, such as those by Brown et al. [2010] help decision makers approach climate change adaptation in a way that is more robust to the uncertainty of future climate.

The use of these projections in this study frames the discussion for key trigger points regarding action in the face of climate change. If a change of +1.5 to 3.5 °C in the annual average temperature or +5 to 15 percent in annual precipitation, the approximate range of most of the future projections, is considered acceptable, then perhaps action is not needed. However, given historical flood events that have occurred in the watershed even before large changes such as these have taken place, it is apparent that there is already flood risk present and the continuing change in climate can increase that risk.

A simple way to apply this information is in the use of a "delta change" method. Historical meteorological data can be perturbed using the simulated average changes in precipitation and temperature (shown in Figures 11 and 12) and used in a hydrologic model to assess the effects of these changes. However, there are many limitations to such a methodology. For example, it does not address the difference in changes to the frequency-intensity relationship in rainfall, or the unequal distribution of increases in temperature between daytime and nighttime, and winter and summer. These limitations make it favorable to use these data illustratively and to use more robust data for impacts analysis.

2. North American Regional Climate Change Assessment Project (NARCCAP) Data Covering the Iowa-Cedar Watershed Formatted for Direct Use in a SWAT Model. The GCMs selected for the NARCCAP analysis are a small subset of the full 23 used in the IPCC report analyses, but were selected using statistical techniques to be representative of the full set of 23. The two GCMs explored in this study were run for a historical period during the 20th century using observed greenhouse gas (GHG) emissions as well as a future scenario for the mid-21st century using the Intergovernmental Panel on Climate Change (IPCC) A2 GHG emissions scenario. The emissions scenario is an estimate of GHG emissions for the 21st century and is based on a number of economic, societal, political and technological assumptions that drive worldwide GHG emissions.

The NARCCAP data are dynamically-downscaled climate scenarios, meaning that large, coarse-scale general circulation model (GCM) data are increased in spatial and temporal resolution by running a regional climate model (RCM) using the GCM outputs as boundary conditions. The result is climate data increased in resolution from the coarse resolution of the GCM, generally, 2-5° spatial resolution and monthly timestep, to the finer resolution of the RCM at about 50 km spatially and 3-hour timesteps.

Using regionally-downscaled climate data directly in a hydrologic model is highly favorable because the spatial resolution of the downscaled climate data is often as good as gauge data in many locations and it does not require any work on the part of the end-user to make the data "work" in their model. Its temporal resolution is better than some gauges, and can provide meteorological variables that are not always available at weather stations. If the gridded climate data are treated like gauges, it is relatively straightforward to run a climate change impacts analysis just as one would run a hydrologic model with observed meteorology as an input.

One important aspect of the NARCCAP data to keep in mind is that these data are considered experimental. The use of regional climate models to dynamically downscale GCM results is being evaluated as a methodology to investigate uncertainty in regional scale projections of future climate. The major conclusion from the Coralville climate change pilot study (which this study leverages) was that the range of results produced by short-window RCM simulation was not generally enough to evaluate the potential impacts of climate change on reservoir management. The limitation of dynamically-downscaled results arises from a short simulation period (less than or equal to 30 years) as well as a tendency for models to produce few extreme events to work with. For this study similar limitations were observed in that the 'interesting' extremes occur too infrequently in the data to evaluate the potential range of effects. For reservoir management it was high streamflow that was of most concern. For a whole watershed, low flows are problematic for municipal water supply, water treatment and various ecological concerns, while high flows cause not just flooding but streambank erosion and sediment transport issues as well. The limitations of capturing extreme events by using the NARCCAP data directly in a hydrologic model to communicate extreme events required an alternative approach in conducting the climate change assessment.

3. Counterfactual Time Series Adjustment Coefficients Applied to Historical Weather Observations. Unlike BCSD data, dynamically-downscaled simulations are not subject to any bias correction, and regional climate models used to downscale the GCM results may not accurately represent the meteorology of the area being simulated. Considering the BCSD data limitations and that using dynamically-downscaled climate simulations directly in a hydrologic model is subject to the biases and uncertainties associated with using models serially (the output of one model as the input to another) a counterfactual analysis was determined to be favorable to minimize biases and more accurately represent the meteorology of the Indian Creek basin.

The counterfactual analysis was used in order to create data from a known baseline or observed historical event, making it easier to communicate the changes caused by the "what-if" scenario, as well as to perform some simple bias correction of the downscaled results in an attempt to more accurately compute the hydrologic response for flooding changes in a watershed based on future climate simulations.

The counterfactual time series used in this study was generated using observed precipitation that caused a flood event with known impacts, then scaling the precipitation in that event using the results of climate simulation. The dynamically-downscaled data in the NARCCAP set include simulations of historical climate (response to historical greenhouse gas emission) and future scenarios (in this case mid-21st century greenhouse gas concentrations based on the A2 emissions scenario). By using the same model pair (GCM and RCM) and the results for historical and future climate, a response function was created (Figure 13). This illustrates the change in intensity of precipitation for a range of expected frequencies between the historical and future climate scenarios. This function represents the response of the model pair to changing greenhouse gas concentration in isolation, which makes it useful for getting around some of the biases that occur in climate models. The complete details of the procedure used are located in Appendix F.

The precipitation events that were investigated for the counterfactual analysis were the August 2009 storm event and storms in April and May 2011. The August 2009 event was the largest since the flood of record in June 2002, was of moderately large magnitude (a precipitation event with about a 4 percent annual chance exceedance) and had a good quantity of supporting data in order to model the event in HEC-HMS, SWAT and GSSHA. The April and May 2011 events were used in developing the GSSHA model as these events occurred after the Iowa Flood Center had installed bridge sensors so there was observed stage (and derived flow) information in order to calibrate the GSSHA model. These events were run in parallel in the HMS model in order to compare model results.

When presenting the flood events under the climate change scenarios in the public dialogue workshop, the flood event shown was the “worse” case storm—the larger magnitude future precipitation event from the two evaluated (Figure 7). This was illustrative of a potential future event that was quite different than observed precipitation and represents increased risk of flooding. However, the downscaled climate results are not exhaustive by any means and do not represent the full range of uncertainty or risk due to continued changes in climate. In other words, the event selected for presentation may be higher in magnitude than historical but it is not necessarily the “highest” magnitude event possible.

The counterfactual analysis supported the theory regarding storm intensities - the intensity of the rarest events would increase in the future. Cumulative distribution functions for the CRCM-CGCM3 simulated daily precipitation are shown in Figure 13. Figure 14 shows how much the rarest events would intensify per the simulations run by CGCM3 and downscaled using CRCM. A 2.5 standard deviation rainfall event (an event expected to be exceeded on average once in about 336 days) could increase 10 to 15 percent in intensity, with rarer events becoming even more intense. The reason for this shift is related to storm intensification that has been occurring over the United States [Climate Change Impacts of Iowa report p. 4] as a result of an increase in the moisture “carrying” capability of the atmosphere via the Clausius-Clapeyron relation [various sources, such as Pall et al. 2007]. The Clausius-Clapeyron relation gives an estimate that atmospheric moisture (specific humidity) increases

exponentially with temperature, at a rate of about 6.5% °C^{-1}. The largest precipitation events occur when all (or nearly all) precipitable water in the atmosphere falls out as precipitation. If more water exists in the atmosphere vis-à-vis an increase in temperature, these storms have the potential to be larger and more intense.

This methodology is limited by several factors. The first is that the counterfactual method is highly dependent on the ability of RCM-GCM pair used to simulate changes in extreme precipitation. The methodology makes an approximation of the frequency-intensity relationship for daily precipitation and may not be favorable to a parametric distribution. Short periods of record undermine the ability to make accurate estimations of the rarest and most extreme precipitation events, which are often of most interest for impacts analysis. This methodology is fairly data and analysis intensive, requiring historical and future climate simulations as well as a frequency analysis of historical precipitation.

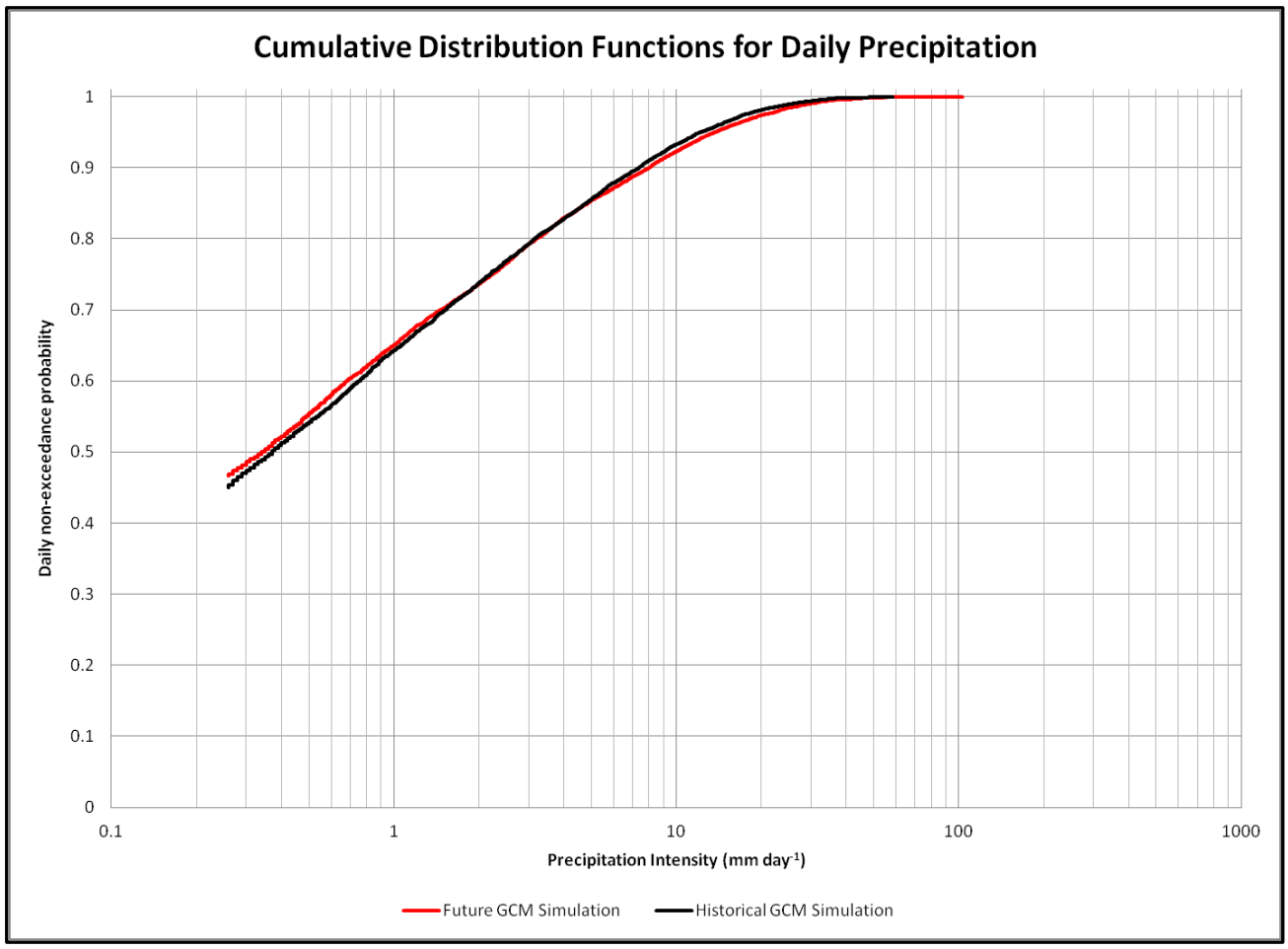

Figure 13: Cumulative Distribution Functions for Daily Precipitation as Simulated by CGCM3 Downscaled Using CRCM

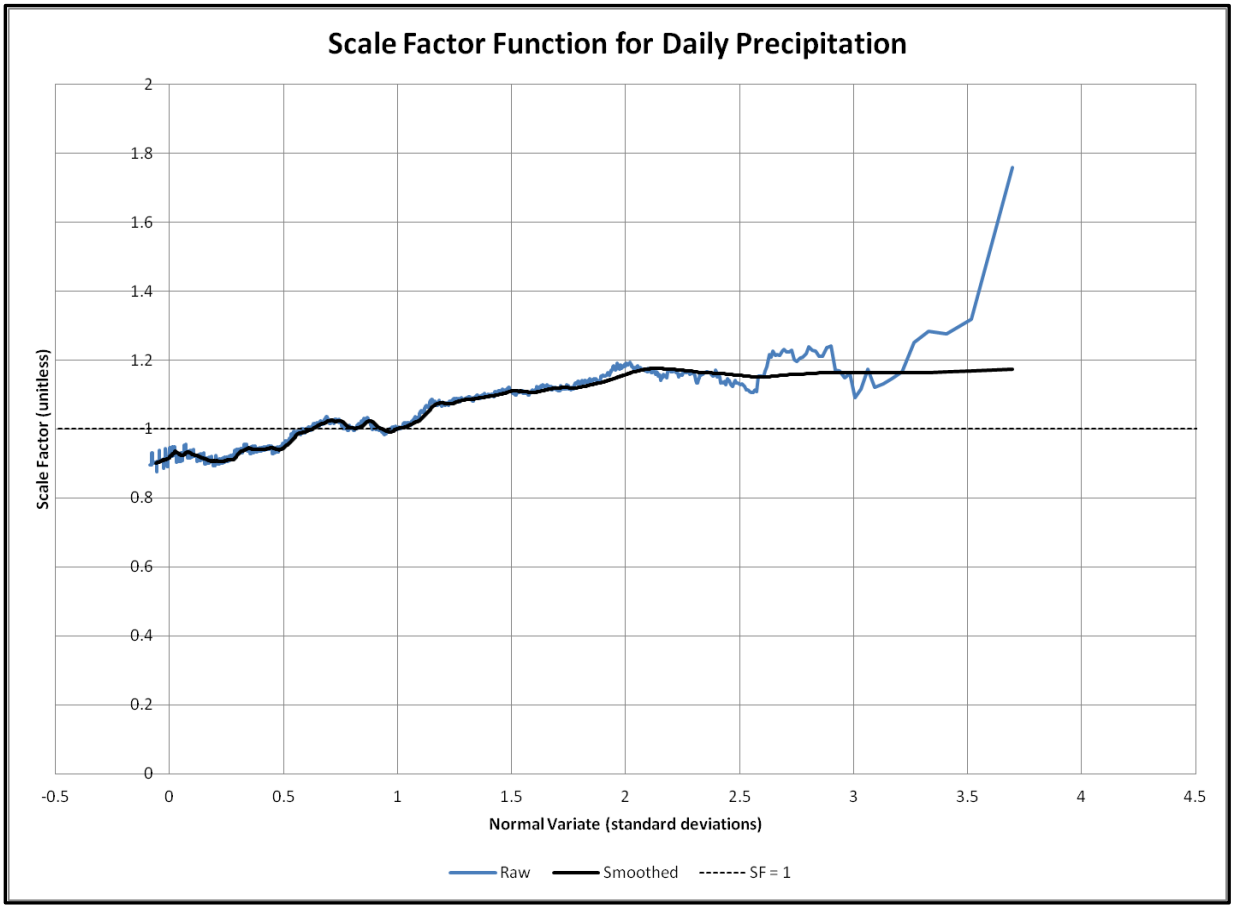

Figure 14: Scale Factor Function for Daily Precipitation as Simulated by CGCM3 Downscaled Using CRCM

5. Results

Stakeholder Dialogue Initiative

The result of this pilot effort was that a collaborative process was able to support a collaborative risk informed decision making process by addressing how climate change considerations can be incorporated into watershed planning so that policies and watershed investments result in a watershed that is robust and adaptive to potential climate changes.

This pilot effort showed that the use of a collaborative public engagement process can bring stakeholders together in a way that furthers their understanding of the risk-informed decision making process by using highly technical and complex information within a framework that is meaningful to the decision at hand. Specifically this pilot effort informed stakeholders that land use change and climate change both have significant impacts on stream flow regimes across a range of precipitation events. Thus, when conducting watershed planning, especially in an urban watershed,

both future development and precipitation trends need to be accounted for as they may compound the impacts of storm intensity and frequency, and therefore, the impacts of flood events.

As a result of this public engagement process the Indian Creek stakeholders now have a uniform vision, set of goals and objectives for determining if actions or other changes may have a beneficial or detrimental impact.

Inundation extents produced by the HEC-RAS model routing HMS-generated flows for the CRCM-CGCM3 model pair through a segment of Indian Creek illustrated the potential change in flooding due to climate change in an easier and more meaningful way to the public dialogue participants than as changes in the hydrograph produced by the HMS model alone (Figure 10).

As a result of this public engagement process the Indian Creek stakeholders now understand that they may continue to experience intense storms but that there are actions they can take to reduce their current and future risk. The stakeholders now have a better understanding of what actions may require changes to policies and ordinances, which may be addressed through specific structural and non-structural solutions and which may benefit from education and outreach campaigns or community-based volunteer efforts.

Comparative Analysis

The hydrologic modeling comparison was intended to address questions related to 1) How do we incorporate climate data in a highly tiled agricultural landscape? and 2) How do we incorporate climate data to evaluate structural and non-structural measures for flood damage reduction? As a result of funding constraints and public workshop timelines the pilot team was not able to address question 1) in great enough depth to draw conclusions about incorporating climate data in a highly tiled agricultural landscape. However, there was general agreement that while tile drainage impacts the hydrologic regime it has little effect on the extreme flood events that public dialogue participants were primarily concerned with. The impacts of climate changes toward a drier climate with more prolonged drought periods is very relevant to the vulnerability of the tile drained agricultural landscape and may be a topic of greater interest if conducting the workshops currently, or for future public engagement, as the region is currently experiencing a drought.

The results of the comparative analysis of hydrologic tools were able to address question 2) related to how climate data may be incorporated into structural and non-structural measures for flood damage reduction. Specifically, Figures 4 & 5 present locations where structural and non-structural measures may be employed based on current flood risk and potential future landuse and climate changes.

The results of the comparative analysis of hydrologic tools determined that event based models may under or overestimate the magnitude or recurrence of flood peaks versus continuous models due to difficulty in estimating the initial conditions. Similarly, continuous simulation lumped parameter

models such as SWAT often estimate initial conditions more accurately but have a limitation in capturing peak discharges in small watersheds with a time of concentration less than one day because rainfall is computed at a daily timestep.

Results of the HMS modeling illustrate that increased urbanization and changing land use have a greater effect on smaller, more common precipitation events with peak flows increasing as much as 60 percent with future land use projections (Table D-8). For larger, less frequent events, soils become saturated and similar runoff volumes are expected for past, present, and future conditions with variance in peak flows around 2 percent.

The resulting changes in precipitation intensity-frequency relations in the counterfactual analysis generally agree with the projected changes in precipitation in the Midwest –the heaviest rainfall may increase in intensity, generally by reducing the frequency of smaller events. For the WRFG-CCSM results, precipitation of moderate frequency (1.5-2.5 standard deviations from the mean, rainfall expected to be exceeded between 0.6-6.7% of days) increased in intensity while all other frequencies generally decreased. For CRCM-CGCM3, all precipitation events above 1 standard deviation from the mean (rainfall exceeded on 15.9 percent of days) increased in intensity.

It is good to illustrate potential changes in risk due to climate change, however each of these is a single point in a cloud of forecasts for future climate change and no single projection can be used effectively to prepare for the future. In this study two scenarios say two different things about the future climate – one changes the precipitation quite a bit and one very little – but even these two different scenarios are not representative of the whole potential future.

Overview

As a result of this effort a participant at the public dialogue workshop commented that the climate change model results don't "substantially change the type of actions necessary to make the watershed more resilient." The public recognized that flood risk comes from a number of places, including climate and land use change, and that the flood responses could be similar, so any solution applied to the watershed will have to address this issue. Using a comparative analysis was positive for reaching the public because they are familiar with the historical events that caused problems, so showing potential changes relative to these historical events likely had a more significant impact.

The Corps pilot team agrees with the participants comment in the previous paragraph that changes may not substantially change the type of actions necessary to make the watershed more resilient and thus conclude that climate change can be incorporated into Corps watershed planning within the framework of the existing guidance and does not require the development of additional guidance.

6. Lessons Learned

- Stakeholders were able to understand the climate change information when it focused on impacts, including the likelihood that extreme events will continue, and that climate change presents an additional factor of uncertainty related to the floodplain.
- Collaboration is critical for leveraging resources and making a significant impact. In this study, numerous products and resources were leveraged to support this project, including partner team members and specialists, and information from past and adjacent studies.
- It is important to adequately prepare for public engagement. With a widely diverse group of stakeholders, it is challenging to address the needs and concerns of everyone; clarifying the goals of each session and letting the stakeholders contribute to the content is most appropriate.
- Technical information related to landuse change and projected future landuse changes can help a group of stakeholders identify their risk threshold. This occurred when stakeholders viewed the future landuse plan where the developed landuse in the floodplain boundary was to nearly double, which they determined unacceptable.
- Using aerial imagery may be an effective tool in taking a group of stakeholders from goal setting and planning to where actions may be implemented to achieve goals and objectives.
- The choice of which hydrologic model is used for a watershed study has important consequences for the utility and accuracy of the model results, and modeling tools should be selected carefully with consideration for the formulation and assumptions for those tools.
- Consideration of climate change impacts can be integrated into the discussion of watershed planning if the impacts can be illustrated to stakeholders in a meaningful and relevant way, and that technical tools can be successfully used to enhance the communication of climate change risk.

7. References

Brown, Casey. (2010). *Decision-scaling for Robust Planning and Policy under Climate Uncertainty*. World Resources Report, Washington DC. Available online at http://www.worldresourcesreport.org

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Pall, P., M.R. Allen and D.A. Stone. (2007). *Testing the Clausius-Clapeyron constraint on changes in extreme precipitation under CO_2 warming*. Clim Dyn (28):351-363. DOI 10.1007/s00382-006-0180-2.

APPENDIX A

CLIMATE DATA AND INFORMATION

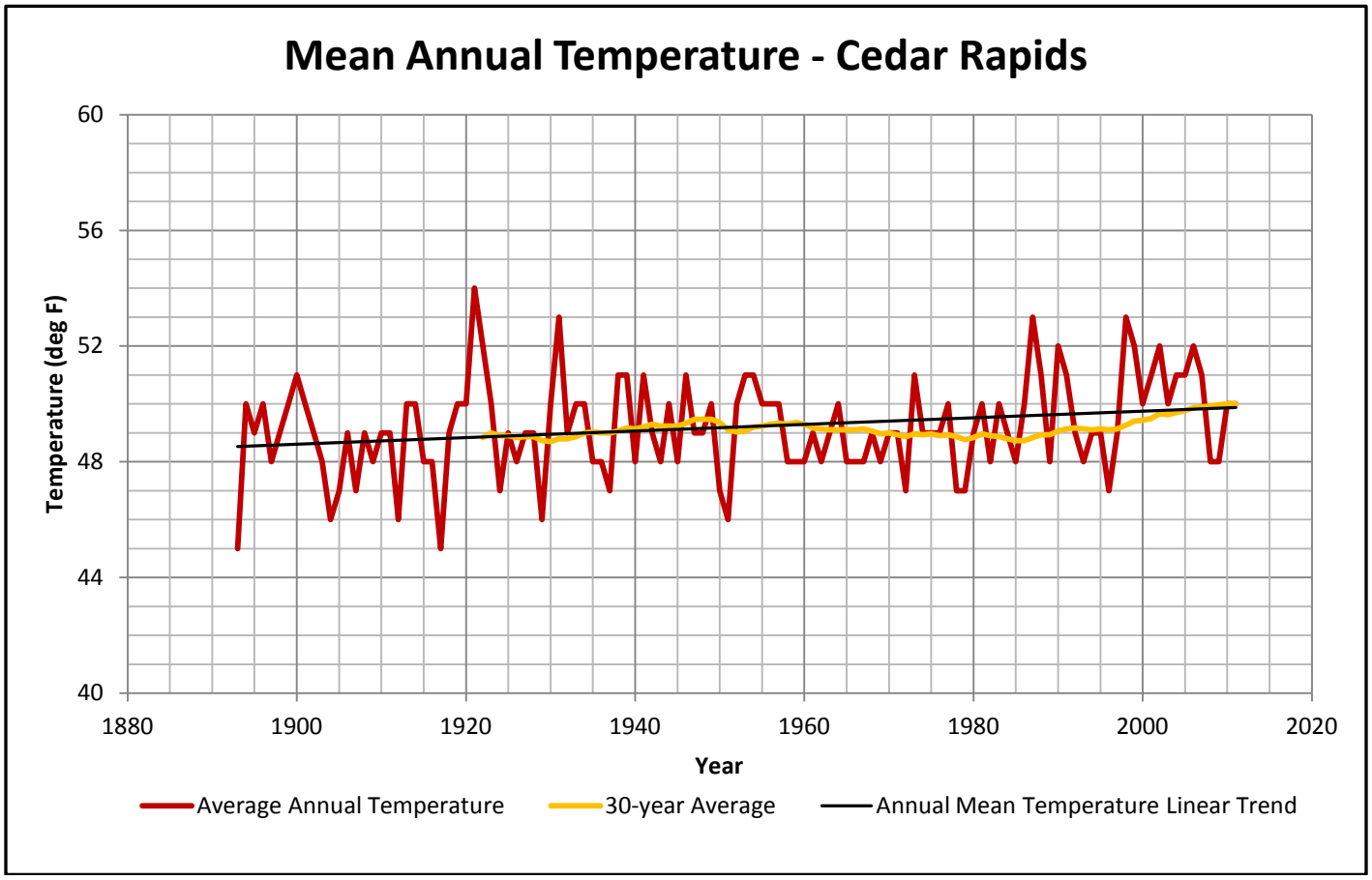

Figure A-1: Mean Annual Temperature, Cedar Rapids, IA Gauge [IEM Climodat]

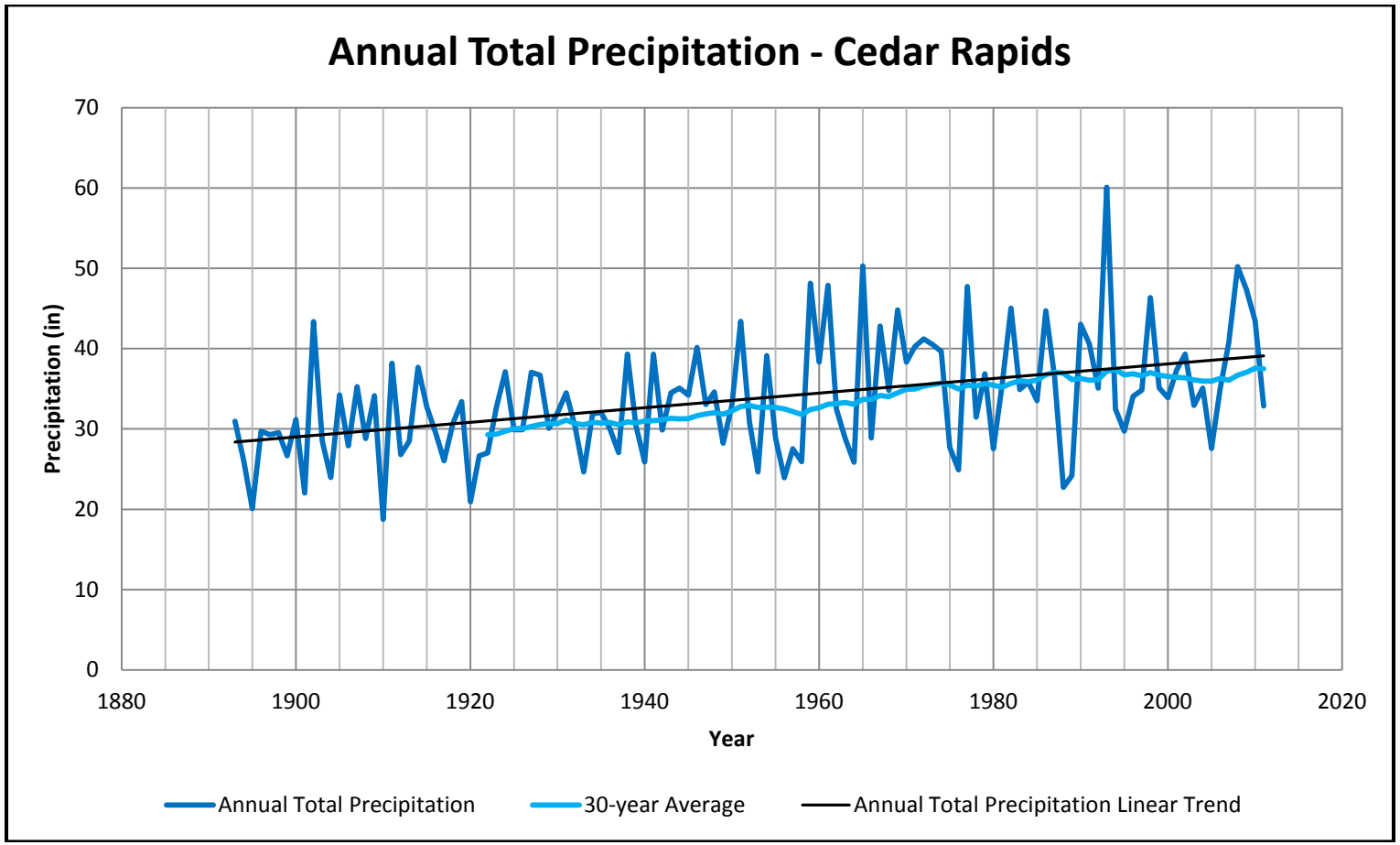

Figure A-2: Total Annual Precipitation, Cedar Rapids, IA Gauge [IEM Climodat]\

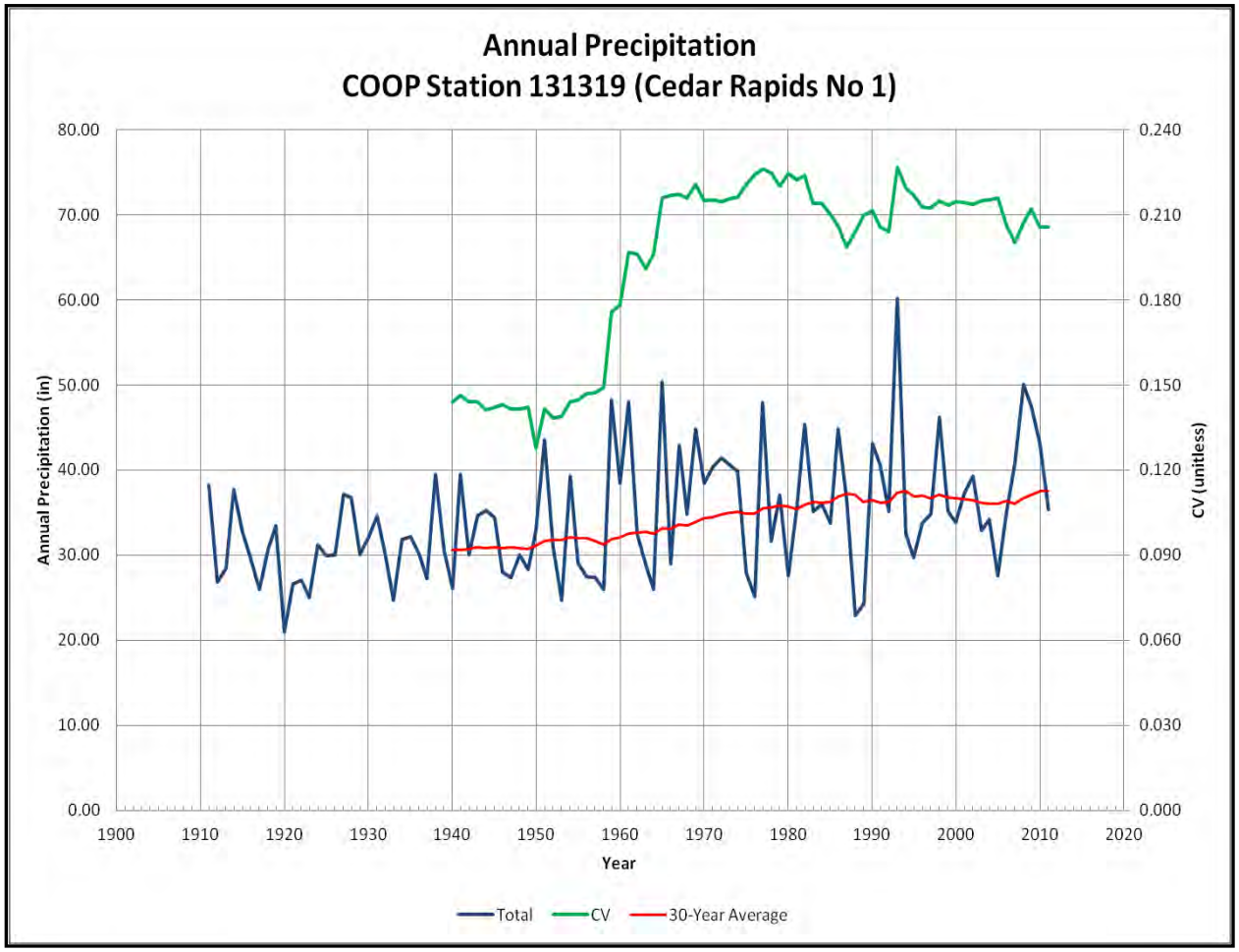

Figure A-3: Annual Precipitation at Cedar Rapids (1911-2011) and the Associated Coefficient of Variation

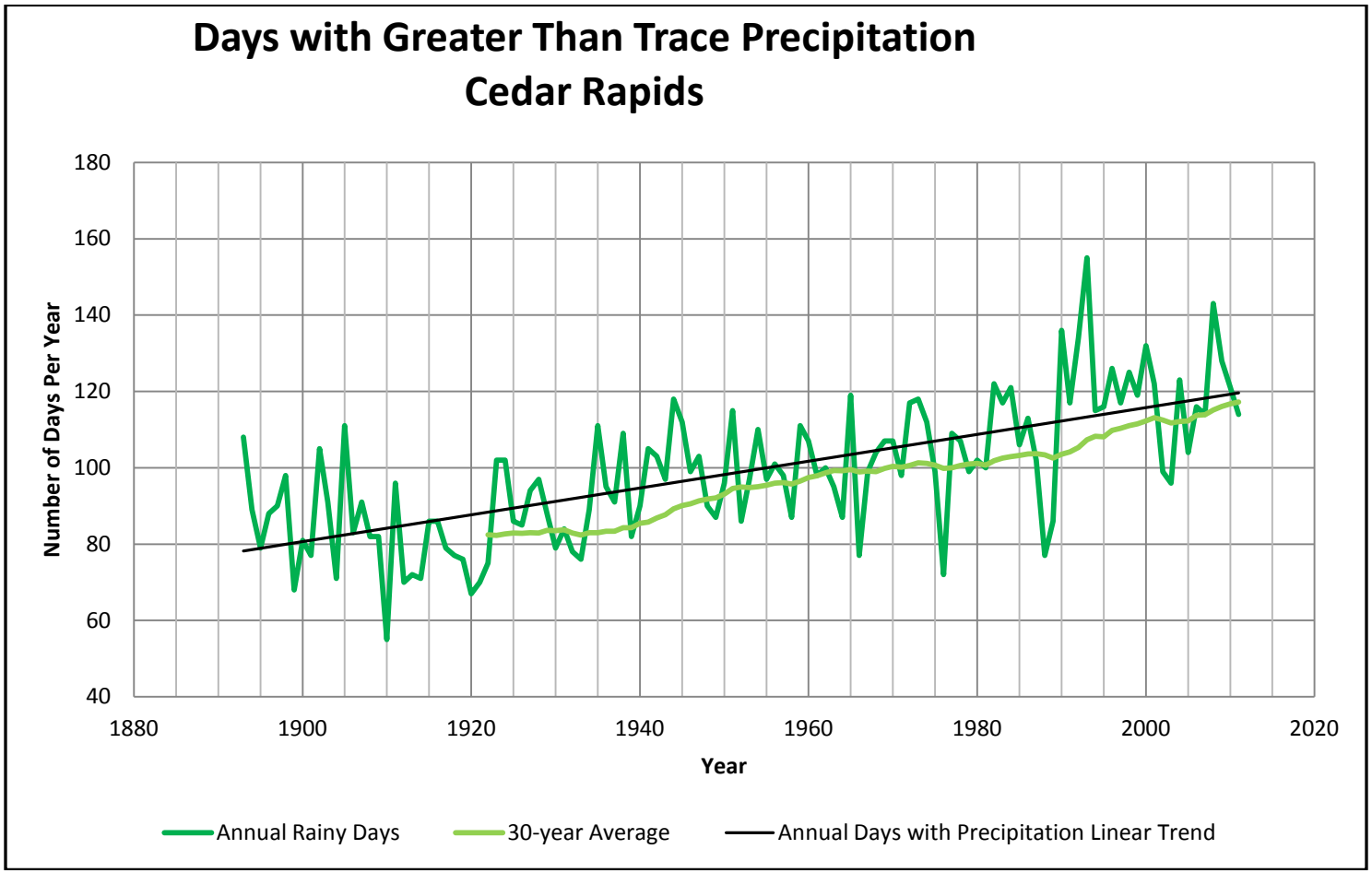

Figure A-4: Number of Days Greater Trace Precipitation, Cedar Rapids, IA Gauge [IEM Climodat]

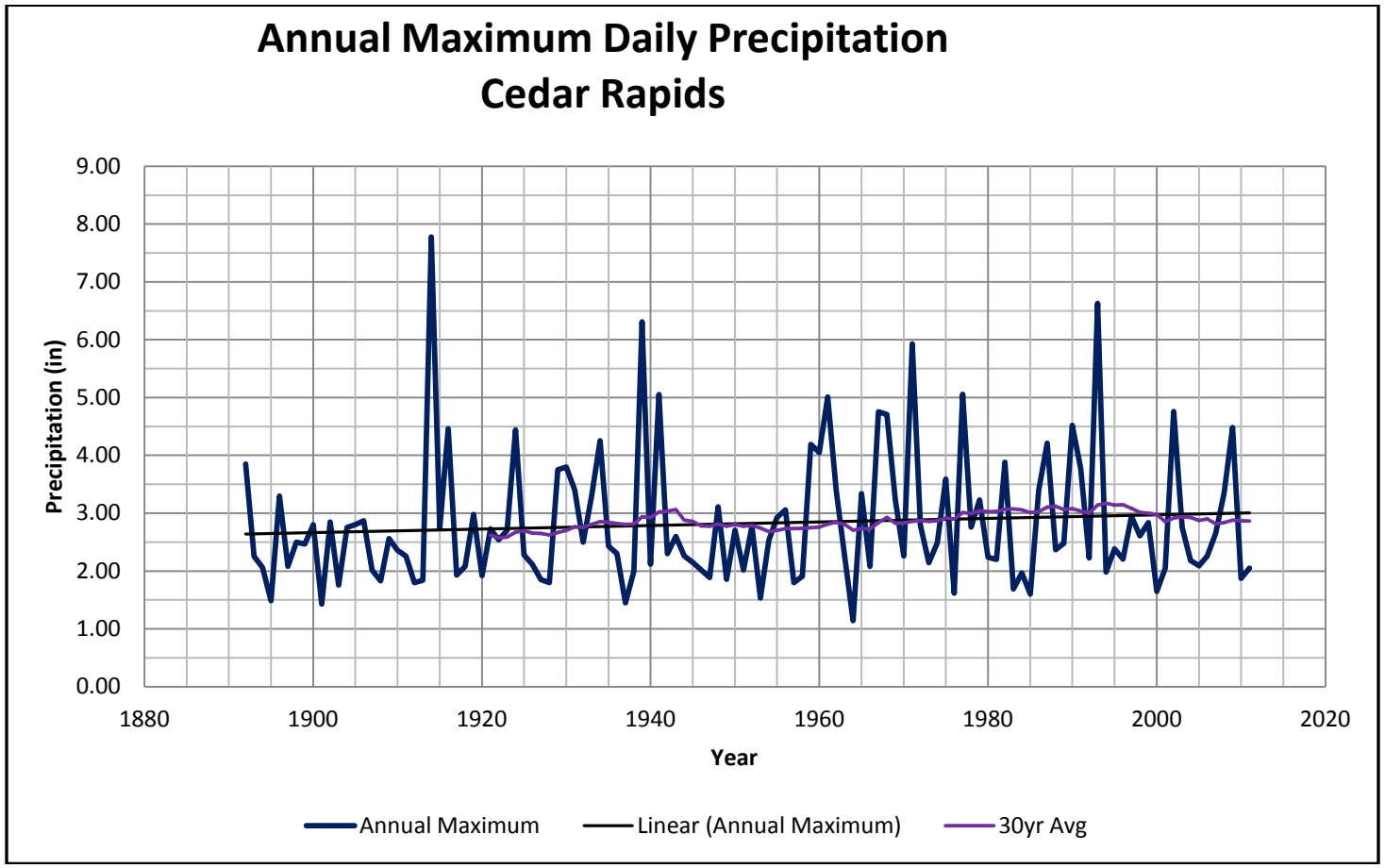

Figure A-5: Annual Maximum Daily Precipitation, Cedar Rapids, IA Gauge [NWS Coop Data]

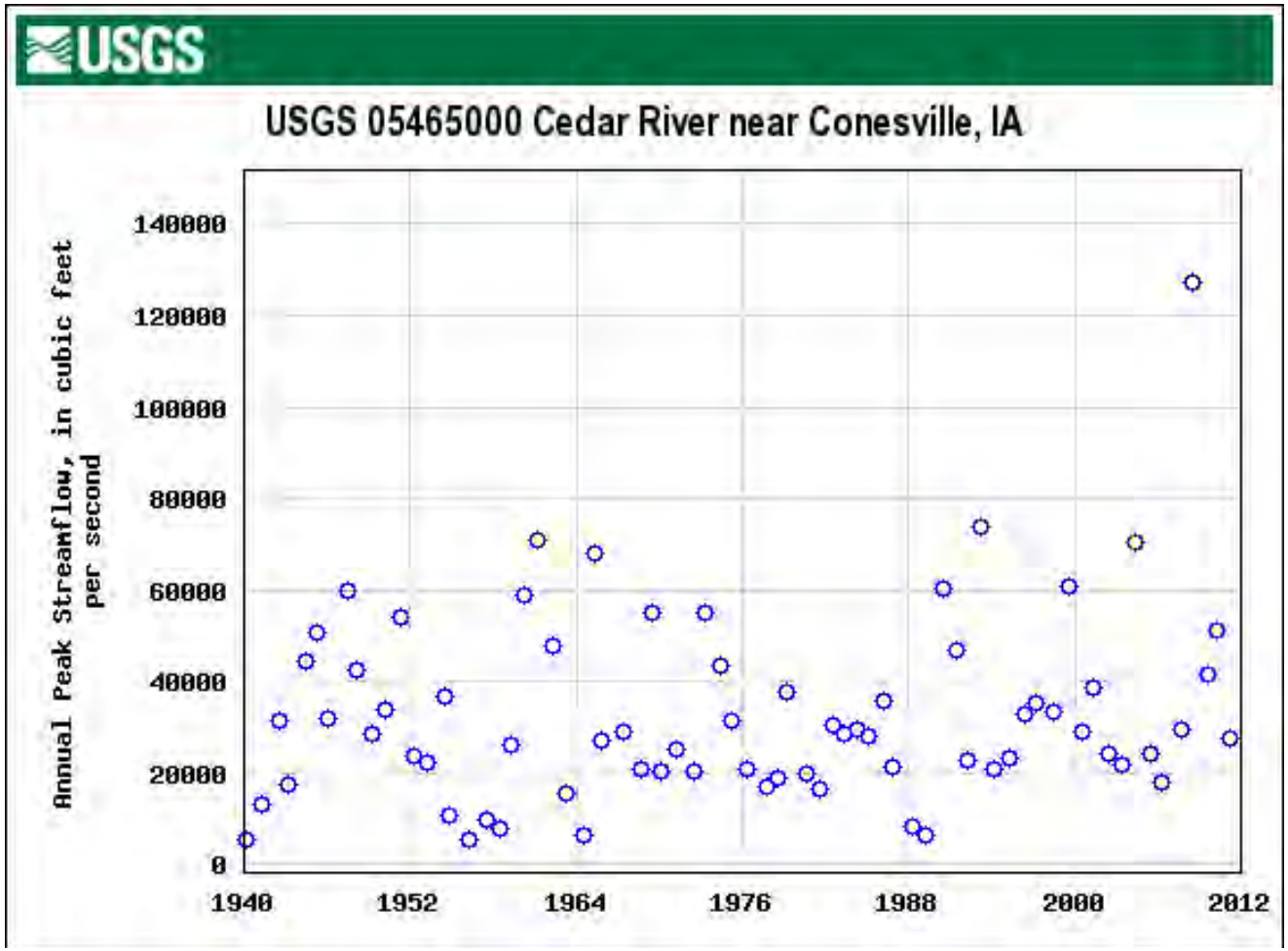

Figure A-6: Annual Peak Discharge for the Cedar River at Conesville (1939-2011) [USGS]

APPENDIX B

STAKEHOLDER ENGAGEMENT: GOALS, OBJECTIVES, AND PERFORMANCE METRICS

- Stakeholder Developed Goals, Objectives and Performance Metrics Spreadsheet
- Full Workshop notes/write-up.

Appendix B
Stakeholder Engagement: Goals, Objectives and Performance Metrics

Table B-1: Stakeholder Developed Goals, Objectives and Performance Metrics Spreadsheet – Workshop 3

	EFFECTIVENESS METRICS									
Goals/Themes:	**Water quantity/flood management**						**Water Quality**			
OBJECTIVES *Identified by participants in Workshop 1*	Reduce flood volume flows		A watershed with very low risk of flood damages				Achieve clean, unpolluted, safe, healthy water through the watershed			
REFINED OBJECTIVES. *Let's get more specific... What do we really care about?*	Reduce extent and duration of large flood events	Reduce extent and duration of frequent flood events.	Reduce damages affiliated with large flood events			Resilient to drought	Reduce Sediment		Reduce Nitrates, bacteria	
DRAFT PERFORMANCE METRICS: *What can we measure to determine how well we are meeting our objectives?*	Stage of 500-yr storm; stream 'flashiness'.	Highest stage of a 5-yr storm	Estimated damages from a (100)-yr equivalent storm, or smaller storms	Number of vulnerable structures in the 100-yr (___% annual chance) floodplain	Number of structures within the 100-yr floodplain +/- __ feet		Concentration of suspended sediment	Rate of bank erosion	Concentration of total dissolved solids (bacteria, nutrients)	Water velocity in stream channels during storm event (measured in key locations)
Alternatives/Measures:										
Current conditions									Sometimes exceeds standards, but not all year	
Future trends (future without): changes/sensitivity to climatic changes										
Buffer strips - legal requirement for permanent buffer strips	partial				varies	partial	if implemented throughout basin			
Wetland Restoration	improved	improved	improved	improved - wetlands on banks replaces development	improved - wetlands on banks replaces development		improved - collects sediment	improved	improved; reduces nitrate processing	+
Smart Growth policies that encourage infill development: *less new impervious surfaces; farmland is preserved; LID elements are considered*	less new impervious surfaces; decrease impacts of urban sprawl	no increase because of LID elements	Farmland preservation??	Develops outside of floodplain - does not increase	Develops outside of floodplain - does not increase		No Change (depends on baseline) - requirements for new detension will negate development			
Conservation till	improved	improved	improved	improved	improved		improved	no change	no change	improved
Reduced use of pesticides and fertilization		no change	no change	no change	no change	no change	no change	no change	significant improvement	no change
Update floodplain regulations and maps										
Stormwater detension / retention	+ + +				improves	improves				

NEW Alternatives Proposed in Workshop 3.
Change city ordinances regarding streambank areas
Sanitary and storm sewer infrastructure - backfill prevention
K-12 Education
Media/PR helps communicate watershed issues and opportunities

Table B-2: Stakeholder Developed Goals, Objectives and Performance Metrics Spreadsheet – Workshop 3

	EFFECTIVENESS METRICS						
Goals/Themes:	**Recreation**						
OBJECTIVES *identified by participants in Workshop 1*	Lots of recreational opportunities						
REFINED OBJECTIVES. *Let's get more specific... What do we really care about?*	Increase access to creek for fishing, wading, canoe/kayak	Increase fishing opportunities - more 'fishable' pools		More trails	Increase recreational use in the watershed		Increase educational programming on the Creek (church, school, CCB, etc)
DRAFT PERFORMANCE METRICS: *What can we measure to determine how well we are meeting our objectives?*	Miles of creek banks that are accessible to public for use (ie not private land)	Pool depth; fish populations and diversity	Fish populations and diversity	Number of miles of trails; connectivity of trail network	Number of visitors per year	Revenue from recreational uses (associated with visitors)	Number of programs and/or participants;
Alternatives/Measures:							
Current conditions							
Future trends (future without); changes/sensitivity to climatic changes							
Buffer strips - legal requirement for permanent buffer strips							
Wetland Restoration				may increase areas for trails			may increase areas for educational opportunities
Smart Growth policies that encourage infill development; *less new impervious surfaces; farmland is preserved; LID elements are considered*				Better utilize existing facilities/trail connectivity			
Conservation till	No change	No change	No change	No change	No change	No change	No change
Reduced use of pesticides and fertilization							
Update floodplain regulations and maps							
Stormwater detension / retention							

NEW Alternatives Proposed in Workshop 3:
Change city ordinances regarding streambank areas
Sanitary and storm sewer infrastructure - backfill prevention
K-12 Education
Media/PR helps communicate watershed issues and opportunities

Table B-3: Stakeholder Developed Goals, Objectives and Performance Metrics Spreadsheet – Workshop 3

	EFFECTIVENESS METRICS						
Goals/Themes:	**Ecosystem**						
OBJECTIVES *identified by participants in Workshop 1*	Healthy ecosystem						
REFINED OBJECTIVES. *Let's get more specific... What do we really care about?*	Increase biodiversity through diverse habitats - woodland, open meadow;	Increase connectivity / habitat corridors for wildlife	Increase good aquatic habitat areas				
DRAFT PERFORMANCE METRICS: *What can we measure to determine how well we are meeting our objectives?*	Acres of woodland and open meadow and wetland	Miles of pathways through connected habitat zones	Stream health indicators: balance of riffle & run zones; pool depth	Stream health indicator: stream meanders	Stream health indicators: Shady areas	Aquatic biodivertisy: Benthic invertibrates or other indicator tools	Stream health indicator: Floodplain connectivity
Alternatives/Measures:							
Current conditions							
Future trends (future without); changes/sensitivity to climatic changes							
Buffer strips - legal requirement for permanent buffer strips							
Wetland Restoration	increased						
Smart Growth policies that encourage infill development; *less new impervious surfaces; farmland is preserved; LID elements are considered*	If green belt along Indian Creek is maintained, habitat could increase						
Conservation till							
Reduced use of pesticides and fertilization							
Update floodplain regulations and maps							
Stormwater detension / retention							

NEW Alternatives Proposed in Workshop 3:
Change city ordinances regarding streambank areas
Sanitary and storm sewer infrastructure - backfill prevention
K-12 Education
Media/PR helps communicate watershed issues and opportunities

Appendix B
Stakeholder Engagement: Goals, Objectives and Performance Metrics

Table B-4: Stakeholder Developed Goals, Objectives and Performance Metrics Spreadsheet – Workshop 3

	ACCEPTABILITY METRICS												
Goals/Themes:	**Community Support for watershed improvements**												
OBJECTIVES *identified by participants in Workshop 1*	** Existing level of community support - Acceptability; * We are accountable for our actions; * Rural and urban interest groups cooperate; * Residents have a sense of urgency; * We understand how we impact others; * People understand watershed and their role*												
REFINED OBJECTIVES. *Let's get more specific... What do we really care about?*	The general public (urban and rural) support the measure					The watershed is understood and treated as a whole; Everyone in the watershed (urban and ag) takes action to improve the watershed							Legal framework (ie, city codes) promotes sustainable watershed management through supporting
DRAFT PERFORMANCE METRICS: *What can we measure to determine how well we are meeting our objectives?*	Are residents and landowners (urban and rural) willing to pay now? Would they vote for it?	Are people willing to support/ implement/ maintain over time?	Is it culturally acceptable?	Are policy makers able to implement policies?	Are they *able* to pay? Are costs and benefits to different members of society distributed fairly?	Will education help motivate to implement this action? (Y/N)	What is the effect on upstream / downstream community? Rural, urban communities?	The community supports a watershed-wide management authority	Compliance with laws, ordinances, utilities and incentives; BMP's are adopted	Number of groups involved in watershed protection/activities.	How many students can define 'watershed'; number of teachers educating about watersheds	People understand that correctly installed BMP's don't increase risks to human health	Percent of community that has adopted (or will adopt) watershed management related code / ordinance
Alternatives/Measures:													
Current conditions													
Future trends (future without); changes/sensitivity to climatic changes													
Buffer strips - legal requirement for permanent buffer strips													
Wetland Restoration													
Smart Growth policies that encourage infill development; *less new impervious surfaces; farmland is preserved; LID elements are considered*													
Conservation till	Depends on demographic												
Reduced use of pesticides and fertilization													
Update floodplain regulations and maps	No/Yes												
Stormwater detension / retention	Yes/No - More education is needed - why does this matter to [illegible]					No							

NEW Alternatives Proposed in Workshop 3:
Change city ordinances regarding streambank areas
Sanitary and storm sewer infrastructure - backfill prevention
K-12 Education
Media/PR helps communicate watershed issues and opportunities

	COST EFFECTIVENESS		
Goals/Themes:	**Economics - Financial Costs**		
OBJECTIVES *identified by participants in Workshop 1*	Costs		
REFINED OBJECTIVES. *Let's get more specific... What do we really care about?*	Short term	Long term	
DRAFT PERFORMANCE METRICS: *What can we measure to determine how well we are meeting our objectives?*	Implementation costs	Maintainance and operation costs	Economic productivity loss costs
Alternatives/Measures:			
Current conditions			
Future trends (future without); changes/sensitivity to climatic changes			
Buffer strips - legal requirement for permanent buffer strips			
Wetland Restoration			
Smart Growth policies that encourage infill development; *less new impervious surfaces; farmland is preserved; LID elements are considered*			
Conservation till			
Reduced use of pesticides and fertilization			
Update floodplain regulations and maps			
Stormwater detension / retention			

NEW Alternatives Proposed in Workshop 3:
Change city ordinances regarding streambank areas
Sanitary and storm sewer infrastructure - backfill prevention
K-12 Education
Media/PR helps communicate watershed issues and opportunities

Table B-5: Stakeholder Developed Goals, Objectives and Performance Metrics Spreadsheet

Indian Creek Watershed Pilot Study Workshop 1
January 26, 2012
Council Chambers, Marion City Hall; 1225 6th Ave, Marion, IA

WORKSHOP SUMMARY & RESULTS

On January 26, 2012, over 50 stakeholders from the Indian Creek watershed convened at the Marion City Council Chambers to kick off a focused dialogue and planning process for the watershed that will take place from January to September 2012. The day started off with presentations about the Indian Creek Watershed and with introductions from the Iowa Cedar Watershed Interagency Team, who will facilitate the process. Through a series of interactive exercises, the group collectively developed a series of vision statements and goals for the watershed that will serve as an overall guide for the next three workshops. Workshop 1 results are summarized below.

Welcome

Stacy Langsdale, US Army Corps of Engineers

- The purpose of this workshop series is to help empower the whole watershed community to action through a clearer understanding of the priority actions and how to implement them. Specifically, we aim to foster a clearer understanding of the issues in the watershed, the range of stakeholders' preferences, the benefits and costs of a range of alternative actions and policies, the uncertainties associated with future climate, and knowledge gaps and priorities for further investigation.
- In this first workshop we will focus on creating watershed visions for the community. Many of you have done this in recent years, but not with this group, who includes representatives from a variety of interests across the whole watershed.

Lon Pluckhahn, City Manager, City of Marion

Watershed Conditions & Initiatives Presentations

Wayne Peterson, Iowa Dept of Ag and Land Stewardship

- Sediment is the biggest pollutant, and nutrients are second biggest concern
- Galloway report described historically 10x more holding capacity in soil
- Ag and Urban areas must work together to solve problems.

Rich Patterson, Indian Creek Nature Center

- Since 1993, every major storm has had higher magnitude. Being in the lower watershed, they see the impacts of all upstream landuse changes.
- Pervious pavement is a readily available option & the Nature Center site is now at 100 percent net infiltration/pervious area

Shannon Ramsey, Trees Forever

- Shannon discussed current initiatives and future projects. Focus is on increasing land permeability with more trees, prairie, natural areas, and rain gardens, and on decreasing mowing.
- People want to see action – 3000 people participated in their process after the 2008 flood.

Matt Fisher, The Nature Conservancy

- This study in Indian Creek is a pilot and will be duplicated in others areas in the Iowa and Cedar Rivers Basin.
- We have to start at the watershed scale because this is where we can affect change.

Jen Fencl, East-Central Iowa Council of Governments

- Described plans and progress for the Watershed Management Authority Phase I Pilot

Co-Creating Our Sustainable Watershed Exercise

The purpose of the group exercise: Beginning the journey towards achieving a sustainable Indian Creek Watershed is a co-creative effort in which members of the watershed community act together to articulate a positive vision and outline specific objectives for the future by creating and maintaining a positive climate where member's energies are directed towards engagement as caring and committed stewards of their supporting lands and waters.

Participants arranged in six groups of 5-8 people and identified a partner to interview. The participants were asked to think of a time when they were part of a sustainable watershed community, and to discuss what made that special. Then, they were asked to specifically identify their own and the community's contributions to this success and why this was successful.

Next individuals were asked to name three wished for the success of the watershed. Each group agreed on the top wishes, summarized here:

Small Group "Wishes" for the Future of the Watershed (Priority Only; Sorted By Topic)

Water Quantity / Flood Control	• Reduce flood volume • Updated floodplain regulations / maps (7 votes) • A watershed with a very low risk of loss of property / life as a result of flooding (4 votes)
Water Quality / Stormwater Mgmt	• Implementation of smaller storm water management zones within watershed (6 votes) • Clean, unpolluted, safe, healthy water (5 votes) • Standardize storm water regulations across basin (5 votes)
Agricultural Land Use	• Conservation BMPs on ag land • Majority of the watershed / land area is in water retention practices such as cover crops, buffer strips, etc (6 votes)
Urban Development	• Appropriate BMPs for future growth and development • More "smart" floodplain development (ball fields, river walks, golf courses, etc) (5 votes)
Recreation & Ecosystem	• Lots of recreational opportunities and a healthy ecosystem (8 votes)
Social & Community	• We are accountable for actions and understand how we impact others (4 votes) • People are connected enough to land to put their money behind it; landowners really care about it (4 votes) • Cooperation of rural and urban interest groups by understanding shared responsibility (5 votes) • Understand what a watershed is and my place within it; threading environmental education through the entire K-12 curriculum (5 votes) • Sense of urgency (4 votes)
Other	• Identify projects that worked well and mimic them, (i.e. Ames, Iowa) (6 votes) • Triple bottom line, not just money; sustainability focus = social / people, environment, economy (5 votes)

Finally, groups were tasked to use the top wishes to script Indian Creek Vision statements that are provocative, grounded, desired, and stated affirmatively. Without too much time for wordsmithing, below are the groups' statements.

Small Group Vision Statements:

- "Flood mitigation with preservation of the eco-habitat using science-based BMP implementation."
- "Indian Creek Watershed plan with vision will identify projects that have worked well in other watersheds, use updated floodplain maps to utilize BMPs effectively and use small-scale watershed associations to catalyze community participation."
- "Utilizing updated floodplain maps and regulations to support implementation of smaller storm water zones within Indian Creek Watershed will produce BMP projects that provide examples for others."
- "The Indian Creek Watershed Plan with vision will break watersheds into management districts that each have goals and objectives consistent with larger plan."

- "The Indian Creek Watershed has lots of recreational opportunities and a healthy ecosystem."
- "The Indian Creek watershed has a low risk of loss of life and properties as a result of flooding"
- "The citizens of the Indian Creek watershed are accountable for their actions and understand how their actions impact others"
- "The majority of people in Indian Creek watershed care enough to put their money behind it"
- "Indian Creek has clean, unpolluted, safe, and healthy water"
- "There is a focus on the triple-bottom line – people, planet, & profit"
- "Develop and Implement standardized storm water regulations across the IC watershed that account for existing and future development"
- "Encourage "SMART" floodplain development that incorporates flood resiliency into function, such as green spaces, river walks, sporting fields and other"
- "Foster cooperation of rural and urban interest groups by acknowledging shared responsibility in addressing management of water quantity and water quality"

Indian Creek Watershed Workshop 2
Thurs, March 29, 2012; 1:00-4:30 pm
Council Chambers, Marion City Hall; 1225 6th Ave, Marion, IA

WORKSHOP SUMMARY

Attendance: 36 people participated, and 6 people facilitated/supported the event. See attached list.

Welcome and Introductory Key Messages
Mary Beth Stevenson, Iowa DNR

- The goal of these facilitated sessions is to help the group come to some consensus surrounding priorities for action.
- As the Interagency Team we want to provide you with the tools to make the changes you want to see in the watershed.
- We will be transitioning this effort to local leadership when this process comes to a close…. So be thinking about what your contribution will be.
- To ensure that our workshops are most relevant to your needs, we welcome your input. Please let us know if you are willing to review or discuss draft agendas with the team.

Indian Creek Water Quality
Presentation by Marty St. Clair, Professor of Chemistry at Coe College

- Coe has had students measuring water quality in the Indian Creek watershed (as well as other eastern Iowa watersheds) for the past ten summers. Marty is willing to address any water quality monitoring needs that the Indian Creek watershed group identifies.
- Nitrate levels in Indian Creek are relatively high, as they are in most eastern Iowa watersheds. There is a strong correlation between the percentage of the watershed in row crops and the average nitrate concentration in the stream. Drinking water standards of 10 mg/L are often exceeded during the summer field season. Nitrate concentrations decrease in Indian Creek as the stream moves through Marion and Cedar Rapids.
- E. coli levels are generally above the levels recommended by the state for a "wadeable" stream. Counts are strongly influenced by precipitation (E. coli increases after a significant rain and decreases after a few dry sunny days). The source(s) of the E. coli are unknown.

Indian Creek: Review of Existing and Historic Trends

Presentation by Toby Hunemuller, Chief Hydrologist, U.S. Army Corps of Engineers

- Urban areas in Indian Creek watershed tripled between 1960 and 2011 (from 8 mi^2 to 24 mi^2). More development means more impervious surfaces (pavement, roofs) that change stormwater flow patterns. Less water flows into the ground, so *more* water flows off the land, and *faster*, into streams and rivers. This causes rivers to reach a higher "peak" flow than before development, and is referred to as 'flashy' hydrology.
- Annual precipitation in Indian Creek has increased by approximately 11 percent from 1950 to 2010. Based on data from a gauge in Marion, it appears that the precipitation in the area is occurring in more frequent precipitation events.
- In watersheds with mixed land use like Indian Creek, floods usually don't occur because of one intense rain storm. They occur when intense rain hits already saturated soils, i.e., when a series of storm events overwhelms the system.
- We can't control precipitation, but we can control where we build and how we use the land that is likely to flood. Structural solutions only help up to a certain size flood and can always be overwhelmed. Effective floodplain management is the best way to prevent or reduce damages.

Group Work Session: Drivers and Challenges to Implementing Actions

Five groups were each assigned one of the themes that emerged from the vision statements developed in Workshop 1 (summary available at: http://iowacedarbasin.org/community/indian-creek-pilot-project). Then groups brainstormed what are the **drivers** and the **challenges** to taking action to reach the goal associated with this theme. The purpose of the exercise was to help understand why actions haven't been implemented quickly, but also to identify opportunities and mechanisms for implementing these actions. Results presented by the groups are shown in the tables that follow.

GROUP 1: DECREASE FLOOD RISK	
Drivers	**Challenges**
Summary/Report-out Notes:	
* Sustainable Development Practices	
* Sustainable Ag Methods	* People like to live next to the water
* Building moratorium	* Current building codes
* Long-term return on investments	* Takes time; costs money
Detailed Notes:	
- No properties located in flood prone areas	
- Build a dam	
- Lots of permeable surfaces, incl green infrastructure & hardscape	
- divert the water	
- retention ponds	- Lack of public support
- long term cost savings (prevention of flood damage)	- Possible property acquisition
- Code changes (building, stormwater, design standards, etc.)	- Private property rights
- Restoring marginal ag land to wetland & native habitats	- Market-driven homes
- less non-native plants & more native plants	- Reduction of tax base
- values	- Who pays

*NOTE: * indicates items prioritized by group*

GROUP 2: CLEAN, UNPOLLUTED SAFE HEALTHY WATER	
Drivers	**Challenges**
Summary/Report-out Notes:	
* Reduce sediment	* Property rights
* Reduce runoff	* Demographics of producer (age, tenant/owners, older, out-of-state)
* Increased BMP use	* Rural/urban divide
* Desire to recreate (fishing, etc)	
Detailed Notes:	
- 303d list of impaired waters in Iowa	
- Fear of bacteria	
- Reduce nitrogen	
- Reduce runoff	- Cost
- Prevent chemicals from entering the stream	- Bank erosion – who owns it? How to fix it? Scale to fix -> multiple miles
- Characterize extent & magnitude of problems	- Lack of science on bacteria
- Conservation certification – 40 hrs – Agren	- Legacy effect to measure change
- In core curriculum	- Is "sacrifice" worth it?
- Food & nutrition movement – locally grown	- Independent efforts vs. group
- Fire to improve habitat	- Disengaged population, lack of connection to land
- Increase appreciation for diversity through ecotourism & recreation	- Jurisdiction issues

*NOTE: * indicates items prioritized by group*

GROUP 3: HEALTHY, PRODUCTIVE AG LAND	
Drivers	**Challenges**
* Inventory BMP locations by topography	Commodity prices
Increase organic matter	Hard to change philosophies
Utilize more no-till	Lack of cost-share funds
Diversification of crops produced and income sources	Timeliness of chemical application
* Education of all involved	Risk of production agriculture
* Promote installation of more BMPs that retain water in watershed – drainage water mgt; bioreactors; wetlands, ponds	Food production needs to be maintained or increased
* Promotion of conservation easement programs.	Lobbying efforts

*NOTE: * indicates items prioritized by group*

GROUP 4: URBAN DEVELOPMENT	
Drivers	**Challenges**
Incentives for Storm Water Utility management	Politics of change (non-alignment of stakeholders)
Implementation of smart/sustainable systems	Public Perceptions
Human & economic costs of flooding and polluted waters	Individual use vs. Community Benefit
Foster Environmental Education/Water usage (Mission Statement: K-12/Community)	Economic Disincentives (increased cost of smart decisions) Change ROI Model
	What does a working system look like? (show me the data)
	Existing codes/regulations
	No priority on environmental education

GROUP 5: RECREATION	
Drivers	**Challenges**
More Access	Concerns with floods and potential rec. dam
No Planning done-not recognized as a destination	Water quality concerns
Wetlands to improve water quality	Inability to make political change
Using ponds/practices to improve WQ for enhancing recreation	Issues of difficult control/ownership
Identifying in-stream issues that can be fixed	Money
Public will	Availability of lands
Finding bite sized solutions	Dam vs. no dam
Public will	Inability to make decisions
Utilization of public lands	Flashy hydrology
Education of developers	Monitoring data
Messaging	

Notes from Whole Group Discussion after Group Report-Outs:

What insights did people glean from exercise? What are the most important drivers? Are there overlaps or themes that may emerge as priority actions? How can we turn the challenges into opportunities? Who can take responsibility for implementation?

- Idea to identify a demonstration project – pick a farm that shows different practices and their effects, perhaps both positive and negative.
- Provide incentives for farmers to implement Best Mgt Practices
- Support from elected officials –Key Messages needed to communicate with officials
- If water quality is presented as an issue (exposure to *E. coli*) then people will resist contact – but what is the health trade-off with a sedentary lifestyle?
- There are far more positives to getting kids into the water/watershed than the risk they're exposed to and getting kids out there gets parents out there.
- Public awareness is the biggest issue driving some issues – people in the room can affect things like code and policy, but getting people over obstacles to taking advantage of the resources takes a larger awareness – it's more systemic and cultural.
- Identify the groups that utilize the creek/trails/etc.
- Multiplicity of solutions, no right or wrong answer; Think long term; Think WHY – this is a great community, with a lot to offer.

A point was raised that it might be beneficial to take some additional workshop time to drill down into the drivers / challenges in order to ferret out more specifics. In attempt to dig deeper into one of the issue categories, the group focused discussion on the topic of public education and encouraging recreation– that if people, especially young people get out an experience the watershed and the ecosystem, then they will care more and be more inclined to act.

- Obesity risk vs. Fear of *E. coli* risk. [Marty St. Clair]: Even though numbers are high, the risk of disease is low to school-age children. Students go do daily sampling and are okay.
- Get the message out that the "Benefits outweigh the risks" (Obesity, inactivity health risks are much greater than risk of e-coli and lack of outdoor free play.
- Environmental health – convey key messages on the link between the environment and health through health professionals, esp. pediatricians – parents/kids visit them regularly and trust them.
- "Year of the River" Festival (2008 activities were cancelled due to flood). Activities to make the river fun & have broad appeal, and send message why we should care about it.
- Plan festivals – give people opportunities to get in the water.

Indian Creek Watershed Group Workshop 4
Thursday, August 9, 2012, 1:00-4:30 pm
Council Chambers, Marion City Hall; 1225 6th Ave, Marion, IA

WORKSHOP SUMMARY

EXECUTIVE SUMMARY:

In this fourth stakeholders workshop, we continued the dialogue regarding steps they can take to reduce their flood risk and improve their watershed overall. In this session, breakout groups explored resources for developing a comprehensive watershed plan, considered land use in the floodplain as well as factors that change "the floodplain," and clarified needs and explored opportunities for building public awareness of watershed issues. Then we shared new information on climate change, the influence of land use changes vs. climate change on hydrologic response to large precipitation events. The group considered what this means for watershed management.

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Workshop Summary
- Watershed Assessment Tools Notes
- Floodplain Management Notes
- Public Awareness Notes

Climate Change Discussion Notes
Appendix A: Watershed Assessment Tools Handouts/Presentation
Appendix B: Climate Change Presentation

Indian Creek Watershed Group Workshop 4: Developing Action Plans for Floodplain Mgmt, Watershed Assessment, and Community Outreach

Thursday, August 9, 2012, 1:00-4:30 pm
Council Chambers, Marion City Hall; 1225 6th Ave, Marion, IA

WORKSHOP SUMMARY

AGENDA

1:00 Welcome & Introductions
Ground Rules
Review of previous workshops
Today's purpose & agenda

1:30 Brief Introductions to Working Group Modules

1. **Watershed Assessment Tools**
   Mary Beth Stevenson, IA Dept Natural Resources
2. **Current Land Use in the Floodplain, and current zoning regulations in each community**
   Jason Smith, U.S. Army Corps of Engineers
3. **Public Awareness of Watershed Issues: Opportunities for Survey and Public Education**
   Matt Fisher, The Nature Conservancy

1:45 **Breakout Groups**
Choose a group to join. Group leader will go into topic in more depth, then lead and discussion to help understand the material better and to develop an action plan.

2:45 BREAK

3:00 Group report-outs and feedback from all (5 minutes each plus discussion)

3:40 Presentation: **Climate Change and You: A Global Phenomenon at a Local Scale**
Greg Karlovits, U.S. Army Corps of Engineers
Discussion: *What does future climate mean for your group topic? How should you incorporate climate change information in your action plan?*

4:20 Evaluations
4:30 Adjourn

WORKSHOP 4 ATTENDANCE LIST

Name	**Organization / Affiliation**
Bruene, John	USDA NRCS local District Conservationist
Fencl, Jennifer	East Central Iowa Council of Governments
Goemaat, Dennis	Linn CCB
Happel, Todd	Anderson Bogert & C.R. Resident
Huebsch, Tony	Resident
Kash, Robin	Neighborhood Network News
Micheel, Bill	Linn Co Planning & Development
Muste, Marian	U of Iowa
Russell, Jason	Linn Co Farm Bureau
Sandstrom, Rick	Creek View Owners Association
Sautter, Emy	Prairiewoods Spirituality Center
Scanlan, David	City of Cedar Rapids Storm Water Mgt Proj Engr
Seeley Jr., Craig E.	Cedar Rapids SWC, Flood Victim/Concerned Citizen
Skopec, Mary	Iowa DNR
Smith, Martin T.	Resident of Cedar Rapids
St. Clair, Martin	Coe College - Chemistry
Stark, Gregg	Sticks in the Water (paddle group)
Stone, Larry	Iowa Assoc Co Conservation Boards
Swore, Chuck	City of Cedar Rapids
Tisl, Jeff	IDALS
Zingula, Curt	Farm Bureau

Facilitation & Interagency Team in Attendance:

Fisher, Matt	The Nature Conservancy
Hunemueller, Toby	U.S. Army Corps of Engineers
Karlovits, Greg	U.S. Army Corps of Engineers
Karnish, Diane	U.S. Army Corps of Engineers
Langsdale, Stacy	U.S. Army Corps of Engineers
Smith, Jason	U.S. Army Corps of Engineers
Stevenson, Mary Beth	Iowa Dept of Natural Resources

WORKSHOP SUMMARY

1. Welcome, Introductions, Ground Rules [Stacy]

After all participants and the team introduced themselves, Stacy proposed the following Ground Rules, which the group accepted (see side bar).

Indian Creek Watershed Group Ground Rules

1) **Come with an Open Mind.**
2) **Ask if you don't understand.**
3) **Stay on Topic* and Share the Floor with Others. *(*Parking Lot for later)***
4) **Focus on *community* ("Us" over "Me").**
5) **Be honest and direct, but kind.**
6) **Confront conflict to seek solutions.**

2. Review of Previous Workshops

- **Workshop 1 – Objectives and Visions (Jan 26, 2012)**
  Recall that participants, arranged in groups and pairs shared and identified wishes and developed visions for the watershed. Some of the high priority wishes included topics which we will explore more today.

- **Workshop 2 – Challenges and Enabling Factors (March 29, 2012)**
  Many of you felt strongly that public awareness is a strong challenge and potential driver for change, so we launched more detailed discussion on value of public awareness and what messages are important to get out.

- **Workshop 3 – Performance Metrics (May 22, 2012)**
  Continued the planning process by taking the objectives we identified in W1 & refined a set of Performance Metrics – these are important for:

3. Where do we go from here?

- **Overall Process:**
  A Primary purpose of this stakeholder engagement process has been to enable your community to adapt to and better manage the new conditions you have been experiencing. We haven't discussed "climate change" overtly much to date because you are living, experiencing a changing climate, so are already motivated to change. But, you still need the tools and resources to come together as a community and work together, and to understand your watershed and your flood risk more clearly. Today Greg will give a presentation on

climate change and what it means for what you can expect in the future; and the possible contribution of land use vs. climate change.

- **Workshop 4 Purpose & Agenda**
  The focus of the meeting is group work on the following three topics, then a discussion of climate change and hydrologic modeling results:

  1. Watershed Assessment Tools - **Mary Beth Stevenson, IA Dept Natural Resources**

  2. Current Land Use in the Floodplain, and current zoning regulations in each community – **Jason Smith, U.S. Army Corps of Engineers**

  3. Public Awareness of Watershed Issues – Opportunities for Survey and Public Education – **Matt Fisher, The Nature Conservancy**

- **Workshop 5 – Opportunities, Examples and Next Steps**
  On Sept 25 we'll discuss transition to your next step. The interagency team will still be available to support you, particularly with technical and planning expertise. We are also going to do what we can to help you form working groups, starting today, solidifying them next session, but we are not planning on reconvening more sessions in the immediate future (but there is nothing stopping you from continuing to meet on your own, or with our participation).

4. Working Groups Notes

Group 1: Watershed Assessment

Tools & Resources Discussion

Indian Creek Watershed

Assessment Tools & Resources:

RASCAL (Rapid Assessment of Stream Corridor Along Length): The DNR provides a half-day training as well as the rugged GPS units that are used for the assessment. The RASCAL is a modified version of the NRCS Stream Visual Assessment Protocol (SVAP) that is usually completed by local staff or volunteers. It uses many of the same assessment criteria, about 25 in all (including riparian land use, bank height, bank vegetation, riparian cover, pool & riffle habitat, etc). The Basin Coordinators (Jeff Tisl & Mary Beth Stevenson) will also sit down with the local group after the assessment is completed to go over the maps and discuss possible next steps for planning and implementation.

- A RASCAL assessment was completed by City of Marion staff roughly 5 years ago for the portion of Indian Creek within the city limits. It is recommended that a complete RASCAL assessment be conducted for the entire watershed (including Dry and Squaw Creeks) to update the older data and provide a more comprehensive look at the watershed.

Land Cover Assessment: DNR, IDALS-DSC, NRCS, and SWCD staff can all contribute to this assessment. The goal is to conduct a 'windshield survey' of the watershed (i.e., a driving tour) making note of all agricultural land uses that are visible from the roadside. DNR can provide tablet computers to facilitate data collection. Once the assessment is completed, the resulting data can be plugged into a model to calculate soil loss and sediment delivery rates in the watershed, which can contribute to a watershed planning effort.

-

Other assessments:

- Water Quality: DNR staff can assist with developing a water quality monitoring plan. Coe College also has an extensive monitoring program that they would like to further enhance within the watershed, increasing the number of monitoring sites and parameters assessed.
- Biological: In some cases, local groups can also request that more comprehensive assessments, such as a biological assessment, be completed. For example, Indian Creek has a biological impairment (meaning the water quality is not adequate to support aquatic life that would otherwise be expected to thrive in the water). DNR could potentially conduct a comprehensive biological assessment of Indian Creek to revisit the data that caused the listing. In addition, no assessments have been conducted on Squaw Creek to date.
- Geologic Mapping: There may be an opportunity for the DNR to visit the Linn County STATEMAP project. See DNR's website for more info on this project: http://www.iowadnr.gov/Environment/GeologyMapping/STATEMAPMapping.aspx

Other Discussion Areas:

Regulatory vs. Technical Assistance: It should be noted that the agency staff that can assist with these assessments are not regulatory and not involved directly in enforcement issues. The goal is to provide technical assistance to help landowners improve their management practices. And in some cases, cost-share may be available to help landowners with making the investment in conservation.

Dry Run Creek, a watershed in Black Hawk County, could be a good model for Indian Creek. The DRC watershed also comprises both urban and agricultural areas. Significant progress in implementing practices is being made particularly in the urban areas. A tour of the DRC project, maybe with a presentation from the DRC Watershed Coordinator, could be an option for interested Indian Creek stakeholders. Their watershed management plan is available at http://www.iowadnr.gov/Environment/WaterQuality/WatershedImprovement/WatershedPlanning/ManagementPlans.aspx.

Flooding vs. water quality: Flooding is clearly the issue that gets much of the attention. It was pointed out that addressing the flooding issue can have additional benefits for water quality, habitat, and recreation.

[SEE APPENDIX A FOR MORE DETAILS]

Group 2: Floodplain Management Working Group

Discussion Notes

The first question asked to the group was concerning whether a floodplain (FP) was a fixed boundary or if it may change. The participants responded a number of ways but two that were captured were:

- The boundary is fixed until it becomes politicized.
- The FP is defined by geography, elevation and topography.

Other themes that were brought to light during this exchange were:

- A comment related to recent climate science research that indicated that the average rainfall has changed from 30" to 33" which once the amount that is used by plants and natural processes is subtracted changes the effective runoff from 7" to 10". This is an increase in 30 percent which the participant connected to a potential change in the FP extent.
- A comment related to concerns about regulation of the FP and who was responsible and whether the current methods were adequate.

The second question the group was asked was what types of Land Uses (LU) are appropriate within the FP boundary? The participants outlined the following list:

- Flood resilient structures such as park equipment, benches, vending booths and other structures that may be restored with a minimal amount of damage.
- Agriculture which includes row crops, pasture, gardens BUT does NOT include CAFOS
- Recreation facilities including ball fields, trails, camp grounds and outdoor amphitheaters
- Conservation areas such as natural habitat, open space areas, wetlands, urban BMP's and Agricultural BMP's.

The group was then asked what was the appropriate amount of each LU in the FP? There was good conversation surrounding the question and the group ultimately decided that there is no magic formula and that you must look at it on a case-by-case basis. They did indicate that one of the data sets that should be considered is the prime farmland layer in order to maximize the use of prime agricultural lands.

The group was then provided two handouts (attachment A and B) related to the current flood risk based on the findings from using FEMA's HAZUS program. The group was provided an explanation that these maps are tools to help identify which census blocks have the highest potential values at risk but that it does not necessarily mean that the structures at an elevation to incur damage. These tools are to help an entity identify where they need to do a site level analysis to see if actions need to

be taken to lower flood risk, namely protecting or removing structures. The group was surprised that while the City of Alburnett only has 1 census block affected that due to the small population that they have a significantly higher potential for structural loss per capita. This is significant because often times the larger communities are identified as having the largest flood risk however, there is a real cost that comes to bear in FEMA cost sharing programs that larger communities have greater resources to meet the cost share. This may mean that the smaller communities are more vulnerable due to their limited resourced in cost sharing or paying for damages.

The participants were provided two more graphics (attachment C&D) which is a map with pie charts of the current LU and the future LU based on an adaptation to the Linn County Rural Landuse Map. The significant item that was discussed was that the current developed area within the FP is around 22 percent and the future developed landuse is planned to be around 40 percent. The group was asked if this is acceptable? The participants were surprised by the relatively large increase in the percentage of development within the FP boundary. There was some discussion concerning new homeowners are not adequately informed when purchasing a home to understand the risks they are undertaking. The group was advised to connect with the public outreach group and discuss how this message may be conveyed better. The participants are sensitive to flooding damage as some of them have personally gone through flood loss and do not wish to have others undergo the same hardship. For these individuals the increase in developed are in the FP boundary was unacceptable. The group was advised that Linn County is actively revisiting the Rural Landuse Plan and may benefits from the watershed authorities input on future development.

[SEE APPENDIX C FOR FIGURES]

Group 3: Public Awareness & Outreach Opportunities

Discussion Notes

This group focused on the following questions, as they related to specific topic areas; discussion notes follow.

- Can the Issue be changed?
- Is the change tangible?
- Is the change measurable?
- What is the behavior, attitude or awareness we'd like to understand
- Who do we need to influence?
- Of multiple groups, who has the most impact or influence (priority)?
- How do we best reach them?
- How do we find out what best motivates them?
- How do we change their motivation?
- How much do we need to do?
- What are the thresholds for success?
- How do we measure change?

ISSUE: FLASH FLOODING

- Not only reduces flash flooding, but reduces erosion, thermal shock to streams, etc.
- Closely linked to soil quality-link?
- This is a positive message: a fix for watersheds!
- Message: Value of farm bill locally

ISSUE: WATER QUALITY

- Drinking Water?
- Accessing the Stream/safety for recreation?
- Message: Value of Farm Bill Locally
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation

ISSUE: AWARENESS OF WATERSHED

- The Cedar River County Conservation Boards are developing a Watershed Awareness campaign that could be readily modified to message RE Indian Creek
- This includes Road Signs, Public Service Announcements, Op-eds, Maps and Powerpoint Presentation(s?).
- What groups could this presentation be given to? Who would be willing to present this information?

- There was a lot of discussion about the simple, yet important need for education of local people about which watershed they live in and what a watershed is and does.
- There was some discussion that this is an "everyone needs to understand" topic
- Maps were one way to easily share a lot of information: Which venues to get these out to people? Also signage in the watershed.
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation
- How to help people understand how their watershed "Works"

ISSUE: RUNOFF PREVENTION

- Not only reduces flash flooding, but reduces erosion, thermal shock to streams, etc.
- Closely linked to soil quality-link?
- This is a positive message: a fix for watersheds!
- Message: Value of farm bill locally

ISSUE: SOIL QUALITY

- Improving soil quality will help to improve flooding issues.
- Closely related to Runoff Prevention-link?
- Improving soil quality is a positive message: a fix for watershed issues!
- Message: value of farm bill locally

ISSUE: BUILDING RESILIENCE

- There was little discussion about this topic. Generally recognized as importance, but probably needs some clarification RE specific topics. May fall under (or be a subtopic) of other categories?
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation
- Message: value of farm bill locally

ISSUE: RURAL URBAN CONNECTIONS

- "We're All in this Together" mentality is important for cooperation and successful outcomes.
- This topic may be linked with "Awareness of Watershed" or less of an issue, but more of a message?
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation
- Need to develop messages of inclusivity across the watershed.

ISSUE: DEVELOPMENT IMPACT

- Understanding of where the floodplain is, where it might be in extreme events is important
- This is closely linked with "Rulemaking" and developing sensible floodplain regulations.

- This could link to "Awareness of Watershed"?
- Message "Green Infrastructure"
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation

ISSUE: WILDLIFE

- Little discussion of this topic. Low priority?

ISSUE: DUMPING

- Discussion that Dumping Continues to be an issue. Signage "If you see dumping call" might help?
- Adopt a Stream opportunities? Other Stream Cleanups?

ISSUE: RULEMAKING PROCESS

- We discussed that few people know or understand how the rulemaking process occurs and why it matters.
- Based on this, it seems like this topic is very closely linked to other issues and might best be included separately in one or more different issues as part of the education/outreach 'campaign'
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation

ISSUE: CONNECTION WITH THE PAST

- Indian creek has lots of history and had a lot of uses in the past. Reigniting these links may be an opportunity to connect people
- Helps to establish a sense of place which links people to their watershed
- Lots of Historical mapping is available and may help to establish those connections to the past and to sense of place.

ISSUE: RECREATION

- Fishing, Swimming, Kayaking/canoeing (a very narrow window for this), pedal/paddle trails, festivals/events
- Many negative messages. Focus on "Fixes" and celebrate opportunities to move from negative watershed connotation

5. Presentation

Climate Change and You: A Global Phenomenon at a Local Scale
Greg Karlovits, U.S. Army Corps of Engineers

[SEE PRESENTATION at http://iowacedarbasin.org/community/indian-creek-pilot-project]
Discussion – Reactions to information presented, and what climate change means for your group topic:

- 100 percent impervious scenario is quite feasible – frozen ground would act impervious
- Probabilities are hard to pin down, so need to plan to be more robust/plan for uncertainty
- Risk – Low probability (~1 in 10K chance), but if it happens, consequences are enormous = talk about probabilities *and* consequences. Toby? – Compare to lottery tickets – low probability & low ticket price, but what if $100 ticket? In Japan – nuclear power is less acceptable because of accident.
- Craig – We need to consider the natural processes – best to let nature take its course & we get out of way; Stacy – Yes, this is the new paradigm among stormwater managers and engineers – it is a change from paving channels so to move stormwater quickly downstream, to now slowing water down to reduce turbulence and prevent worse flooding downstream; Marian – In Belgium the concept of living with floods is normal and designed as such
- Rule of thumb – develop 1' above the floodplain – but there should be some sensitivity analysis on that to rethink those elevations
- Communities need to individually assess risk rather than waiting on the federal gov't (or whoever) to come down with stricter regulations. A good example is Cedar Falls – they are restricting development in the 500-yr floodplain without state / fed regulations.
- Flood victims are still motivated to change, but what about the new generation that hasn't gone through floods – do we need to wait for another flood for change? No – those who remember must 'lead by example' and establish new standards. Unfortunately, Cedar Rapids is right now continuing to develop in the 100-yr floodplain – even though they just finished cleaning up from the flood – but perceived economic benefits appear to outweigh the benefits of restricting development in the floodplain.
- On a positive note: the power of technology – it is much more feasible to put out a floodplain map that shows inundation levels and educating potential homebuyers. We need to make that information available. Technology can help us elevate the discussion to make more rational decisions and push policy makers to change stormwater design systems.
- Informing Homebuyers: (a) Idea: a mobile app to show your potential home and where it is on the floodplain. (b) Truth in lending – let's move towards fully informed homebuyers. Risk assessment should be done.
- A Corps study in 1967 said the Cedar could have a flood of 167,000 cfs (?) – What would the Corps now predict is the [probable maximum flood]? The historical record shows that peak flood flows have increased with each flood in recent decades/years.
- Why are we still continuing to incentivize building in the floodplain, such as building the Federal courthouse in Cedar Rapids?

Indian Creek Watershed Group Workshop 5: Opportunities, Examples, and Next Steps Tuesday, September 25, 2012; 1:00-4:45 pm; Council Chambers, Marion City Hall; 1225 6th Ave, Marion, IA

WORK SHOP SUMMARY

Agenda

1:00	**Welcome & Introductions** **Review of workshop process** **Today's purpose & agenda**	Stacy Langsdale *USACE*
1:20	**Examples from Related Efforts**	Mary Beth Stevenson *IA DNR*
	• Duck Creek Stream Restoration	Jason Smith *USACE*
	• Successes and Challenges from the Dry Run Creek Advisory Board *Ashley, the Watershed Coordinator for the Dry Run Creek Watershed Improvement Project, will share experiences, accomplishments, and lessons learned from Dry Run Creek in the Cedar Falls/Waterloo area. During Q & A, consider what we can apply here in Indian Creek.*	Ashley Kittle *Black Hawk Soil and Water Conservation District*
2:20	**Public Awareness of Watershed Issues**	Matt Fisher *The Nature Conservancy*
	• Watershed Management Authority update and future opportunities	Jen Fencl *ECICOG*
	• Statewide public survey of watershed awareness	Dr. Kajsa Dalrymple *U. of Iowa*
2:30	**Break**	
2:45	**Landscape Changes – Issues and Opportunities** *We will look at aerial images of watershed features, such as stream straightening and development, and discuss opportunities for improvement and associated action items.*	Jason Smith
4:00	**Review of Accomplishments** **Opportunities to Continue** **Review of Action Items / Next Steps**	Stacy Langsdale
4:30	**Celebration**	All

Action Items – Things That You Can Lead or Get Involved In:

- Bring your ideas to those who can help identify the steps you need to take, and any resources needed.
- Conduct RASCAL assessments – you can borrow the GPS devices from Iowa DNR and receive a half day of training. You will then walk along the stream and collect data. DNR will load the data into a GIS map and the Basin Coordinators will provide assistance in interpreting the maps and provide guidance on next steps.
- Continue to build community awareness. Matt Fisher (TNC) will reconvene his breakout group from the August 9 Workshop to prioritize the ideas generated.
- Watershed Management Authority – funding decisions will be made in October. If awarded the grant to establish, then WMA will:
    1. Collect data
    2. Identify information gaps
    3. Form a stakeholder advisory group *
    4. Form Focus Groups; Goal-Setting Work Groups to set priorities; Set an implementation schedule *
    5. Generating support for implementation – it will take 18 months (Jan 2013 – Jul 2014) to develop the plan, so it is important to generate and maintain support among the public and decision makers for *implementation* of the plan during this time. *

    ** Good opportunities to participate*

    UPDATE: the WMA did receive $187,000 for planning assistance
- Talk to Dr. Kajsa Darymple (U. of Iowa) about survey work and tools for public outreach
- Engage other stakeholder voices who were missing from this effort (example: developers, more residents, elected officials); take leadership on this to overcome stigma of gov't "helping"
- Share success stories with the public! Also, explain the complexity of the problems.
- Use National Flood Insurance Program as motivation to reduce flood risk
    - Linn Co has applied for the FEMA Community Rating System - Earn discounts on community rates for flood insurance rates through actions to reduce risk (http://www.fema.gov/national-flood-insurance-program/community-rating-system)
    - Homeowners, developers, utilities pay into escrow account
- The Cedar River Education Project materials (PowerPoint slides, handouts) are ready now. Talk to Dennis Goemaat, Linn County Conservation Board about hosting a presentation at your service club, church, or any other group that may benefit from learning about the Cedar River

Watershed. For more info, visit their website: (http://cedarriverwatershedproject.wordpress.com/)

- Contact elected officials about Stormwater Management Issues. Farm Bill could include incentives for conservation practices in agricultural areas.

Workshop Notes:

A. Duck Creek Stream Restoration Examples (Jason)

Duck Creek is a relatively small, but successful project in Davenport, IA where streambank stabilization took place. You can see in the images (*see slide presentation*) that the results are pretty dramatic.

Q & A, Discussion:

- Length of stream segments? Not sure, maybe a couple hundred feet in each section.
- How funded? Utility fund
- Note – there is a training session on Duck Creek next week.
- Jason – USACE is trying to create a "one-stop-shop" for local groups to get the information rapidly, and avoid confusion of many steps, but we need the communities to come to them with plans/ideas for what they want to do.
- Rick – cheaper to work on this as a scheduled project (proactively) than waiting until there is a crisis
- Gregg S - note that the plans shown are modern – older bank restoration was ugly; the concrete used introduced contaminants, and was ineffective – eroded around it – often resulted in ugly concrete in the middle of the stream.

B. Dry Run Creek Watershed Improvement Project [Ashley Kittle]

Presentation Notes (See Slides):

- The incentive for this effort was that in 2002, a 2.8 mile section put on State's list of impaired waters because macroinvertebrates were absent. The project focuses on urban issues.
- RASCAL assessment was done – map shows where intervention is most needed.
- Pollution sources – ag, urban, and streambank
- We developed a 2009 Watershed Mgt Plan, but established TMDL's in 2011 – this was backwards - better to do TMDL first to include in the WM Plan.
- Phase 1 is 10-year period; end of phase 3 = 2090, so extensive plan!

- Stormwater management practices – there have been advancements in past years, and the [Iowa stormwater] guidance does continue to evolve with minor tweaks, but this need not be a reason to delay projects.

Recommendations:

- Form an advisory board that includes diverse expertise and roles.
- Develop Watershed Management Plan – this is your road map. Work with Jeff Tisl – Area Basin Coordinator, and others will help you get resources you need.

Q & A / Discussion:

- It takes time to implement and see change.
- Deadlines? Strict deadlines for Phase 1 – prioritize immediate urgent concerns
- Matt - Sense of urgency is important, but long view is good for efforts that need more thought and time to implement.
- Mary Beth - Shows long-term investment in the watershed.
- Mary Beth - TMDL is like a "pollution diet" – how much do you need to decrease pollutants to meet goals? Flooding issues are not addressed in TMDL.
- Matt – TMDL is a way to leverage EPA funding, but otherwise, is not needed.
- Ashley – Can get WIRB $ without TMDL or watershed plan. Mary Beth – however, this is getting more competitive, so a comprehensive approach helps to get grant dollars.
- Robin – Is Parks and Recreation $ available to local gov't staff? Mary Beth – yes, lots of information out there.
- RASCAL – is a way to go out and document and pick your priorities. Todd (City of Marion) – borrowed the instrument for a couple days and did the survey – now we have the data. Rick - Creates a benchmark measure – you repeat over time. GPS unit collects data on water quality. Did in March before vegetation grew in. Took just a few hours. Best to have same person do this for consistency. 15-minute training, then Todd did it (though training now is more lengthy – half day). Some units include camera so can take photos.

<u>Update of WMA – [Jen Fencl]</u>

Watershed Management Authority – funding decisions will be made in November. If awarded the grant to establish, then WMA will:

1. Collect data
2. Identify information gaps

3. Form a stakeholder advisory group *
4. Form Focus Groups; Goal-Setting Work Groups to set priorities; Set implementation schedule*
5. Generating support for implementation – it will take 18 months (Jan 2013 – Jul 2014) to develop the plan, so it is important to generate and maintain support among the public and decision makers for implementation of the plan during this time. *

   * *Good opportunities to participate*

Discussion:

- Where does money go? How do we communicate to public that we aren't "wasting" taxpayer funds to just plan? Money goes to support staff, fire students, to biologic assessment, data collection, etc…
- Marie - Gazette has published quite a bit of publicity
- Mary Beth – we are here because we want to collaborate on Indian creek. Expectation of agencies collaborating with public – we want to get that message out and need your help on *how* to get the message out.

Univ. of Iowa Water Sustainability Initiative [Kajsa Darymple]

- How do we communicate to the public the recommended behaviors and key messages? We don't have the current baseline understanding of public awareness and behaviors to know what to say. I have a small grant to do state-wide phone survey. Behavior change is based a lot on motivation. Launching survey in the spring; we can do a geographic breakdown of the results for this region;
- Happy to be a resource for organizations. Can assist with connection between media, pubic and individual.
- Goal is to do this survey every year, so we can track trends. Can include specific questions about specific campaigns. What does the public find as a credible source? Now look to neighbors instead of organizations.
- Brand new group – developing water sustainability program
- Rick – we have tools, classes…. How do we make it work faster? We're forming group, how can we be your guinea pig? Is there a way to collaborate?

Landscape Changes – Issues and Opportunities [Jason Smith]

Jason reviewed workshops to date, focusing on topics related to land use and showed results the team presented. (See presentation)

- What is the level of risk you are willing to accept? Are you willing to bear the consequences if climate changes, or if upstream develops? Frozen ground could create 100 percent impervious land, and that is something we deal with in Iowa, so is a real concern.
- Appropriate use of floodplains. Note the difference between flood magnitude extents is small in some areas, but significant real estate in other areas – cities may reluctant to give up much more real estate to make room for the river.

Watershed Aerial Imagery With GIS Data Layers:

- Dry Creek 7 – Stream was redirected out of the field and straightened to follow alongside road. If you returned the stream to its natural course through the wetland, this longer stream longer stream segment would:
    - reduce the *frequent* flood events
    - improve water quality and aquatic habitat
    - increase fishing opportunities
    - But, may need to buy conservation easements on ag land to ensure continuation of this revised use even if property changes ownership.

- Dry Creek South Feeder 2 – stream is channelized to accommodate housing development, but will it maintain channeled route? Will you need to invest in bank stabilization over time?
    - Rick noted that he looked at a house there and the sump pump runs constantly.
    - Gregg – this creek used to be a trickle, but has become a ranging torrent because of upstream development. Jason noted this is a real example of "hydromodification." Balance between individual and community interests/decisions. Each community is currently making decisions independently.
    - Todd – Marion worked with an older community (in the lower left of the image) – there is now a sediment basin in a large area, as well as another behind a couple houses, and many other actions…. So there is a plan in place.
    - Jason – so this is an opportunity to mitigate impacts. This is somewhere with current risk. Must look at increased risk in future. Benefits would include reducing damages from large events.
- East Indian Creek 4 - Rural Pasture areas; streambank has been trampled by livestock. Opportunities for fencing, buffers; ag BMPs
    - Benefits - would reduce damages from Frequent Events, improve water quality and ecosystem habitat

- But, there are Drivers and Resistors to change. How would a group overcome challenges?
- Craig – we need to coordinate with other entities with same agendas, for example – pollution is wildlife abuse – find a group with related agenda. So, stakeholders may be able to garner support.
- Gregg – we want to engage with others and overcome the stigma that government is coming in to "help." Stories of what we are doing to improve the watershed need to be told – public needs to know the good stories or they think everything is going to "hell in a hand basket." They also need to know interrelations and complexities – but not an easy story, since public only gets dribs and drabs of messages.
- Craig – potential litigation to others who increased their flood risk. This would be an incentive to motivate future increases to flood risk, although don't want to open a can of worms.
- Rick – flood insurance? There are people in these businesses with responsibility to communicate.
- Jason – Linn Co. has applied to be in the Community Rating System – actions that buy down flood risk will buy down flood insurance. But, talked to a farmer that will make more money off drought crop insurance than last year's crop. Need to have a little bit of everything.
- Ethanol cost in flooding?
- Robin – suggestions: (1) make homeowners in floodplains share the responsibility; (2) developers pay into escrow account; (3) stormwater utility pays to clean up water;
- Jason – ecological evaluation is hard to measure in monetary units. Earth Economics, NGO, will be releasing study results soon.

Workshop 5 Attendance List

Stakeholders in Attendance:

Bading, Vince	City of Robins
DeVries, Marie	Linn County Solid Waste Agency Planner
Fencl, Jennifer	East Central Iowa Council of Governments
Frana, Bruce	Linn Soil and Water Conservation District
Hagen, David	Hawkeye Area Community Action Program & Resident
Halloush, Ghassan	Alltrans, Inc & Resident of Marion
Happel, Todd	Anderson Bogert & C.R. Resident
Huebsch, Tony	Resident
Kash, Robin	Neighborhood Network News
Prucha, Tera	Cedar Rapids Stormwater Coordinator - Pub Works
Sandstrom, Rick	Creek View Owners Association
Scanlan, David	City of Cedar Rapids Storm Water Mgt Proj Engr
Seeley Jr., Craig E.	Cedar Rapids SWC, Flood Victim/Concerned Citizen
Smith, Martin T.	Resident of Cedar Rapids
St. Clair, Martin	Coe College - Chemistry
Stark, Gregg	Sticks in the Water
Steigerwaldt, Todd	City of Marion, Gen Mgr Municipal Water
Stone, Larry	Iowa Assoc Co Conservation Boards

Facilitation Team and Presenters in Attendance:

Dalrymple, Kajsa	University of Iowa
Fisher, Matt	The Nature Conservancy
Frolich, Wendy	U.S. Army Corps of Engineers
Kittle, Ashley	Black Hawk Soil and Water Conservation District
Langsdale, Stacy	U.S. Army Corps of Engineers
Smith, Jason	U.S. Army Corps of Engineers
Stevenson, Mary Beth	Iowa Dept of Natural Resources

APPENDIX C

STAKEHOLDER ENGAGEMENT: TECHNICAL INFORMATION PRESENTED

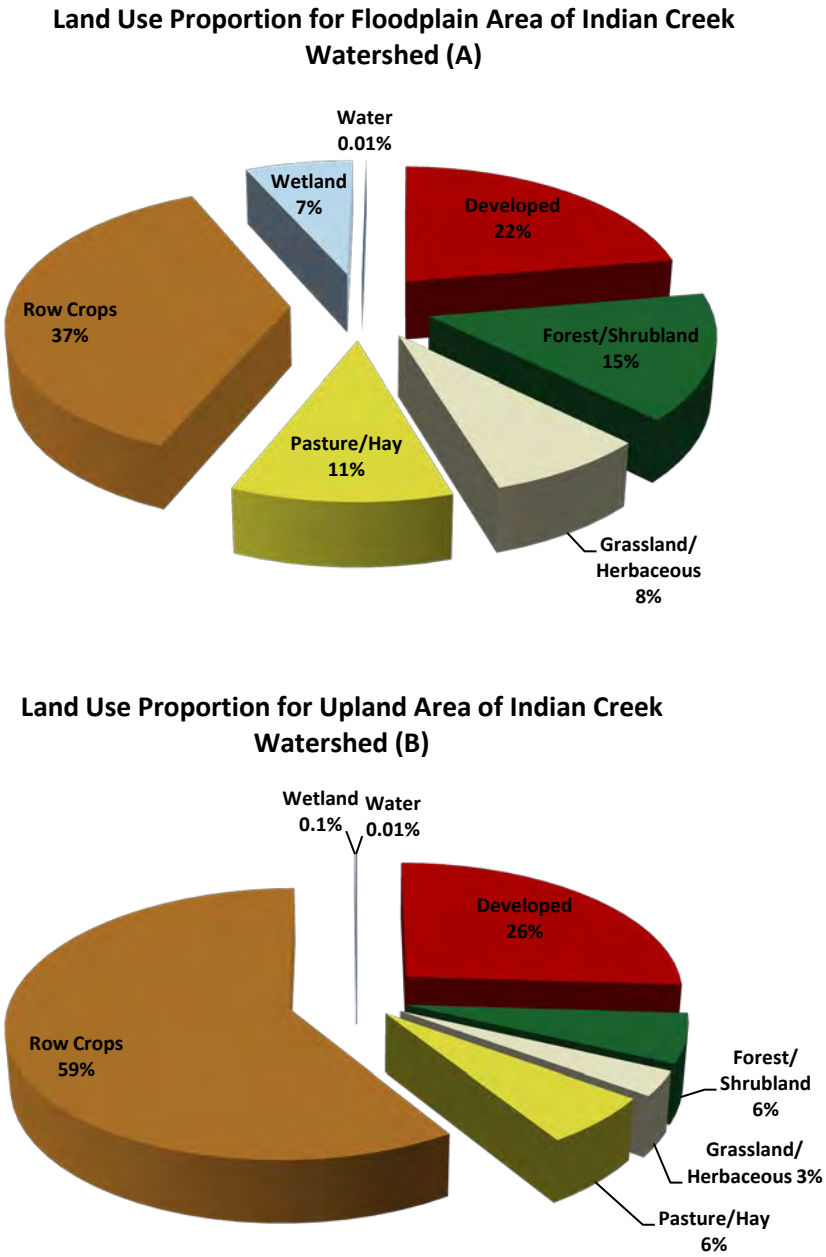


Figure C-1: Comparison of Land Use Proportions (A)Within and (B) Outside of the 1% Annual Exceedance Probablity Floodplain Based on Approved FEMA-FIRM Map

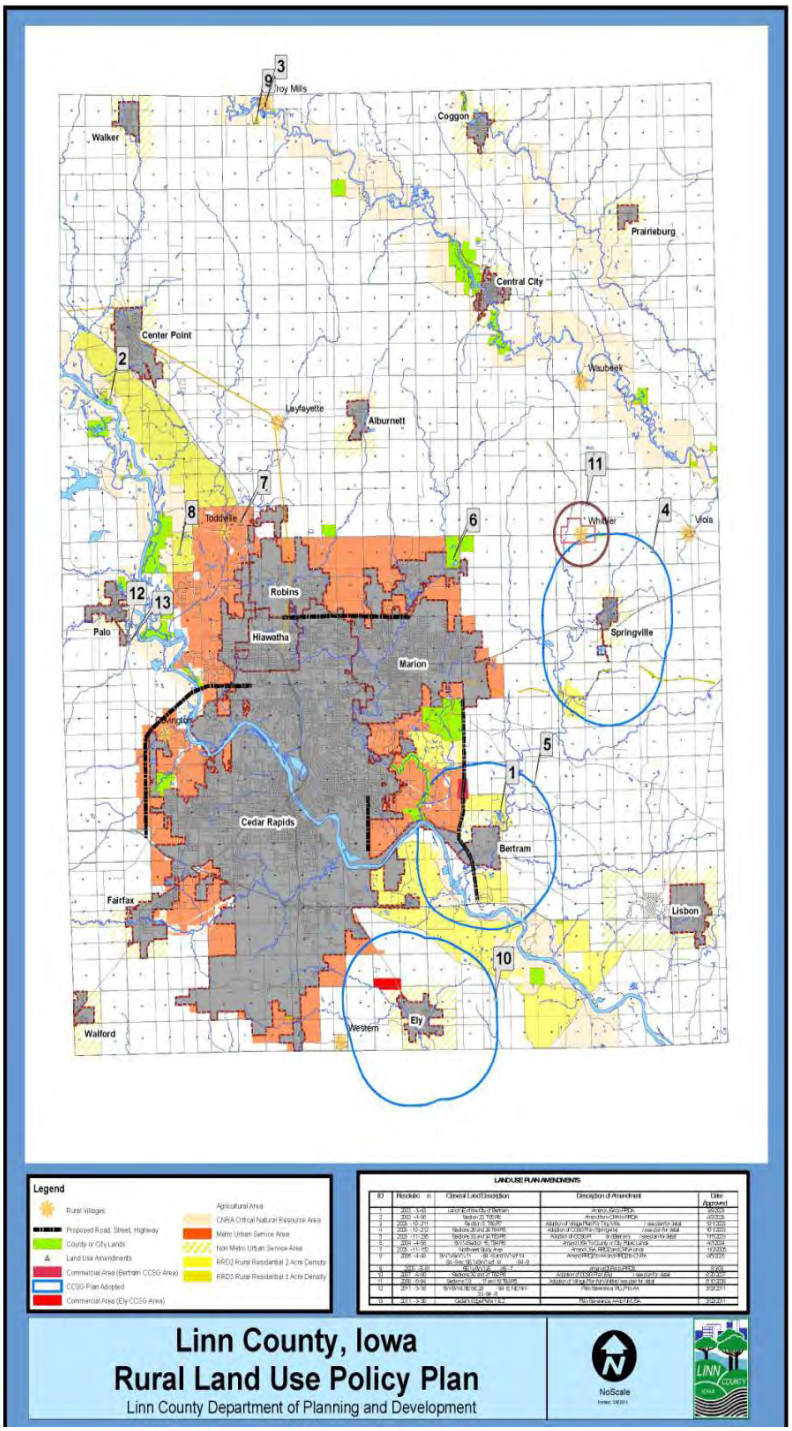


Figure C-2: Linn County Rural Land UsePolicy Plan

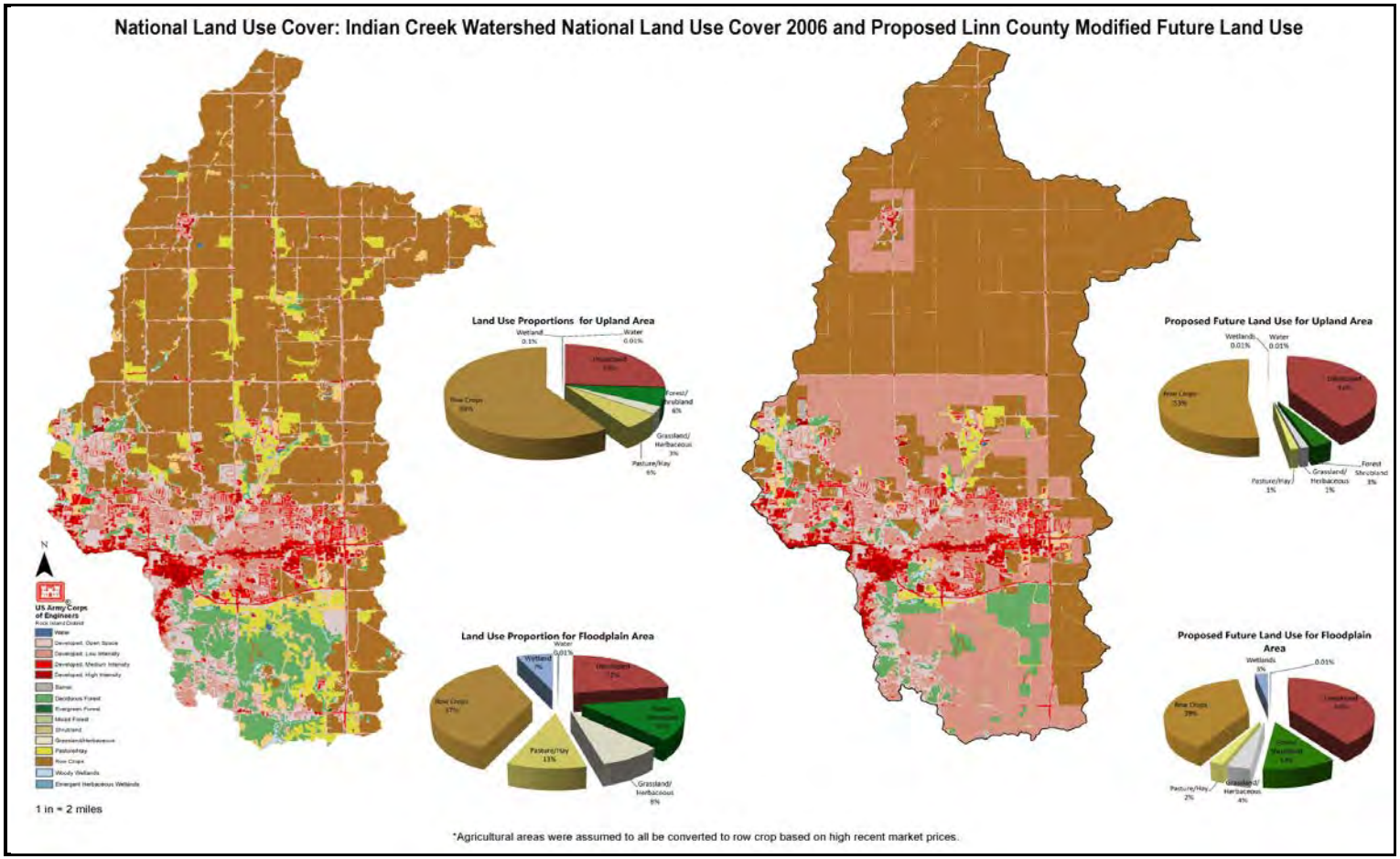
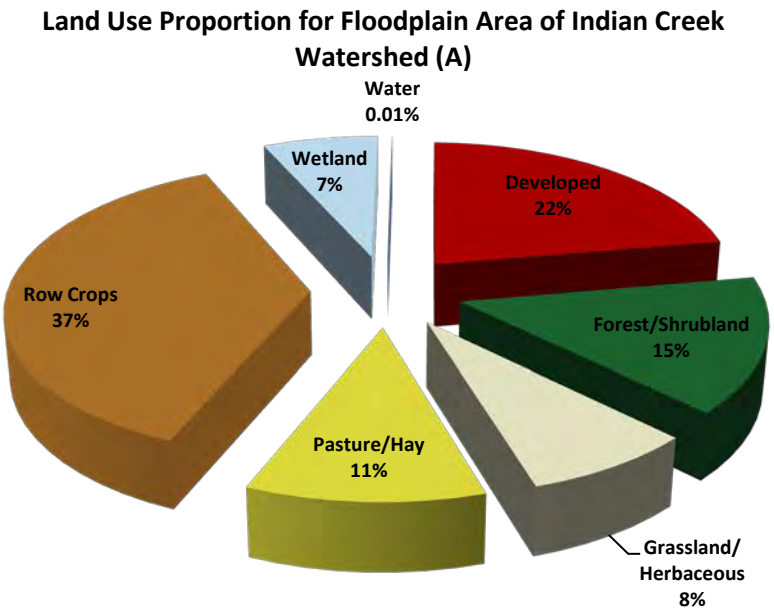


Figure C-3: Existing and Future Land Use by 2006 NLCD Land Use Types



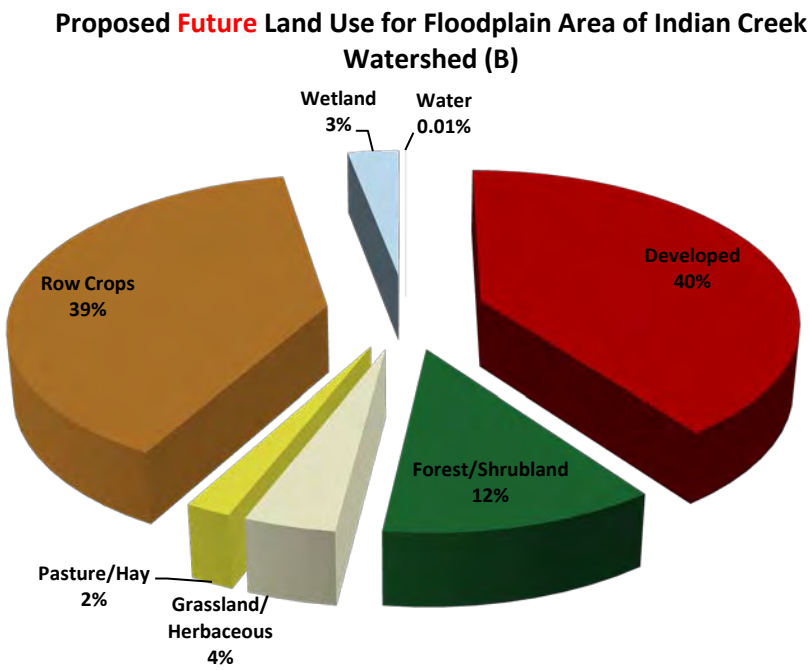


Figure C-4: Comparison of (A) Current and (B) Future Floodplain Land Use Proportions

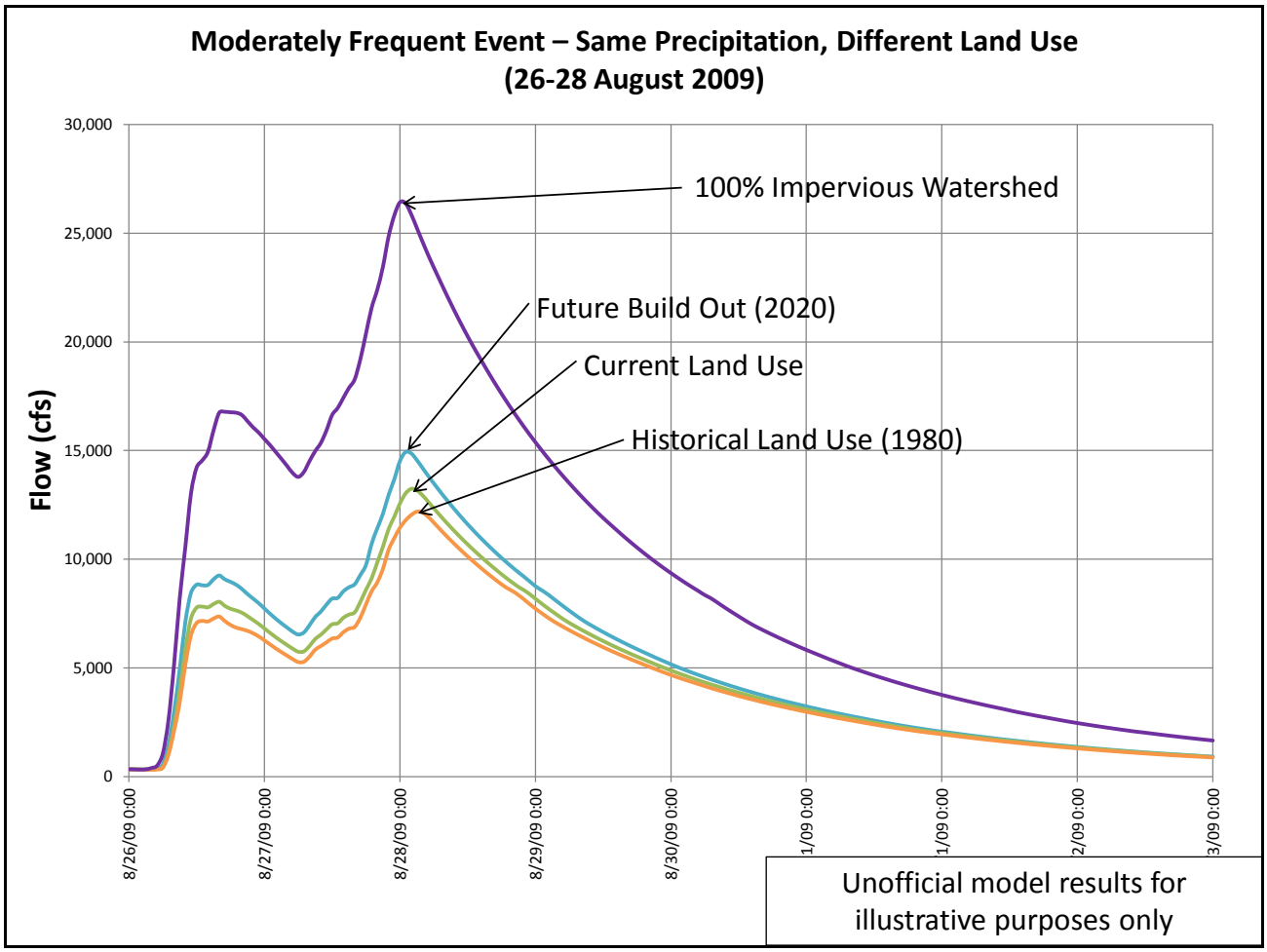


Figure C-5: Hydrologic Comparison of Land Use and Potential Impervious Landscape Response

APPENDIX D

INDIAN CREEK WATERSHED HEC-HMS MODELING - SUMMARY OF PARAMETER CHANGES FROM PRESENT TO PAST AND FUTURE

Loss—Initial & Constant

It should be noted that loss rates are not directly based on soil types or quantities, but are adjusted solely through specified initial and constant loss rates. If soil types throughout the basin were to change, initial and constant loss rates would need to be further adjusted to illustrate any possible effects this would have on infiltration.

Impervious (%)

Present (2011)—Examined, outlined, and measured continuously impervious areas to determine a percentage by subbasin. Total *developed* area was then measured and used to ration out impervious areas in the 1980s and 2020.

Past (1980s)—Outlined *developed* areas in orthophotos from the 1980s by subbasin. A ratio was then determined between the 1980s developed area, 2011 developed area, and 2011 %impervious area to determine the 1980s %impervious.
Ex: (%impervious2011) / (developed area2011) = (%impervious1980s) / (developed area1980s)

Future (2020)—GIS shapefiles were acquired from Linn County outlining future areas of development. The areas were then quantified by subbasin and compared to the 2011 developed area ratios and %impervious values. A future %impervious value was then determined by ratio as it was for the 1980s data.

Initial and Constant Loss Rates

Present (2011)—Initial and constant loss rates were initially determined for the present time frame through calibration while staying within the ranges of 0 to 1.5 inches for initial loss, and 0 to 0.30 in/hr for constant loss.

Past & Future (1980s & 2011)—Present initial and constant loss rates were adjusted based on the type and area of soil that had been or will be covered by development. The uncovered areas of easily infiltrated soils such as Sand, Loamy Sands, and Sandy Loams were quantified in present, past, and future conditions. A percent difference was then computed from present to future or past state. The "present" loss rate was then adjusted by the percent difference for the respective state.
Ex: (loss1980s) = (loss2011) x (1 + %difference1980to2011)

Transform—Clark Unit Hydrograph

Present (2011)—Tc and R were determined for present conditions by performing overland routing estimations based on stream length and longest flow path to compute the time of concentration. Estimated ratios from literature of R/(Tc+R) were then used to estimate R.

Past (1980s)—Stream lengths were traced from1980s orthophotos and distances determined. The updated distances were then used to compute Tc and the same R/(Tc+R) ratios used to determine R.

Future (2020)—The percent difference was determined between 2011 and 1980 and assumed to be the same between 2011 and 2020 to determine 2020 stream lengths. Updated distances were then used to compute Tc and the same R/(Tc+R) ratios used to determine R.

Routing—Muskingum-Cunge

Present (2011)—Reach length was measured by tracing current orthophotos in GIS and channel slopes computed. An average cross-section was chosen from the HEC-RAS model and entered into HMS as an eight-point input. Average Manning's n values were also used for each reach channel and left and right overbanks.

Past (1980s)—Stream lengths were measured with 1980s orthophotos and channel slopes computed. All other parameters remain the same as 2011.

Future (2020)—The percent difference was determined between 2011 and 1980 reach lengths. This difference was then applied between 2011 and 2020 to estimate 2020 reach lengths. All other parameters remain the same as 2011.

Table D-1: Peak Flow Summary—High Flow Models (June 2002 Events)

June 3-4, 2002 Event-Peak Flow Summary—Indian Creek Above Squaw Creek				
Source	**Peak Flow (cfs)**	**%-Difference Flow from "Present"**	**Inundated Area (ac)**	**Difference in Inundated Area from "Present" (ac)**
USGS Indirect Measurement*	24,300*			
1980 (Past) Conditions	19,715	-2.2	3,631	-38
2011 (Present) Conditions	20,157		3,669	0
2020 (Future) Conditions	20,593	+2.2	3,704	+35

Note: This indirect measurement was categorized by the USGS as having "poor" accuracy indicating a possible error of 25% or more.

Table D-2: Peak Flow Summary—High Flow Models (August 2009 Event)

August 26-28, 2009 Event-Peak Flow Summary—Indian Creek Above Squaw Creek				
Source	**Peak Flow (cfs)**	**%-Difference from "Present"**	**Inundated Area (ac)**	**Difference in Inundated Area from "Present" (ac)**
Indirect Measurement*	13,832*			
1980 (Past) Conditions	9,862	-8.2	2,895	-84
2011 (Present) Conditions	10,738		2,979	0
2011 (Present) Conditions with Climate Change	14,886	+38.6	3,397	+418
2020 (Future) Conditions	11,651	+8.5	3,056	+203

**Note: High water mark measured by the City was equated to rating curve from HEC-RAS model to determine a flow.*

Table D-3: Parameter Summaries—High Flow Models (June 2002 & August 2009 Events)

Transform Method—Clark Unit Hydrograph						
	Tc (hr)			**R (hr)**		
Subbasin	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**
SE	3.88	3.88	3.88	0.97	0.97	0.97
NE	5.62	5.56	5.50	1.40	1.39	1.38
SW	4.21	3.93	1.38	1.80	1.69	1.58
NW	3.98	3.90	3.81	0.99	0.96	0.95
Above Squaw Creek	2.89	2.80	2.72	0.72	0.70	0.68

Table D-4: Parameter Summaries—High Flow Models (June 2002 & August 2009 Events)

Loss Method—Initial & Constant									
	Initial Loss (in)			**Constant Loss (in/hr)**			**% Impervious**		
Subbasin	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**
SE	0.92	0.90	0.88	0.06	0.05	0.045	4.78	9.28	19.91
NE	1.00	1.00	1.00	0.05	0.05	0.05	1.00	1.00	1.00
SW	0.91	0.85	0.79	0.06	0.05	0.045	6.03	14.41	24.17
NW	1.00	1.00	1.00	0.05	0.05	0.05	1.42	1.42	1.42
Above Squaw Creek	0.80	0.80	0.71	0.06	0.05	0.045	17.15	17.58	30.05

Table D-5: Parameter Summaries—High Flow Models (June 2002 & August 2009 Events)

Baseflow Method—Recession*			
Subbasin	**Initial Discharge (cfs/mi^2)**	**Recession Constant**	**Threshold Flow (cfs)**
SE	0.50	0.90	50
NE	0.50	0.90	50
SW	0.18	0.90	50
NW	0.10	0.90	50
Above Squaw Creek	2.50	0.90	50

**Note: These parameters represent 1980, 2011, and 2020.*

Table D-6: Parameter Summaries—High Flow Models (June 2002 & August 2009 Events)
Routing—Muskingum Cunge

2011 Conditions					
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**L.B.Manning's n**	**R.B.Manning's n**
RIC4	14,424	0.0028595	0.045	0.06	0.06
RIC3	11,603	0.0028595	0.040	0.075	0.075
RIC2	17,131	0.0028595	0.040	0.08	0.07
RDC2	67,517	0.0011476	0.045	0.095	0.080
RDC1	5,464	0.0011476	0.040	0.055	0.055
RIC1	57,784	0.0012875	0.032	0.06	0.06
1980 Conditions					
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**L.B.Manning's n**	**R.B.Manning's n**
RIC4	14,437	0.0028708	0.045	0.06	0.06
RIC3	11,973	0.0028708	0.040	0.075	0.075
RIC2	16,578	0.0028708	0.040	0.08	0.07
RDC2	74,878	0.0010450	0.045	0.095	0.080
RDC1	5,264	0.0010450	0.040	0.055	0.055
RIC1	58,023	0.0012823	0.032	0.06	0.06
2020 Conditions					
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**L.B.Manning's n**	**R.B.Manning's n**
RIC4	14,411	0.0028463	0.045	0.06	0.06
RIC3	11,245	0.0028463	0.040	0.075	0.075
RIC2	17,702	0.0028463	0.040	0.08	0.07
RDC2	60,879	0.0012584	0.045	0.095	0.080
RDC1	5,671	0.0012584	0.040	0.055	0.055
RIC1	57,547	0.0012928	0.032	0.06	0.06

Table D-7: Parameter Summaries—High Flow Models (June 2002 & August 2009 Events)

Stream Lengths & Channel Velocity*							
	Longest Flowpath (ft)			**River Length (ft)**			**Approx. Vel. (ft/s)**
Subbasin	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**	
SE	49,744	49,885	50,026	42,989	43,159	43,329	6.60
NE	46,048	45,739	45,433	36,480	36,290	36,102	5.60
SW	83,040	75,941	69,449	80,142	72,980	66,459	6.94
NW	45,346	44,610	43,886	36,815	36,264	35,722	6.50
Above Squaw Creek	64,105	63,506	62,913	58,023	57,784	57,547	8.00
**Note: Velocity parameters represent 1980, 2011, and 2020.*							

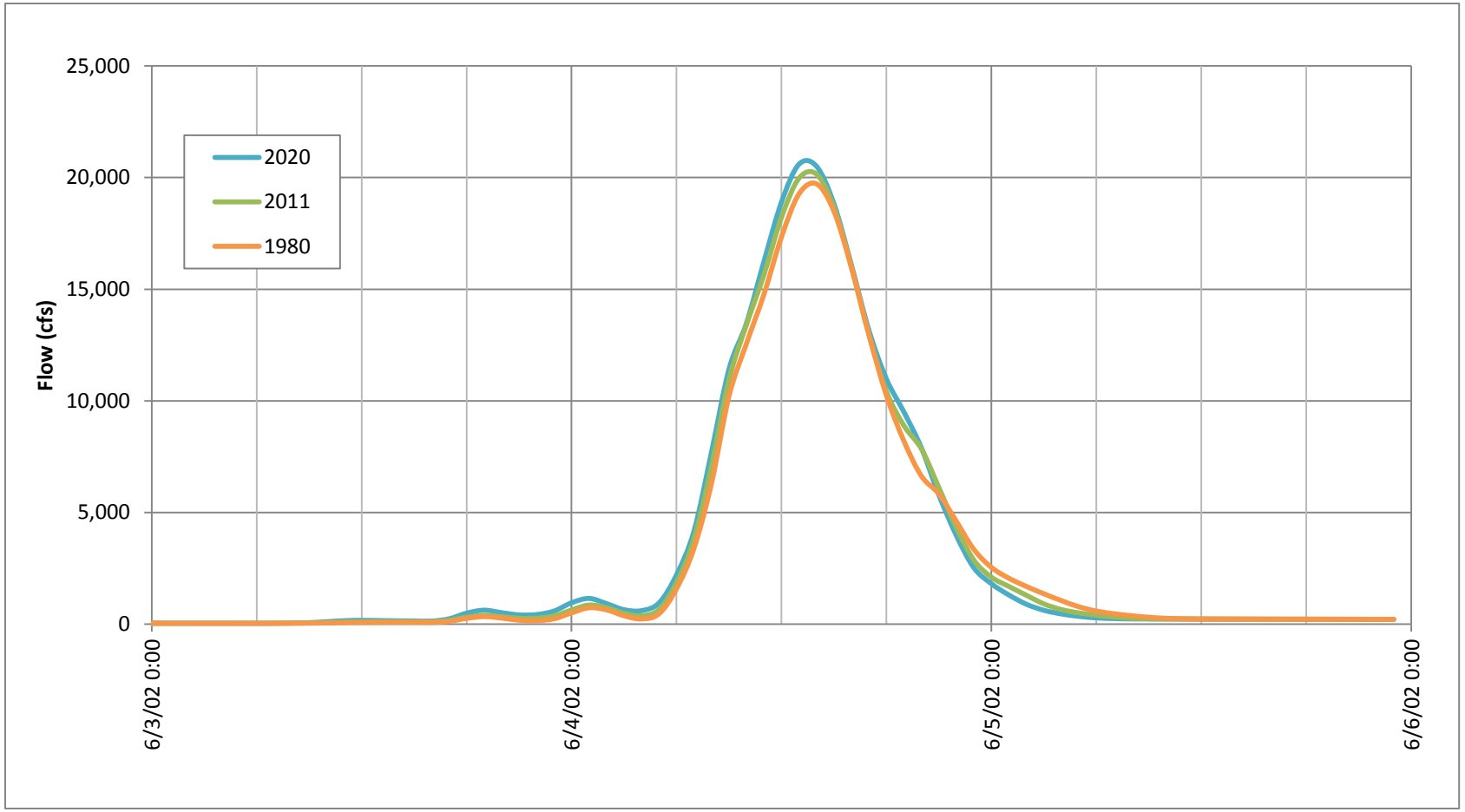


Figure D-1: 3-4 June 2002 Events in Indian Creek Watershed, HMS Results Above Squaw Creek

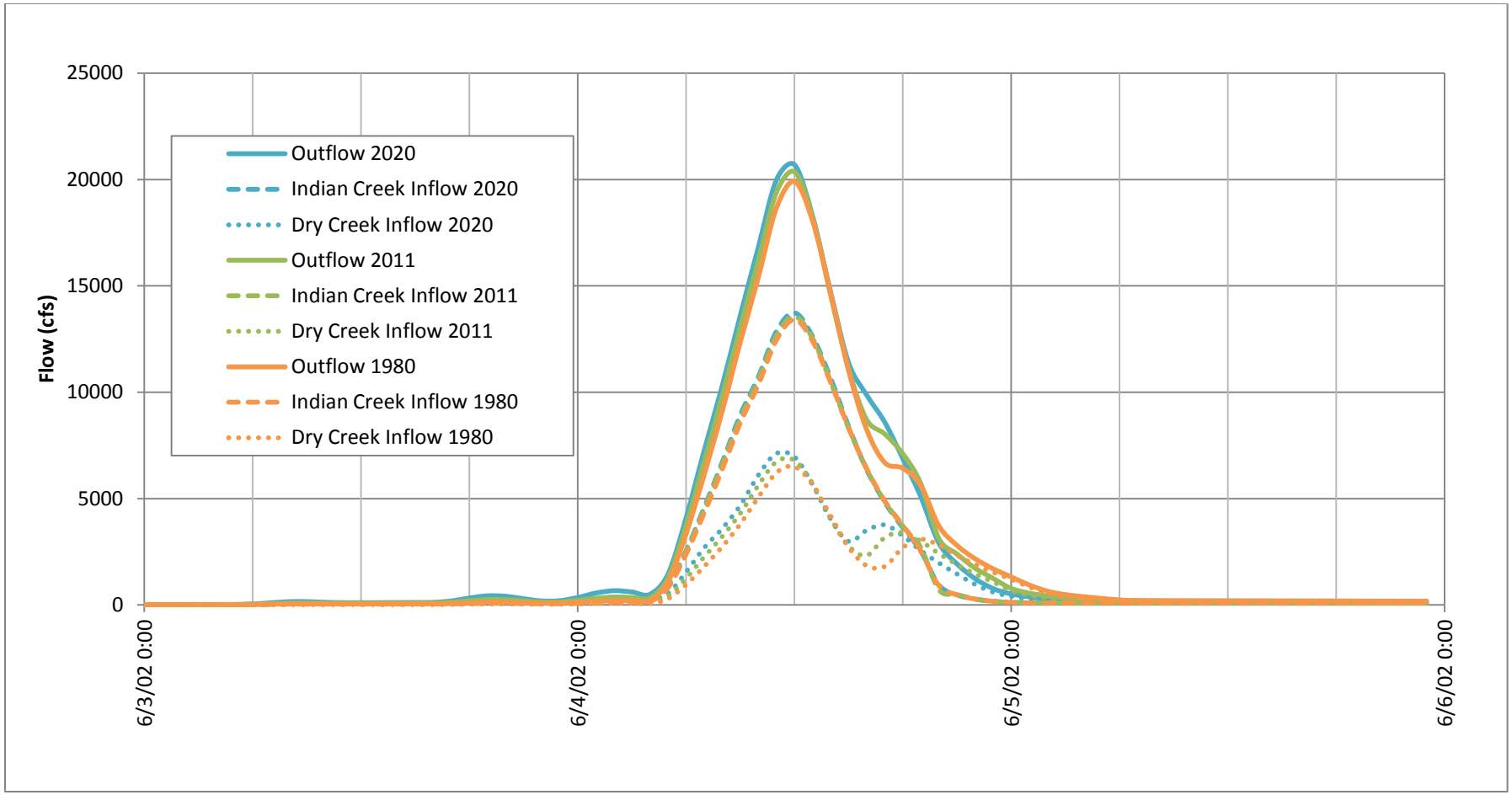


Figure D-2: 3-4 June 2002 Events in Indian Creek Watershed, HMS Hydrograph Results Before and After Confluence

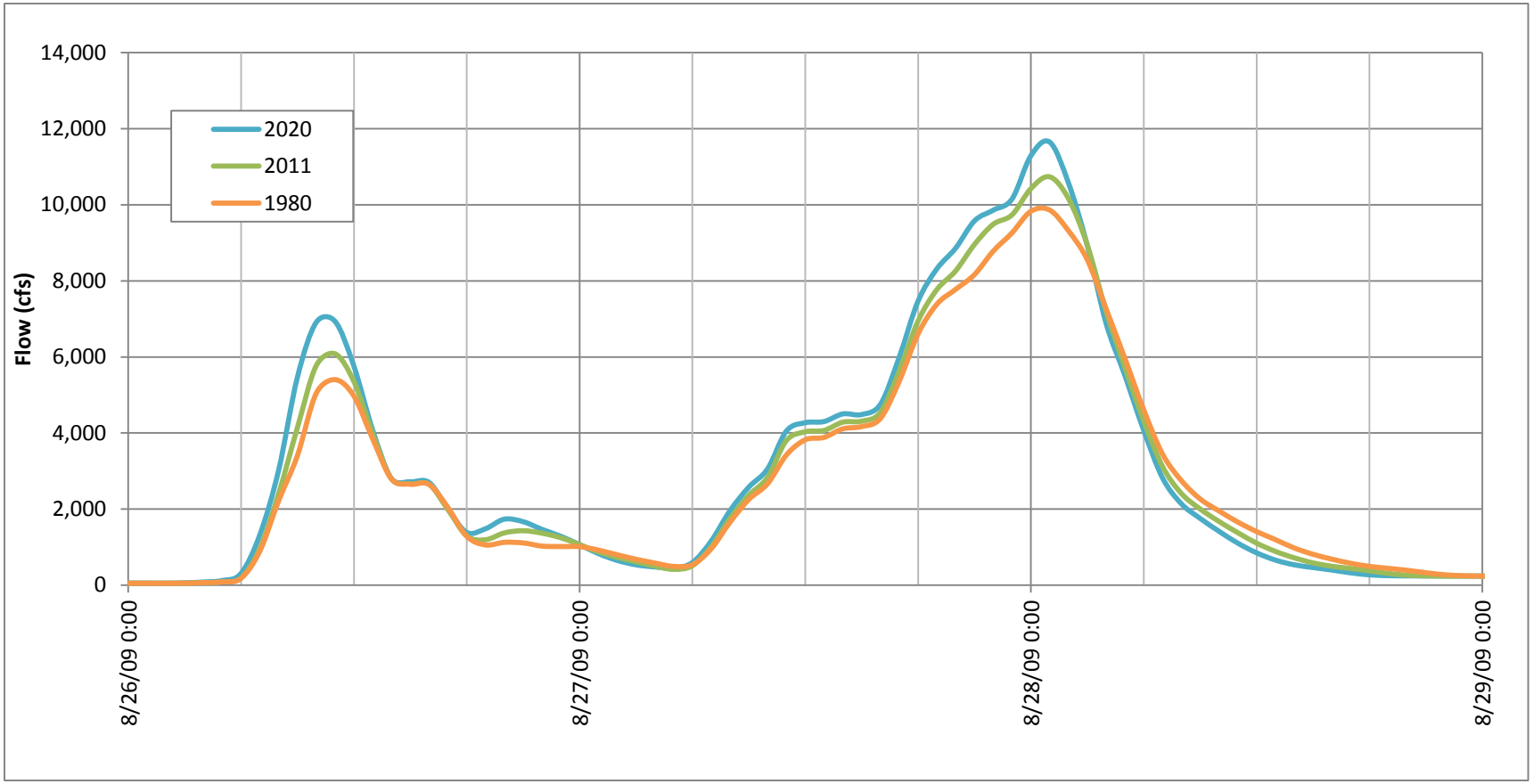


Figure D-3: 26-28 August 2009 Event in Indian Creek Watershed, HMS Results Above Squaw Creek

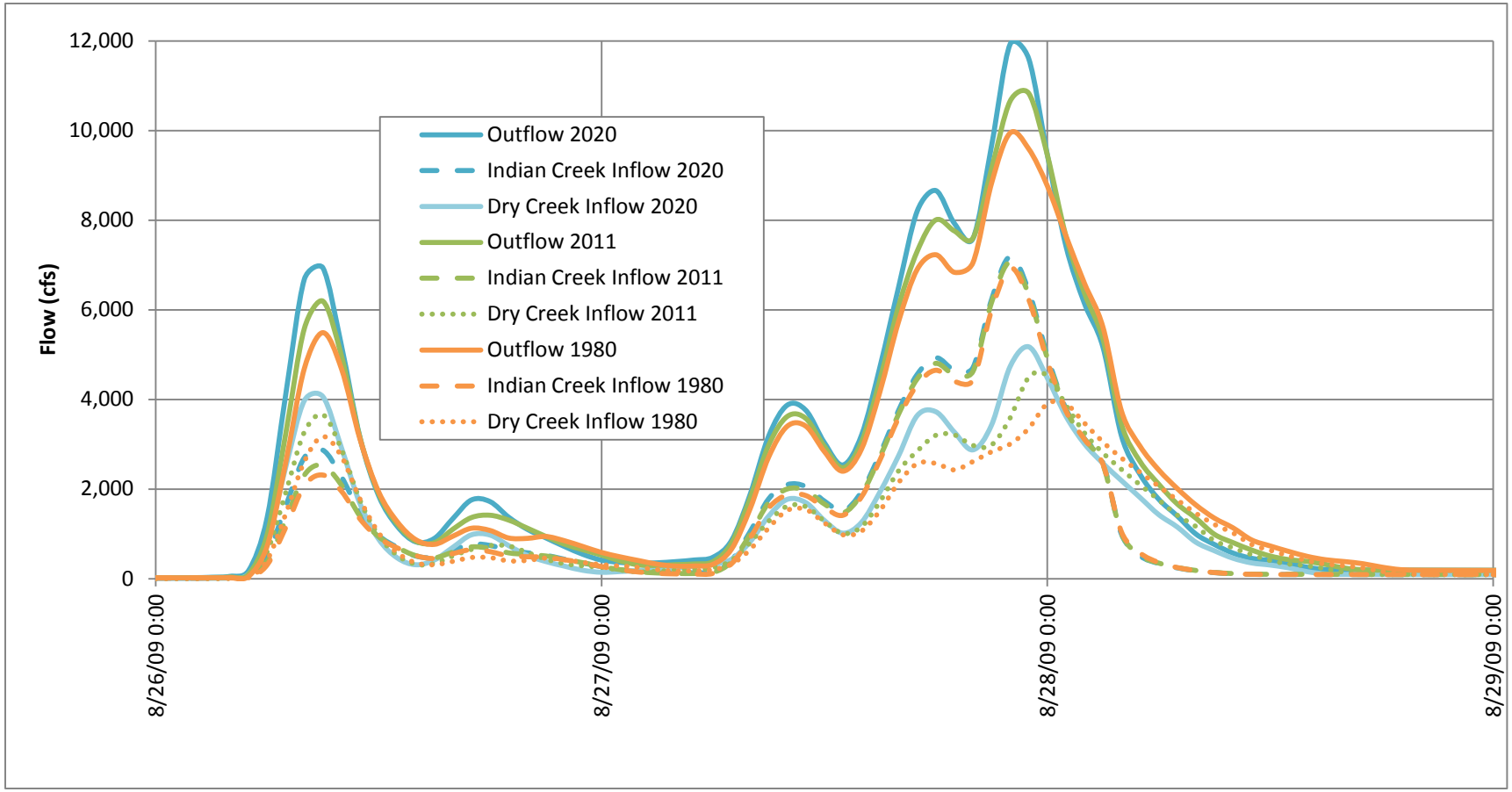


Figure D-4: 26-28 August 2009 Event in Indian Creek Watershed, HMS Results at Dry Creek/Indian Creek Confluence

Table D-8: Peak Flow Summary (May 2011 Event)

May 24-26, 2011 Event-Peak Flow Summary—Indian Creek Above Squaw Creek				
Source	**Peak Flow (cfs)**	**%-Difference from "Present"**	**Inundated Area (ac)**	**Difference in Inundated Area from "Present" (ac)**
Observed Flow*	460			
1980 (Past) Conditions	347	-27.0	157	-32
2011 (Present) Conditions	475		189	0
2020 (Future) Conditions	760	+60.0	242	+53

**Note: From University of Iowa stream sensor data.*

Table D-9: Parameter Summaries—Peak Flow Summary (May 2011 Event)

Transform Method—Clark Unit Hydrograph						
	Tc (hr)			**R (hr)**		
Subbasin	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**
SE	8.71	8.73	8.75	4.69	4.70	4.71
NE	10.14	10.06	9.98	6.76	6.71	6.65
SW	14.91	13.68	12.56	14.91	13.68	12.56
NW	10.92	10.73	10.55	7.28	7.16	7.03
Above Squaw Creek	8.82	8.80	8.72	2.23	2.21	2.18

Table D-10: Parameter Summaries—Peak Flow Summary (May 2011 Event)

Loss Method—Initial & Constant									
	Initial Loss (in)			**Constant Loss (in/hr)**			**% Impervious**		
Subbasin	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**
SE	0.92	0.90	0.88	0.26	0.25	0.25	4.78	9.28	19.91
NE	1.00	1.00	1.00	0.25	0.25	0.25	1.00	1.00	1.00
SW	1.17	1.10	1.03	0.30	0.28	0.26	6.03	14.41	24.17
NW	1.10	1.10	1.10	0.10	0.20	0.20	1.42	1.42	1.42
Above Squaw Creek	0.80	0.80	0.71	0.18	0.18	0.16	17.15	17.58	30.05

Table D-11: Parameter Summaries—Peak Flow Summary (May 2011 Event)

Baseflow Method—Recession*			
Subbasin	**Initial Discharge**	**Recession Constant**	**Threshold Discharge**
SE	0.50	0.90	50
NE	0.50	0.90	50
SW	0.18	0.90	50
NW	0.10	0.90	50
Above Squaw	2.50	0.90	50

*Note: These parameters represent 1980, 2011, and 2020.

Table D-12. Parameter Summaries—Peak Flow Summary (May 2011 Event)
Routing—Muskingum Cunge

24-26 May 2011					
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**L.B.Manning's n**	**R.B.Manning's n**
RIC4	14,424	0.0028595	0.045	0.06	0.06
RIC3	11,603	0.0028595	0.040	0.075	0.075
RIC2	17,131	0.0028595	0.040	0.08	0.07
RDC2	67,517	0.0011476	0.045	0.095	0.080
RDC1	5,464	0.0011476	0.040	0.055	0.055
RIC1	57,784	0.0012875	0.032	0.06	0.06
24-26 May 1980					
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**L.B.Manning's n**	**R.B.Manning's n**
RIC4	14,437	0.0028708	0.045	0.06	0.06
RIC3	11,973	0.0028708	0.040	0.075	0.075
RIC2	16,578	0.0028708	0.040	0.08	0.07
RDC2	74,878	0.0010450	0.045	0.095	0.080
RDC1	5,264	0.0010450	0.040	0.055	0.055
RIC1	58,023	0.0012823	0.032	0.06	0.06
24-26 May 2020					
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**L.B.Manning's n**	**R.B.Manning's n**
RIC4	14,411	0.0028463	0.045	0.06	0.06
RIC3	11,245	0.0028463	0.040	0.075	0.075
RIC2	17,702	0.0028463	0.040	0.08	0.07
RDC2	60,879	0.0012584	0.045	0.095	0.080
RDC1	5,671	0.0012584	0.040	0.055	0.055
RIC1	57,547	0.0012928	0.032	0.06	0.06

Table D-13. Parameter Summaries—Peak Flow Summary (May 2011 Event)

Stream Lengths & Channel Velocity*							
	Longest Flowpath (ft)			**River Length (ft)**			**Approx. Velocity (ft/s)**
Subbasin	**1980**	**2011**	**2020**	**1980**	**2011**	**2020**	
SE	49,744	49,885	50,026	42,989	43,159	43,329	1.80
NE	46,048	45,739	45,433	36,480	36,290	36,102	1.60
SW	83,040	75,941	69,449	80,142	72,980	66,459	1.60
NW	45,346	44,610	43,886	36,815	36,264	35,722	1.20
Above Squaw Creek	64,105	63,506	62,913	58,023	57,784	57,547	2.00

**Note: Velocity parameters represent 1980, 2011, and 2020.*

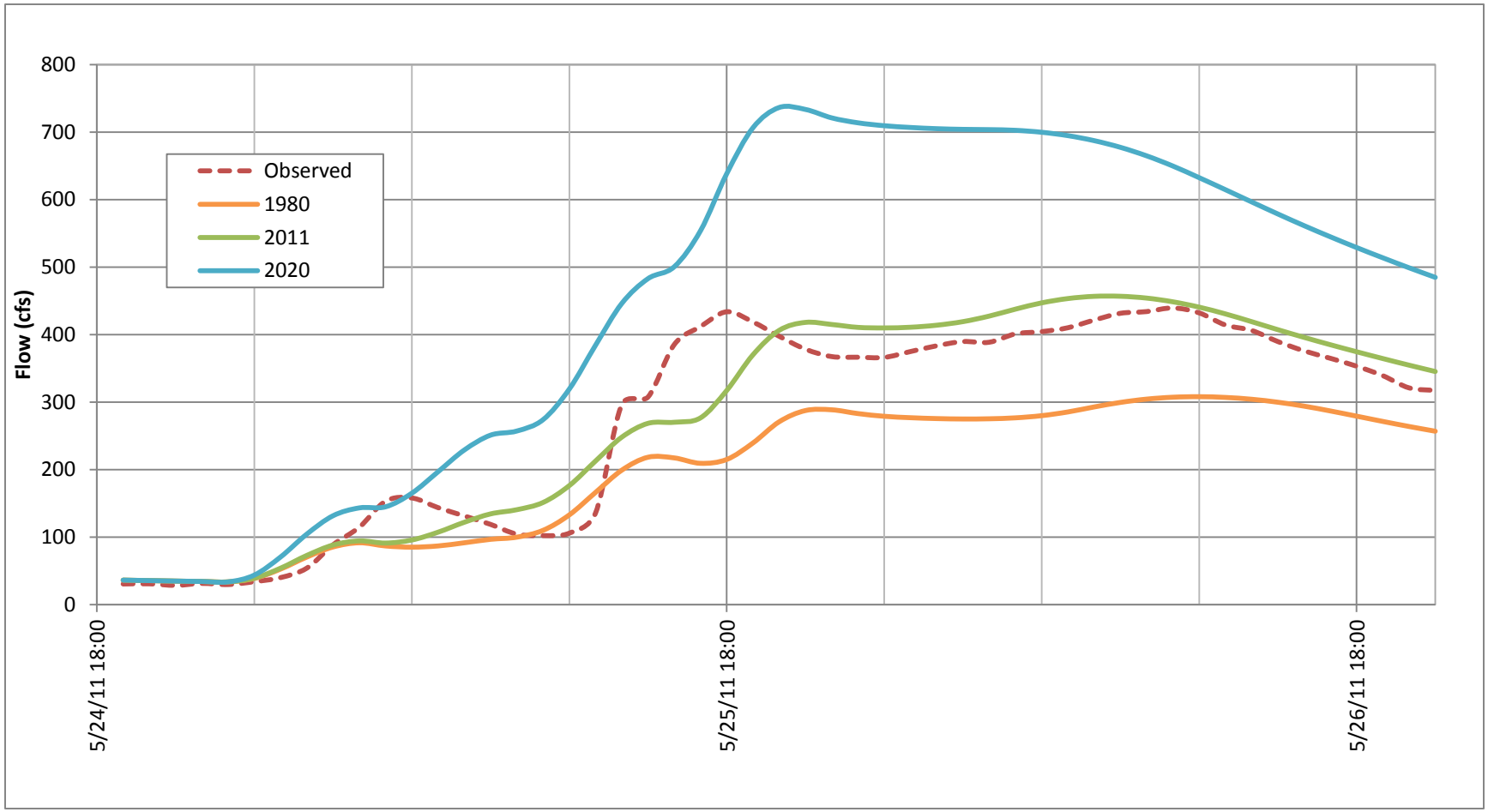


Figure D-5: 24-26 May 2011 Events in Indian Creek Watershed, HMS Results above Squaw Creek

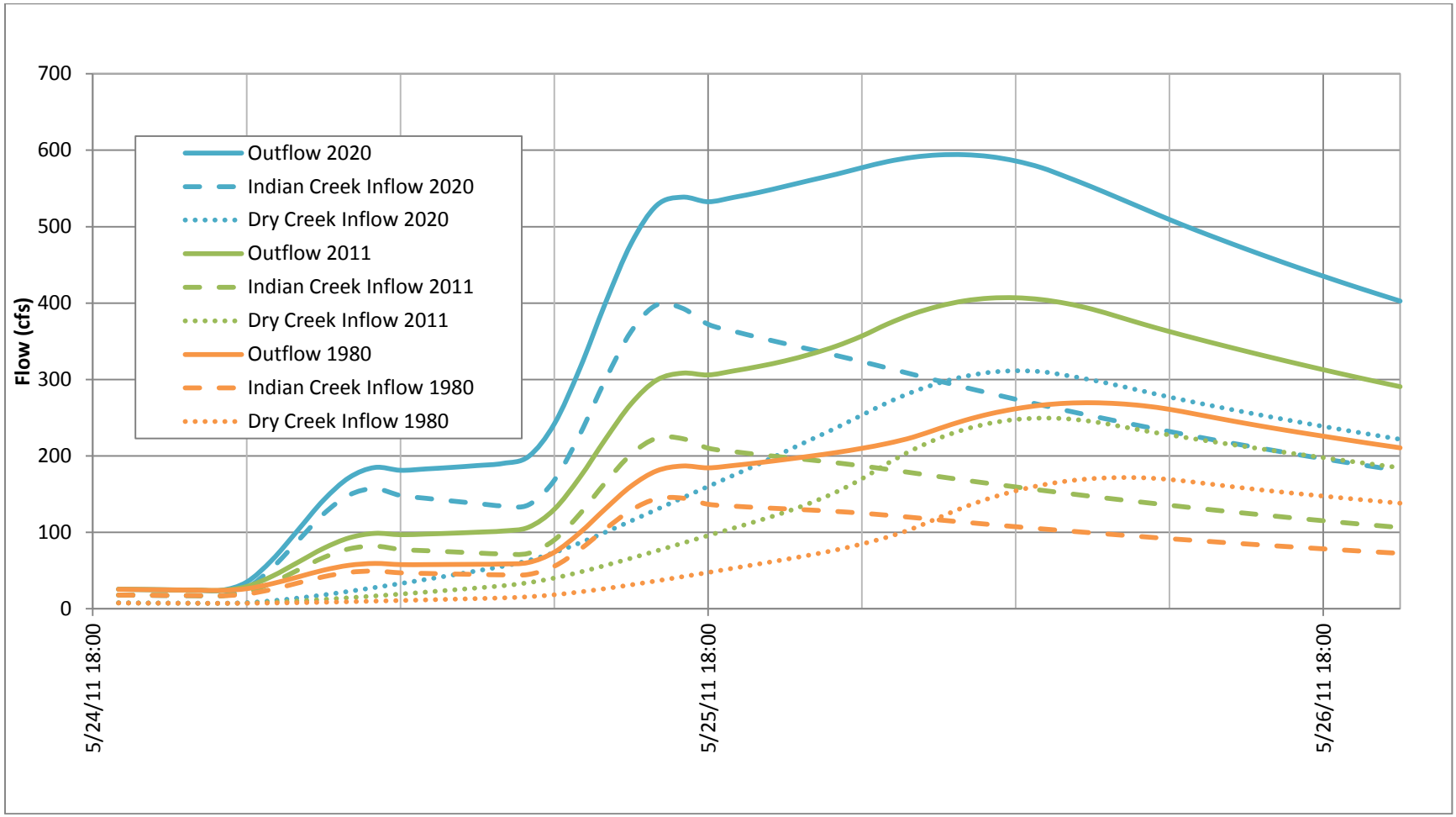


Figure D-6: 24-26 May 2011 Events in Indian Creek Watershed, HMS Results at Indian Creek/Dry Creek Confluence

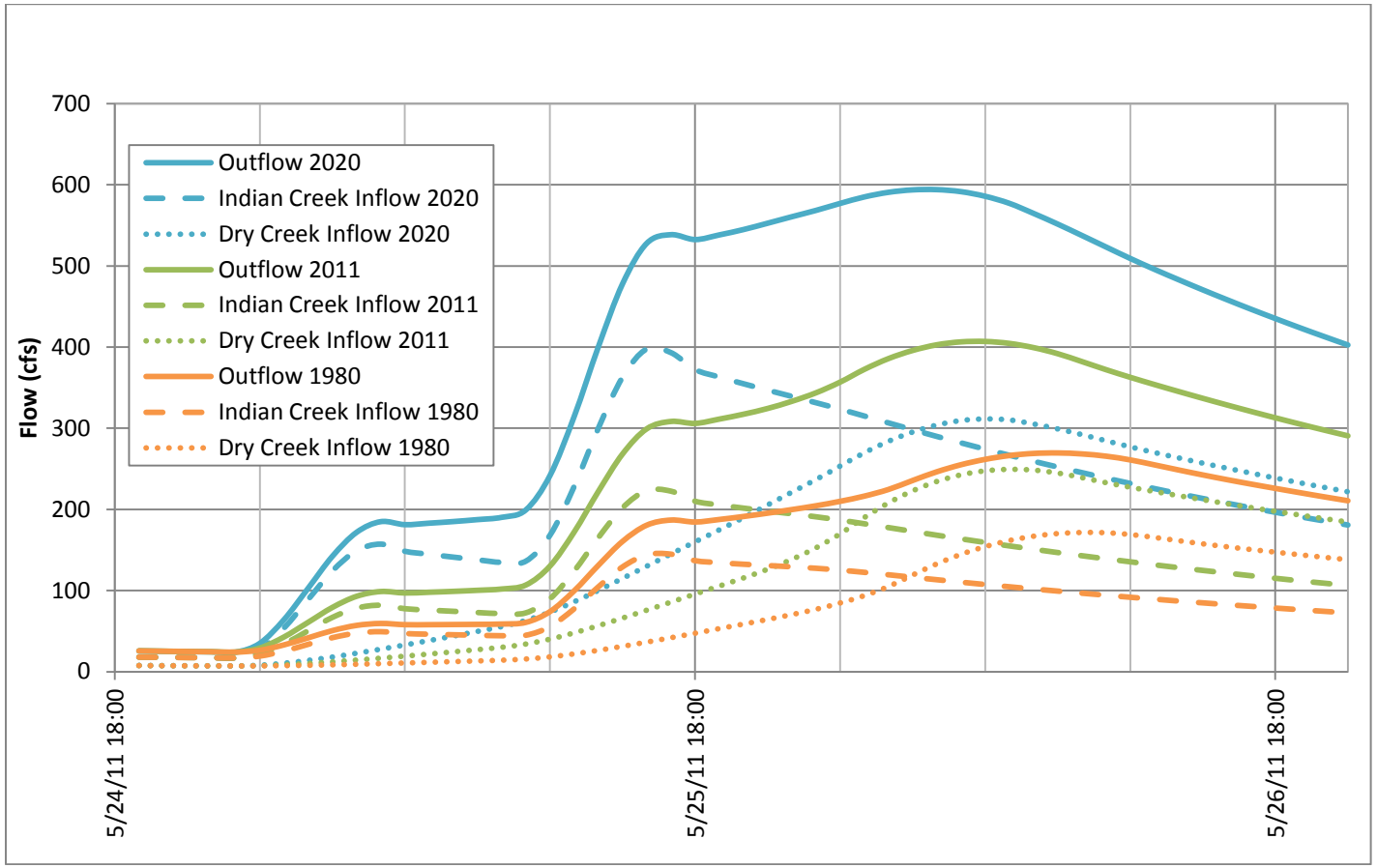


Figure D-7: 24-26 May 2011 Events in Indian Creek Watershed, HMS Results at Indian Creek/Dry Creek Confluence

APPENDIX E

CLIMATE CHANGE SCENARIO EVALUATION

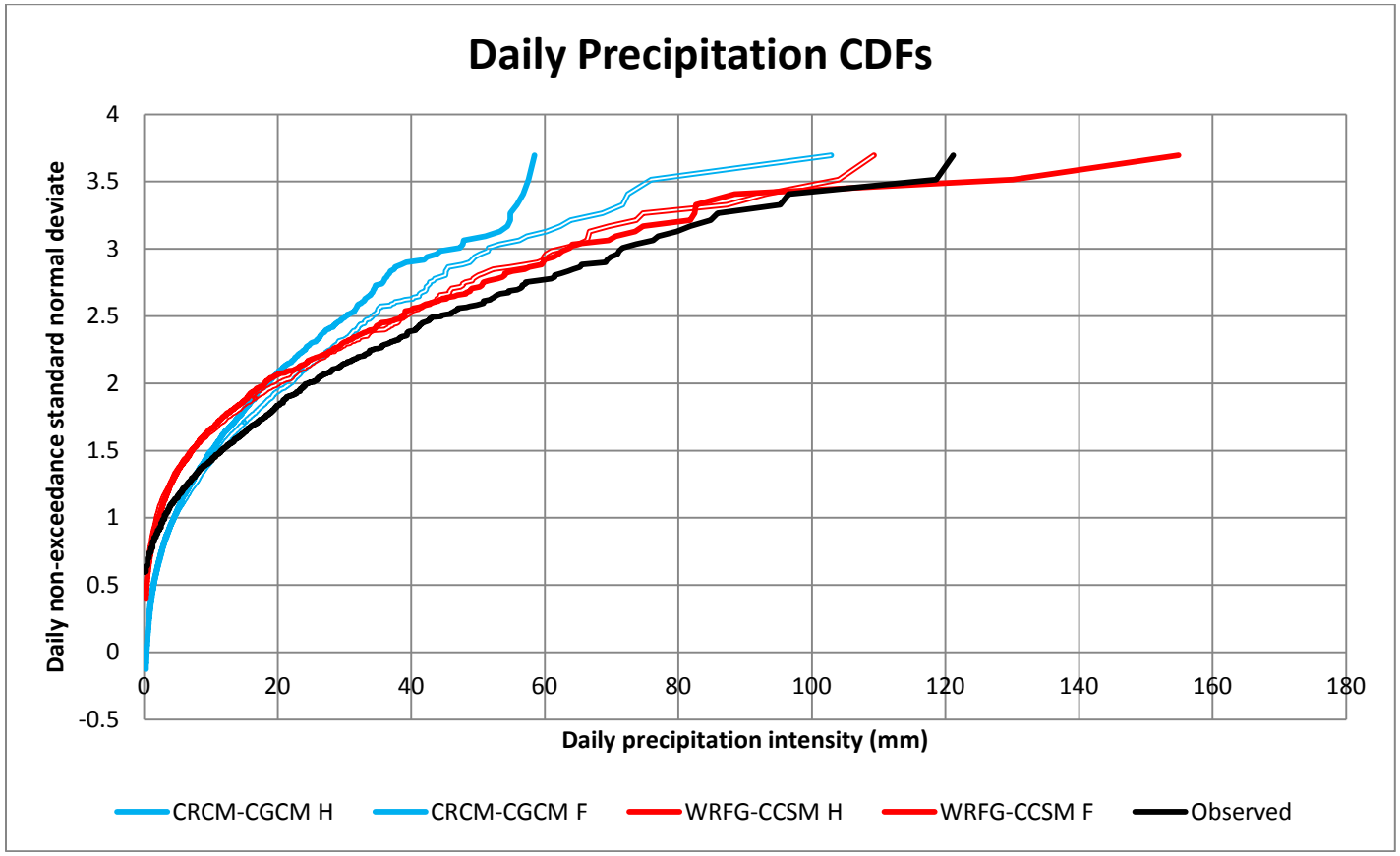


Figure E-1: Daily Precipitation Non-Exceedance Cumulative Distribution Functions for the CGCM3 Climate Model Downscaled Using CRCM and the CCSM Model Downscaled Using WRFG

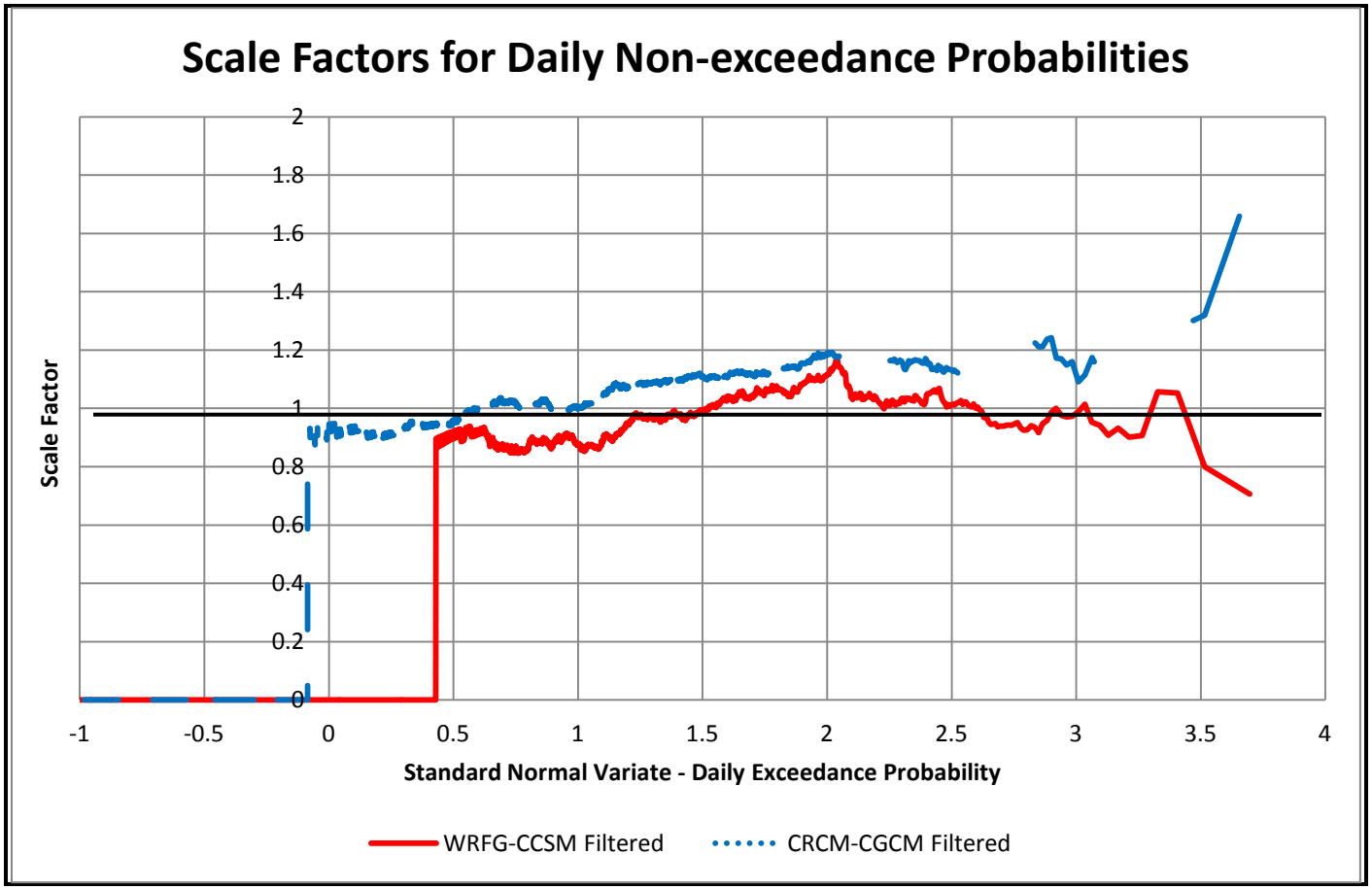


Figure E-2: Daily Precipitation Scaling Factor Plot for Two RCM-GCM Pairs

Table E-1: Scaling Results for 2009 Indian Creek Flood Event for Two GCM-RCM Pairs

CRCM-CGCM3				
Date	**Observed Precipitation (in)**	**Historical Probability**	**Scale Factor**	**Future Precipitation (in)**
08/24/2009	0.00	0.7145	0.994	0.00
08/25/2009	0.00	0.7145	0.994	0.00
08/26/2009	2.46	0.9979	1.211	2.98
08/27/2009	4.48	0.9997	1.277	5.72
08/28/2009	0.00	0.7145	0.994	0.00

WRFG-CCSM				
Date	**Observed Precipitation (in)**	**Historical Probability**	**Scale Factor**	**Future Precipitation (in)**
08/24/2009	0.00	0.7145	0.939	0.00
08/25/2009	0.00	0.7145	0.939	0.00
08/26/2009	2.46	0.9979	0.949	2.33
08/27/2009	4.48	0.9997	1.053	4.72
08/28/2009	0.00	0.7145	0.939	0.00

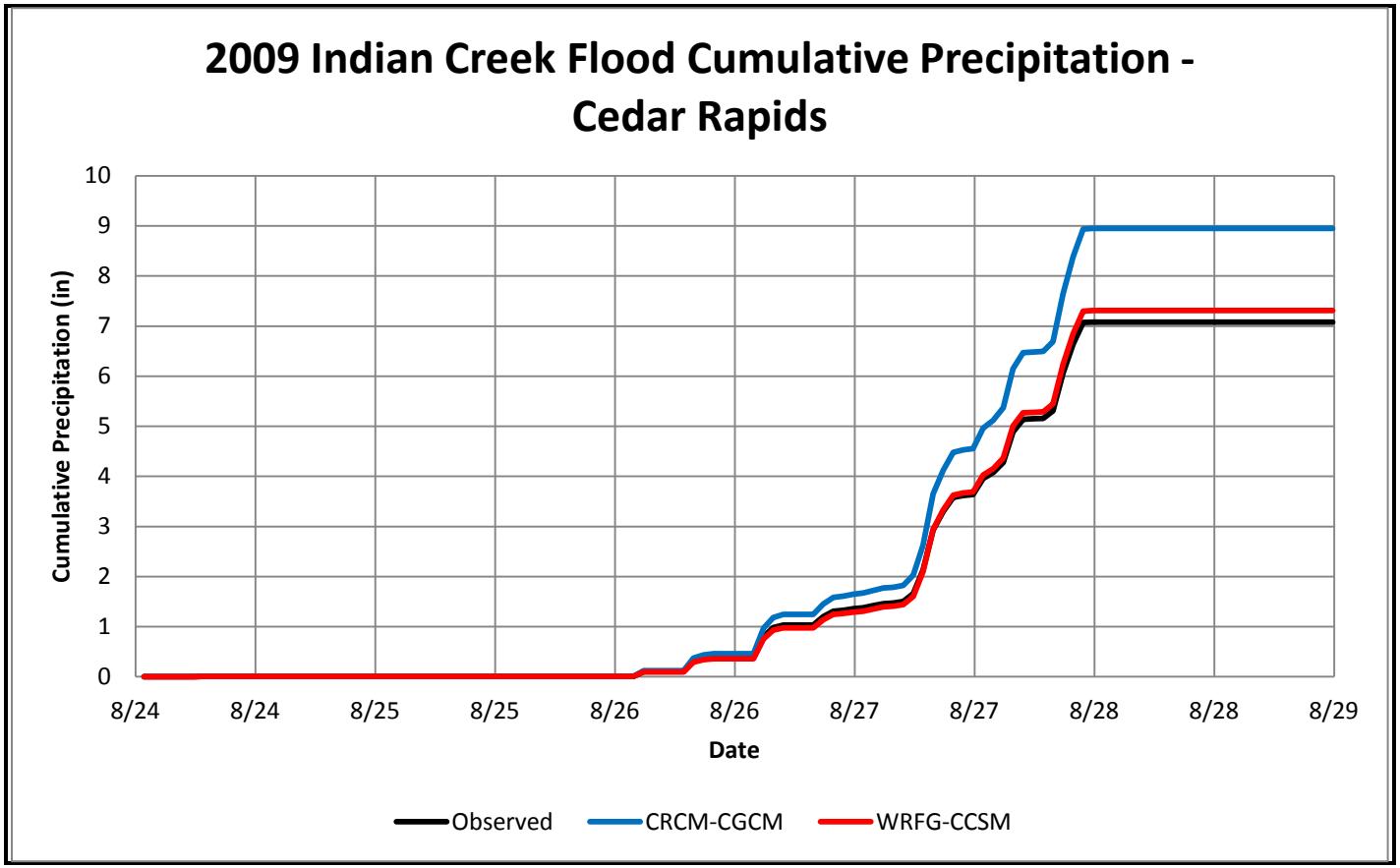


Figure E-3: Cedar Rapids, IA Gauge Scaling Results for 2009 Indian Creek Flood Event (Cumulative Precipitation)

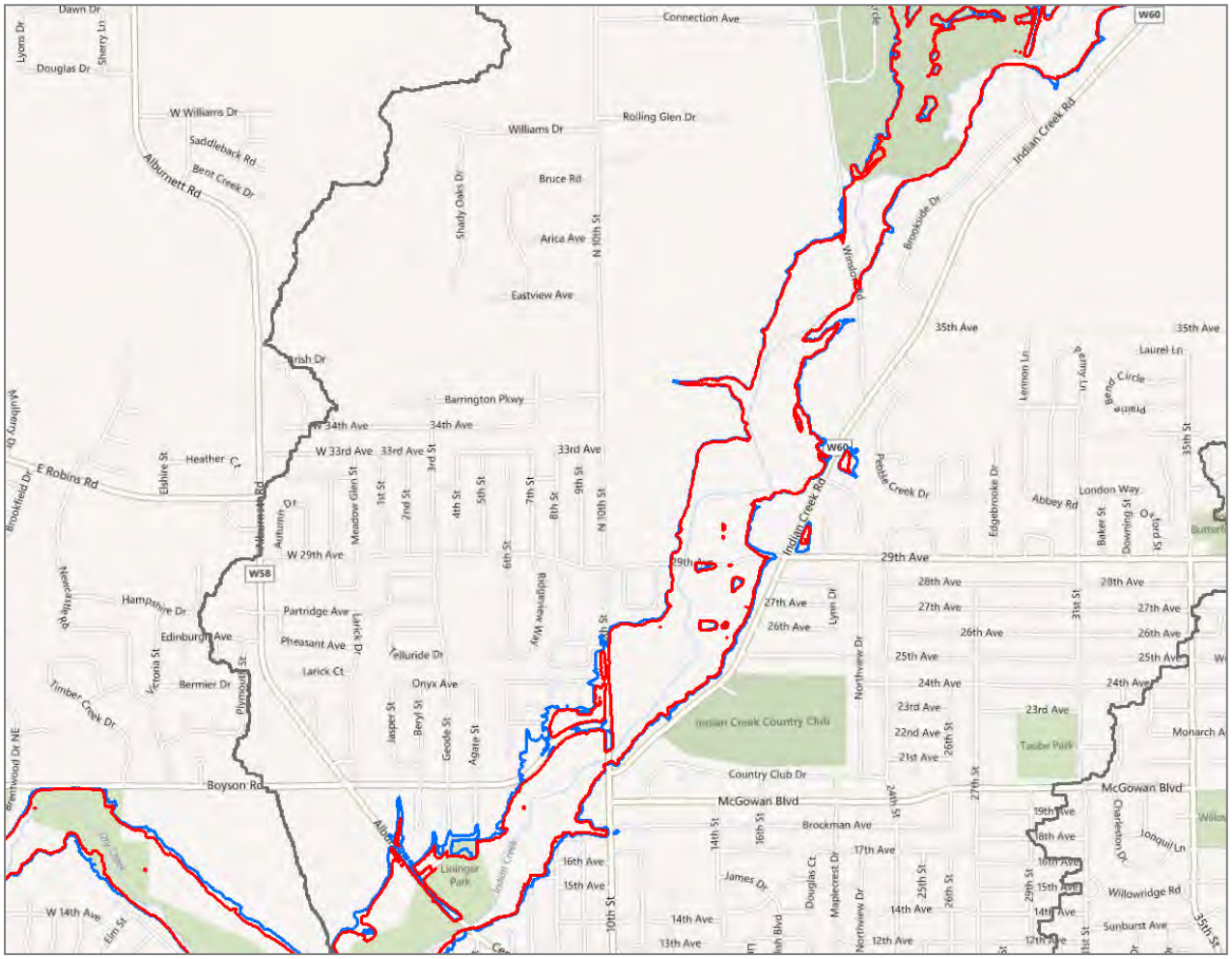


Figure E-4: Selected Inundation Extents For CRCM-CGCM3 Scaling The 2009 Indian Creek Flood Event

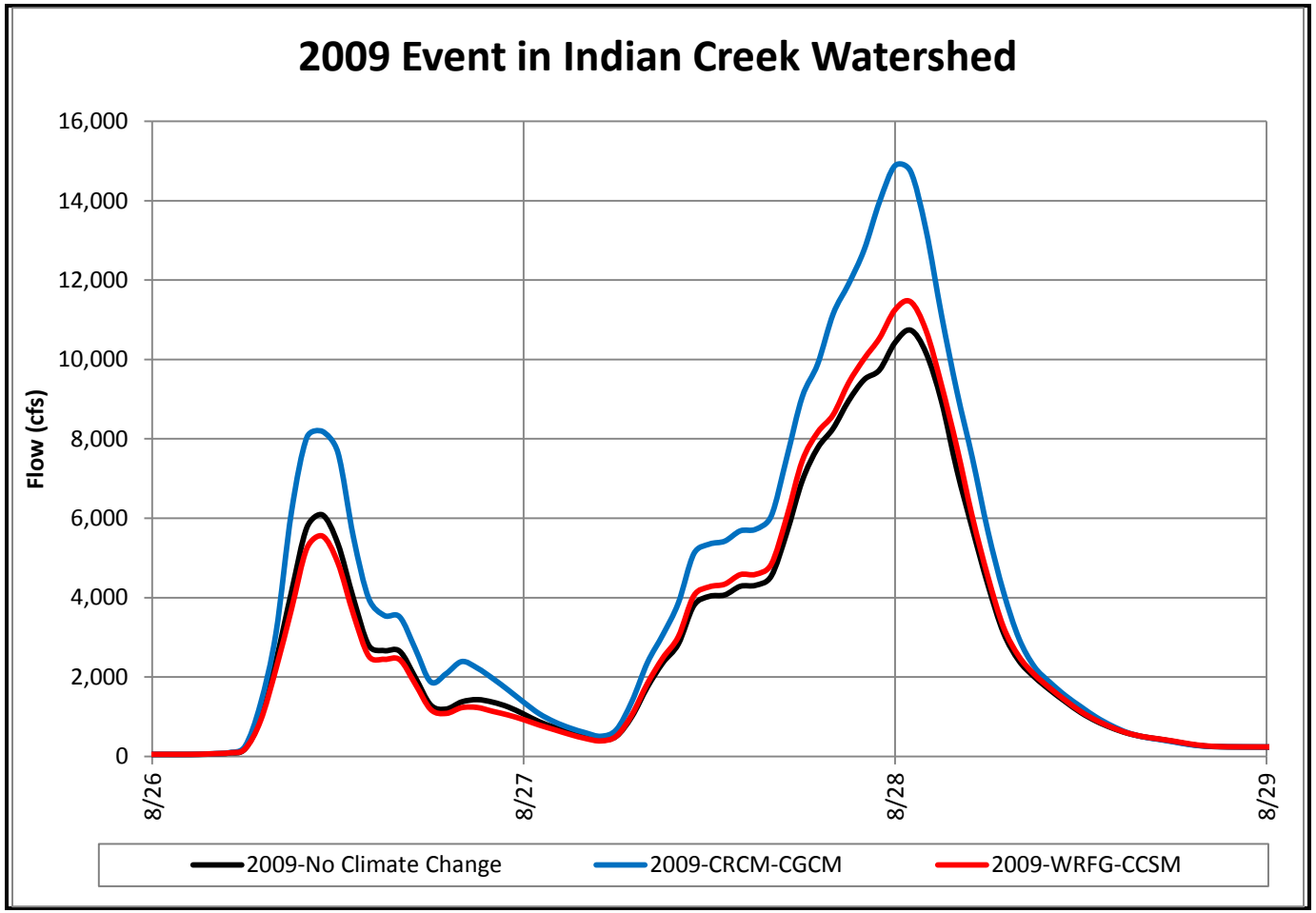


Figure E-5: Hydrograph Results for 2009 Indian Creek Event Using Two RCM-GCM Pairs Historical (Red) and Future (Blue).

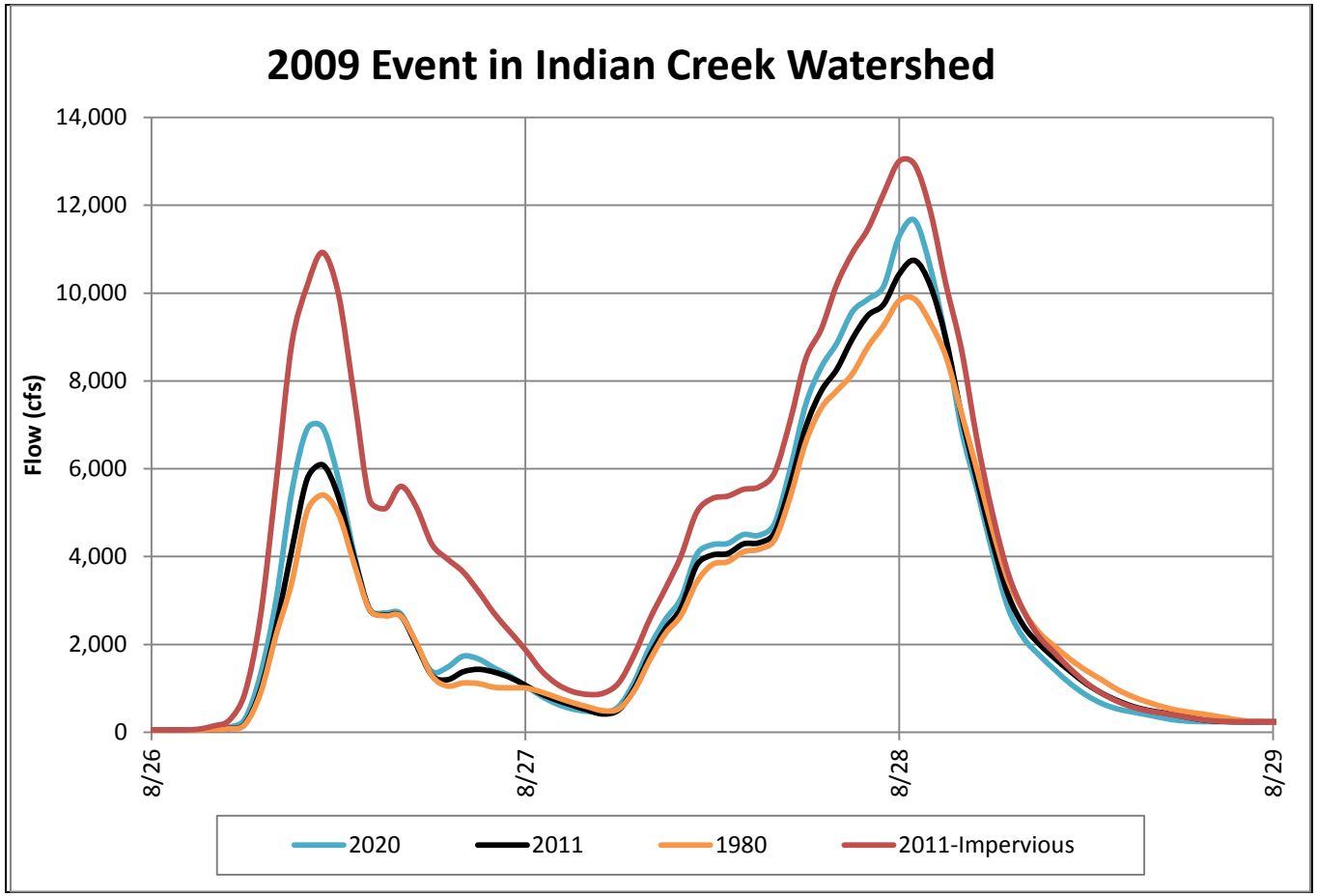


Figure E-6: Land Use Effects on 2009 Flood Event in Indian Creek. Historical (1980), Current (2011) and Proposed Future (2020) Urbanization Levels, as Well as a Completely Impervious Basin (2011-Impervious)

APPENDIX F

COMPLETE PROCEDURE FOR COUNTERFACTUAL ANALYSIS

Appendix F
Complete Procedure for Counterfactual Analysis

Purpose

The counterfactual timeseries analysis can be used to simulate the impact of climate change on a known historical meteorological or hydrological event using the results of climate change simulations.

Data Requirements

- Historical period-of-record daily precipitation
- GCM backcast (historical) run downscaled daily precipitation
- GCM future run downscaled daily precipitation
- Event precipitation hyetograph with daily or sub-daily precipitation

Notes

- This procedure may also be used for other meteorological variables such as temperature but has not been tested on anything except precipitation.
- This procedure may not accurately represent the scaling of individual timesteps if using sub-daily data for an event because it distributes the total climate "adjustment" evenly over each timestep, which may nor may not be a good assumption.
- This procedure assumes that the downscaled climate data can be analyzed for a single grid cell and compared to a nearby observation gauge and that the response is homogeneous. As the downscaling procedure produces an area-average grid, treating the grid cell center as a "station" may not be appropriate in areas where the meteorology is highly variable. This is probably a good assumption for the relatively flat Rock Island District (highly varying topography rapidly changes meteorology with over an area.)
- The use of a frequency-based scaling factor for the climate data is intended to bypass some of the inherent biases present in the downscaling method and the GCM itself. Instead of trying to take direct values from any climate result, we are using a "response function" – the ratio of change from historical to future computed by the GCM for each non-exceedance probability. We also avoid some bias by using a frequency analysis of historical observed data.
- The patterns in the response function can oscillate and behave somewhat strangely so be cautious with its use. If a smooth curve is desired, you may consider a parametric option (instead of the nonparametric plotting positions try fitting a distribution) but fitting a distribution to data containing zeroes (especially many zeroes as daily precipitation does) can be perilous. A smoothing function such as local averaging has not been tested but for a rough analysis this may work. See Figure F-2 for a smoothed scaling curve.

- It is important to remember that the probabilities computed with the plotting position are for *daily* non-exceedance, so a return interval computed from this probability will be an n-*day* storm, not an n-*year* storm. An annual frequency analysis would need to be used to determine annual non-exceedance probabilities (and thus the return interval in years.)
- This procedure does not use different scale factors by month or season, but such factors may be appropriate if there is sufficient data to create a frequency analysis for more specific time periods.

Procedure

1. Perform QC of all input datasets. Check for missing data values, total period of record, unreasonable values, homogeneous units, etc. Climate model data have periods of record generally less than 30 years. The full historical record should be at that length or longer. If using sub-daily precipitation for the event to be scaled, make sure the aggregated daily totals match the historical daily precipitation totals for that event.
2. Perform an empirical frequency analysis of the historical period-of-record daily data. It is important that all data being used for this analysis are at 24-hour (daily) timestep. This can be done in Excel or HEC-SSP, for example. This procedure assumes Excel is being used.
    a. Including days of zero precipitation, sort/rank the data from smallest to largest.
    b. Count the number of valid values (*n*) and assign an index (*i*) to each value with 1 corresponding to the smallest value and *n* corresponding to the largest.
    c. Use the Weibull plotting position formula to compute the empirical non-exceedance probability for the daily precipitation. $p = \frac{i}{n+1}$
3. Perform the same empirical frequency analysis for both the backcast and future GCM-projected precipitation. Use the same length of record for both (truncate the longer series if there is one.)
4. For each empirical probability in the GCM sets (they should be equal as *n* will be equal for the two sets) compute the ratio of the future precipitation quantile to the historical.
5. Create a table with the two columns containing the empirical probability from Step 3 and the ratios from Step 4.
6. Using the daily totals from the event hyetograph for the event to be scaled, find the empirical non-exceedance probability for each day of the event using the frequency table in Step 2 (interpolate if necessary.)
7. Using the computed probabilities from Step 6, find the daily scaling ratios from the table produced in Step 5. Divide the ranked future precipitation value by the historical value for each probability. If the future precipitation value is zero, the scale ratio should be given a value of zero.

$$k_{p_i} = \frac{\theta_f(p_i)}{\theta_h(p_i)}$$

where
p_i is the non-exceedance probability for ranked item *i* using the Weibull plotting position
k_{pi} is the observed precipitation scaling factor for quantile p_i
θ_f is the daily total precipitation for the future/forecast climate scenario for quantile p_i
θ_h is the daily total precipitation for the historical/backcast climate scenario for quantile p_i

8. Multiply each timestep in the event hyetograph by the scaling ratio in Step 7 corresponding to the daily exceedance probability for each day of the event (in Step 6.)

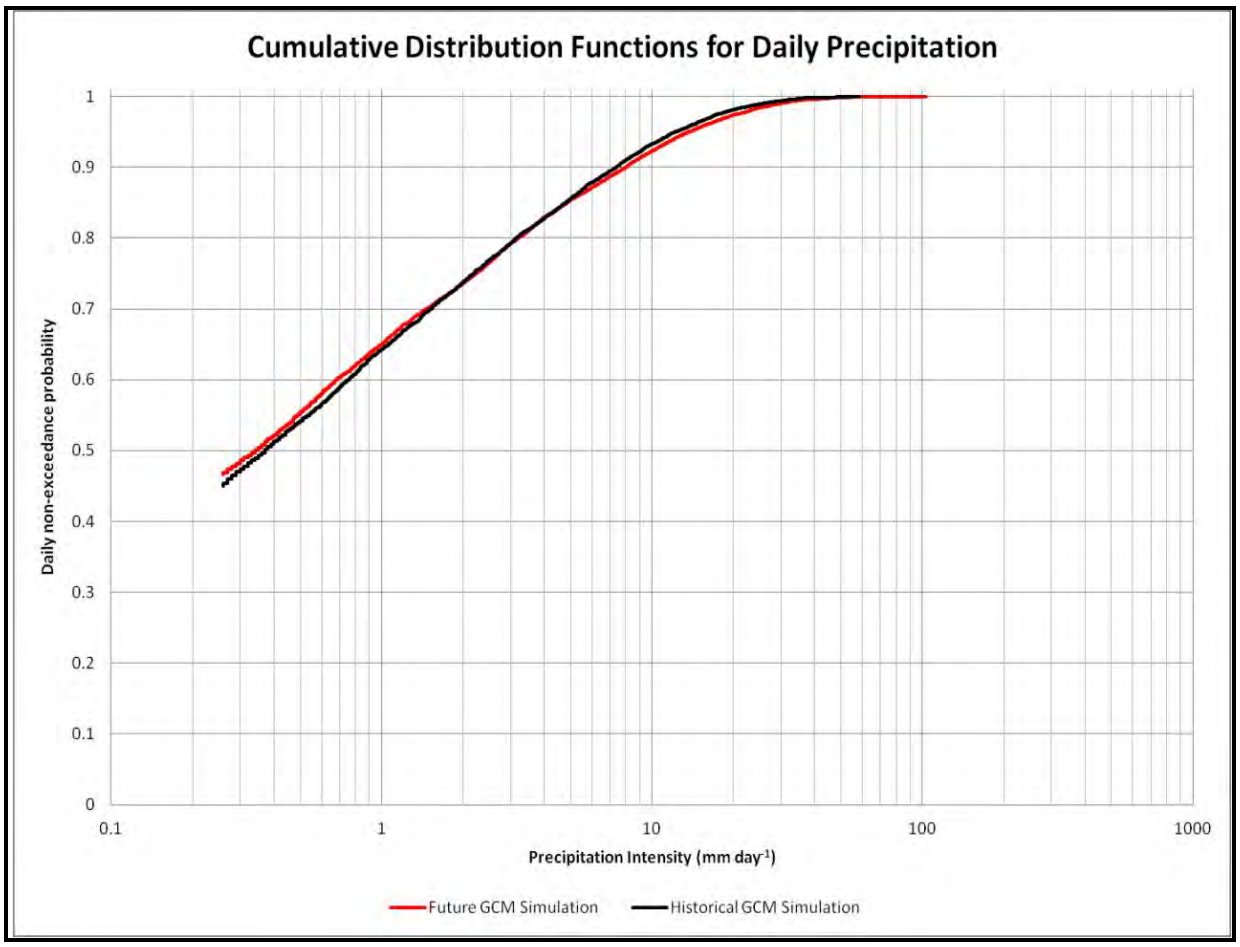


Figure F-1: Daily Precipitation Cumulative Distribution Functions for Historical and Future GCM Simulations The ratio of the precipitation intensity for the two simulations for each probability yields the scale factor.

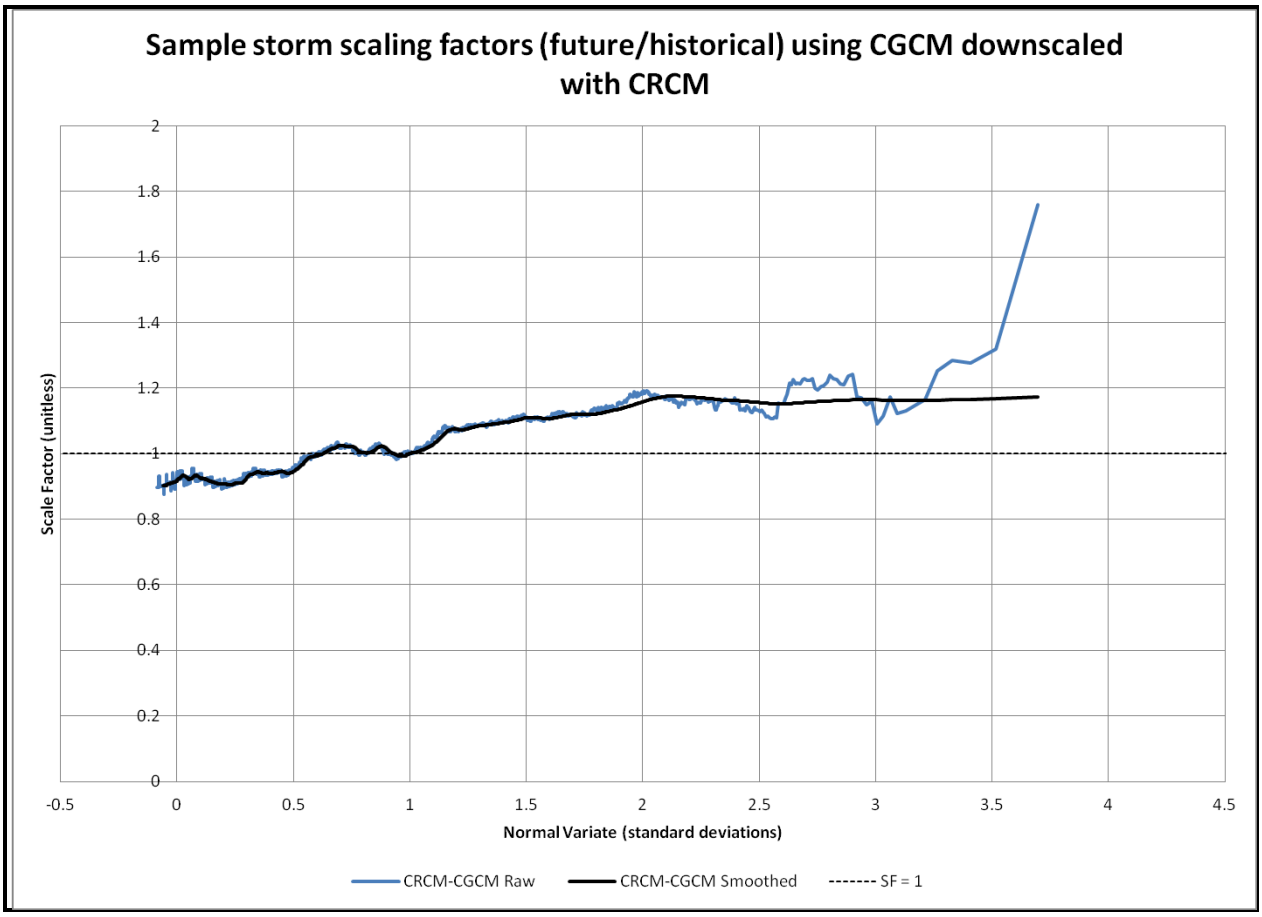


Figure F-2: Daily Precipitation Scaling Factors for a Sample Grid Cell Using {GCM=CGCM3 RCM=CRCM}. The x-axis has been converted from exceedance probabilities to a normal variate. The non-exceedance probability can be found in ms excel using NORMSDIST(Z) where 'Z' is the normal variate.

Table F-1: Sample Segment of Table Produced in Step 5

Daily Non-exceedance P	Scale Factor
0.532435	0.932362
0.532544	0.932209
0.532654	0.932268
0.532764	0.932327
0.532873	0.932387
0.532983	0.932446
0.533092	0.932506
0.533202	0.932776
0.533311	0.93282
0.533421	0.932863
0.533531	0.932907
0.53364	0.93295