Informing the Vermilion River Watershed Plan through Application of the Cold Regions Hydrological Model Platform

Centre for Hydrology Report No. 12

John Pomeroy, Xing Fang, Kevin Shook, Cherie Westbrook, and Tom Brown

Centre for Hydrology
University of Saskatchewan
117 Science Place
Saskatoon, SK
S7N 5C8

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and
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Prepared by

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1 Executive Summary

The Vermilion River Basin has been identified as one of most altered basins in the North Saskatchewan River Basin by the North Saskatchewan Watershed Alliance. Of all the basin altering activities, wetland drainage is thought to be the most important one in impacting watershed hydrology. The Cold Regions Hydrological Model (CRHM) has had recent developments that make it particularly appropriate to evaluate the impacts of Canadian Prairie wetlands on hydrology. In light of the importance of wetlands in the Vermilion River Basin and the capability of CRHM, this study had five objectives:

1) Setup CRHM for the Vermilion River Basin and conduct preliminary tests using local meteorological data.
2) Develop an improved wetland module that incorporates the dynamics of drained wetland complexes in the physically based, modular Prairie Hydrological Model of CRHM.
3) Refine CRHM results using advances in the improved wetland module, additional parameter data and other adjustments as necessary.
4) Demonstrate scenarios/sensitivity of landscape components such as wetlands and uplands to support planning decisions and make recommendations for land and watershed management.
5) Apply CRHM results to fortify recommendations and support decision making during initial plan implementation.

The objectives were addressed with the following methodology. Existing data on precipitation, hydrometeorology, wetland characteristics, stage and extent, drainage pattern and land cover in the Vermilion River Basin were compiled. The existing CRHM Prairie Hydrological Model formulation was set up on the basin and test runs conducted and compared to streamflow hydrographs over multiple years. Then, improvements to the Prairie Hydrological Model formulation of CRHM were made so that CRHM could simulate sequences of many wetlands of varying sizes. The improved model was evaluated through hydrological simulation and quantitative analysis of streamflow and then used in sensitivity analysis of the effect of changing wetland drainage/restoration on streamflow for the Vermilion River. The model was then used to evaluate wetland manipulation and climate scenarios to fortify recommendations, explore options and support decision making for the implementation of the Vermilion watershed plan.

The original CRHM Prairie Hydrological Model with a single wetland simulation predicted soil moisture in the growing season reasonably well and provided a fair prediction of snow accumulation. These simulations showed better predictive capability in the upper part of VRB than the lower part. The middle section of Vermilion River has been channelized and operation of the Morecambe structure further complicates streamflow prediction as water management via the control structure operation has many hydraulic and engineering guidelines. Its simulation is thus better suited to water management models than to hydrological models such as CRHM. The streamflow response of the Vermilion River Basin at its mouth was found to be dominated by channel hydraulics and the control structures in the lower basin and so it is influenced by wetlands only to the extent that the management regime of these control structures is affected by upstream hydrological behaviour of the tributaries with respect to volume and timing of streamflow inputs to the structures. It is expected that streamflow along the main channel of the

Vermilion River in the lower part of the basin will be little impacted by changes to the hydrology of wetlands in the upper basin. Changes in the upper basin streamflows are more likely to be controlled by changes in the basin hydrological processes rather than in-stream water management and/or channel modifications and therefore the upper basin streamflows are more likely to show the effects of the manipulation of wetland storage.

The upstream tributaries that are likely to be more sensitive to wetland extent and capacity were therefore the subject of further focussed study and model evaluation. Improvement to the initial CRHM prairie hydrological model setup for Vermilion River Basin was made by including a dynamical wetland network in each sub-basin, improving maximum depressional storage parameterisation, estimating annual initial conditions for depressional storage, interpolating precipitation amounts and updating forest canopy and soil infiltration modules in the model. The dynamical depressional storage network is an improved parameterisation of the dynamics of wetland storage and fill-and-spill drainage interaction between wetlands in the prairie pothole region compared to the previous single wetland HRU approach as it provided better predictions of seasonal and peak discharges. These are the primary concerns of watershed managers and land owners.

Various types of sensitivity simulations were conducted for the upstream VRB sub-basins using the improved CHRM model setup. Hydrological processes were examined in detail for sub-basin 6. The results indicate that draining wetlands leads to decreases in cumulative snowmelt, actual evaporation, and seasonal depressional storage fluctuations and causes increases in blowing snow sublimation, infiltration, and seasonal soil moisture fluctuations. The opposite occurs when wetlands are restored. Streamflow was examined for all upstream VRB sub-basins and the results suggest that wetland drainage leads to increases in annual discharge and flow duration. Conversely, wetland restoration results in decreases in annual discharge and flow duration. The large impact of drainage on reducing the seasonal filling of depressional storage and reducing evapotranspiration means that more water is available for streamflow generation despite reduced snowmelt, increased sublimation, infiltration and soil moisture storage change. Mixed results were found for the impact of wetland manipulation on peak discharge, but, in general, drainage increased it and restoration decreased it at the sub-basin level. As spatial scale increased from small first order (headwater) upstream sub-basins to larger sub-basins, the increases in annual discharge, peak discharge and flow duration with wetland drainage declined (or reversed for peak flow), indicating non-emergent wetland drainage impacts on streamflow with increasing basin size. These non-emergent drainage impacts are anticipated to be even smaller at the scale of the whole VRB due to management of streamflow through large control structures. The impacts of wetland restoration on decreasing annual flow and flow duration were retained or even slightly increased at larger scales suggesting spatially consistent streamflow impacts from wetland restoration at larger spatial scales. It is not yet known if these emergent restoration impacts are important for the whole VRB, as downstream water management may overwhelm the wetland restoration effects on streamflow. As basin scale increases, the retention of streamflow impacts from wetland restoration contrasts with the decrease in impacts from wetland drainage and the causes of this are not fully understood and require further study.

The selective drainage and restoration with respect to wetland size and location was very instructive. Manipulation of larger wetlands in the lower section of each sub-basin was found to cause greater changes (e.g. increases or decreases) in annual and peak streamflow and streamflow duration compared to manipulation of smaller wetlands in the upper section of sub-basin. This is partly due to larger wetlands occupying a greater area than smaller wetlands, but also due to an apparent gatekeeper function for large wetlands in the lower part of the basin – if they are not filled then they will not pass on inflows received from upstream wetlands. The hydrological function of smaller and upper wetlands was small, but the impact of manipulating the larger, lower wetlands did not equal the impact of manipulating all wetlands in a sub-basin. Clearly manipulating the gatekeeper wetland function alone is less effective than whole basin wetland manipulation. If upstream streamflows have not changed, then there is no multiplier effect from manipulating the storage capacity of the gatekeeper wetlands.

Scenario simulations focussed on manipulating the gatekeeper wetland under recent climate and a flood scenario using the same improved model setup of CRHM as the sensitivity simulations. Specific scenarios examined included i) an enlarged gatekeeper wetland in each sub-basin, ii) extremely wet conditions, iii) extremely wet conditions with an enlarged gatekeeper wetland and iv) draining the gatekeeper wetland. The results suggest that the decreases in streamflow, peak and duration with gatekeeper enlargement that are sometimes found in small headwater basins are not evident downstream at larger basin scales and therefore are non-emergent with increasing scale. Draining the gatekeeper wetland led to inconsistent responses in various sub-basins that accumulated to an insignificant impact on downstream streamflow at larger spatial scales. Tripling precipitation inputs to the model created a scenario that simulated extremely wet conditions, which caused drastic increases in streamflow. Enlarging the depressional storage capacity of gatekeeper wetland under the tripled precipitation scenario had no impact on annual discharge, peak discharge and flow duration compared to that with the original wetland extent. This suggests that extra storage offered by enlarging a single gatekeeper wetland is insufficient to influence the hydrology of extremely wet conditions and hence prevent flooding. The enlarged gatekeeper is only effective in reducing flows at small scales under moderate to dry conditions.

2 Introduction

The Vermilion River Basin (VRB) is located in the Parkland Natural Region of Alberta and drains 7,860 km^2, approximately 14% of the North Saskatchewan River Basin. The hydrology of this region is typical of the central Canadian Prairies with:

- long periods of winter (usually 4-5 months) with occasional mid-winter melts with the snowcover modified by wind redistribution and sublimation of blowing snow (Pomeroy *et al*., 1993),
- high surface runoff from the major spring snowmelt event as a result of frozen state mineral soils at the time and the relatively rapid release of water from snowpacks (Gray *et al*., 1985),
- deep soils characterized by good water-holding capacity and high unfrozen infiltration rates (Elliott and Efetha, 1999),
- most rainfall occurring in spring and early summer from large frontal systems and the most intense rainfall in summer from convective storms over small areas (Gray, 1970),
- numerous small post-glacial depressions known locally as "sloughs" or formally as wetlands; the majority of which do not drain to any major drainage systems (LaBaugh *et al*., 1998) and are internally drained forming closed basins (Hayashi *et al*., 2003) and non-contributing areas in normal conditions (Godwin and Martin, 1975); occasional connection among these depressions during wet conditions through the "fill and spill" mechanism (van der Kamp and Hayashi, 2009),
- groundwater is water supply source for many municipal and industrial use and is recharged via a depression-focused mechanism beneath wetlands (van der Kamp and Hayashi, 1998, 2009; Hayashi *et al*., 2003).

The dominant land cover, covering 80% of the basin area, is annual or perennial cropland; while native grassland, wetland, and deciduous or coniferous forest occupy the rest of basin. The VRB has been identified as one of most altered basins in the North Saskatchewan River Basin by the North Saskatchewan Watershed Alliance (NSWA, 2005). Of all the basin altering activities, wetland drainage is thought to be the most important one in impacting watershed hydrology. The earliest drainage in the VRB was carried out in the Holden Drainage District in the upper basin starting in 1918. Subsequent drainage has occurred throughout the basin. Concerns relating to wetland drainage include enhanced flooding, deterioration in water quality, and impacts on the aquatic ecosystem. These concerns are of great interest to the NSWA that is responsible for completing 'a locally-developed and supported watershed plan that balances social, economic, and environmental needs of the watershed community'. Of interest to the NSWA is whether the application of the Cold Regions Hydrological Model Platform (CRHM) in the VRB can contribute to the development of this watershed plan by quantifying the effects of changes in wetland storage on streamflow.

CRHM is a physically based, distributed, modular, object-oriented model development platform (Pomeroy et al., 2007). The component modules have been developed based on the results of 50 years of research by the University of Saskatchewan and Environment Canada in prairie, boreal, mountain and arctic environments. The system is very flexible and creates 'purpose-built' models for particular basins, environments and predictive needs. Parameters are selected from

soil/land cover characteristics and other basin knowledge. Current modules that are suitable for the prairie environment include: blowing snow sublimation and redistribution, energy balance snowmelt, infiltration to frozen soils, snowmelt runoff, evaporation from unsaturated surfaces, soil column drainage and mass balance, wetlands, Muskingum routing. Module improvements have focused on the wetland module and the incorporation of a dynamic multiple wetland structure into the model in order to more accurately simulate interconnected complexes of wetlands as often found in prairie river basins. The model runs on sub-basins which are broken down into Hydrological Response Units (HRUs). HRUs are the smallest land units having definable hydrological characteristics. It is assumed that variability within a HRU is smaller than variability between HRU. They need not directly drain to any stream or wetland – hence they can be used to determine the contributing area draining to a basin stream. Their relative physical location in the downstream sequence of flow within a sub-basin is important to simulations but the precise geographical location of an HRU need not be exactly known. CRHM requires information of basin parameters such as soil type, vegetation, wetland extent, flow direction and substantial information on wetland extent and land cover in the Vermilion River Basin has been made available via NSWA and its cooperating agencies. As the model is driven by surface meteorological observations, weather data collected from Environment Canada and Alberta Government stations in and near the basin has been collated and compared so that a hydrometeorological dataset could be synthesized for the Vermilion River Basin.

In light of the importance of wetlands in the Vermilion River Basin and the capabilities of CRHM, this study had five objectives which were completed in two phases:

Phase 1:

1) Setup CRHM for the Vermilion River Basin and conduct preliminary tests using local meteorological data.

2) Develop an improved wetland module that incorporates the dynamics of drained wetland complexes in the physically based, modular Prairie Hydrological Model of CRHM.

3) Refine CRHM results using advances in the improved wetland module, additional parameter data and other adjustments as necessary.

4) Demonstrate scenarios/sensitivity of landscape components such as wetlands and uplands to support planning decisions and make recommendations for land and watershed management.

Phase 2:

5) Apply CRHM results to fortify recommendations and support decision-making during initial plan implementation.

Accordingly, the methodology to address these objectives is to:

Phase 1:

a) Compile existing data on precipitation, hydrometeorology, wetland characteristics, stage and extent, drainage pattern and land cover in the Vermilion River Basin. Examine Environment Canada and Alberta Environment weather station data and convert to CRHM observation files. Review existing data sources of wetland characteristics and extent, drainage pattern and land cover and compile using GIS and other methods. Set up

the existing CRHM Prairie Hydrological Model formulation for the basin, conduct test runs and compare to streamflow hydrographs over multiple years.

b) Improve the CRHM Prairie Hydrological Model. Specifically, change the wetland module so that it simulates sequences of many wetlands of varying sizes, which interact with each other to generate streamflow via the spill and fill runoff mechanism.

c) Evaluate the improved CRHM Prairie Hydrological Model in the Vermilion River Basin through hydrological simulation and quantitative analysis of streamflow. For streamflow, both annual and peak flows are the parameters of interest.

d) Use the improved CRHM Prairie Hydrological Model in sensitivity analyses of the effect of changing land cover and wetland drainage/restoration on streamflow for the Vermilion River. Assess the hydrological impacts of drainage at downstream locations as well as the drainage effects on wetland states using model simulations of the hydrological processes and functions of prairie wetlands. Assess the hydrological sensitivity of wetland drainage/restoration and land cover change progressively from the current state to a 'highly altered state' or from the current state to a historical state.

Phase 2:

e) Generate results on requested scenarios using the improved CRHM Prairie Hydrological Model to fortify recommendations, explore options and support decision making for the implementation of the Vermilion watershed plan.

3 Study Site and Datasets

3.1 Site Description

The VRB is located in the east central part of Alberta, with its western basin border approximately 80 km southeast of the City of Edmonton. It is situated in the Parkland Natural Region of Alberta with a gross drainage area of approximately 7,860 km^2 (Figure 1); the basin includes eighteen towns, with Vegreville, Vermilion, and Two Hills being the most populated centres. There are 23 sub-basins in the VRB (Table 1), and its main channel drains easterly from the headwater area (i.e. sub-basin 15) to the outlet area (i.e. sub-basin 9). The basin is generally characterized by low relief with elevation ranging from 561 m above sea level (m.a.s.l.) at the outlet to 733 m.a.s.l. in the headwater area; slopes are gentle and range from 0.6% to 3.3%. The dominant land covers in the VRB are for agricultural land use (e.g. annual/perennial croplands, pasture), with smaller amounts of native grassland, wetland, and deciduous/coniferous forest (Figure 2). The major surficial materials are glacial till which consists of an unsorted mixture of clay, silt, sand and gravel (Currie and Zacharko, 1976), with relative small amount of the local till located near the main stem of Vermilion River (Figure 3). The 30-year (1971-2000) annual mean air temperature at the town of Vegreville is 2.3°C, with monthly means ranging from -13.8°C in January to +16.3°C in July. The 30-year average annual precipitation at Vegreville is 373.6 mm, of which 76.4 mm occurs as snow in the winter (Environment Canada, 2010). The VRB is composed of numerous small post-glacial depressions known as "sloughs" or wetlands; the majority of its wetlands are internally drained and do not drain to any major drainage systems (LaBaugh *et al*., 1998). These closed sub-basins are non-contributing areas for streamflow in normal conditions (one-in-two-year flood) (Figure 4). Many wetlands have been drained or modified for many decades; these activities can be traced back as early as 1918 in the Holden Drainage District (sub-basins 15 and 16).

3.2 Data Organization

Various data were acquired through the North Saskatchewan Watershed Alliance (NSWA), Environment Canada, and Alberta Environment as well as Alberta Agriculture and Rural Development. The datasets include GIS, meteorology data, hydrometric data, soil moisture observation, and field observations of snow survey. These datasets are used either to set up the CRHM's parameters and observation files or evaluate the model's performance.

3.2.1 GIS Dataset

The GIS dataset acquired from the NSWA consists of 25-m ASTER DEM, wetland inventory, land cover, and surficial geology for the basin. The wetland inventory includes both historical (1949) and current (2004) wetland drainage conditions and hydrography. The land cover is 30-m classification which was derived from Landsat in 2000. In addition, other GIS data such as stream order, hydrology, and water bodies used in the HSPF model by Golder Associates, Ltd. (Golder Associates, 2009) were also obtained but are not used in the CRHM setup.

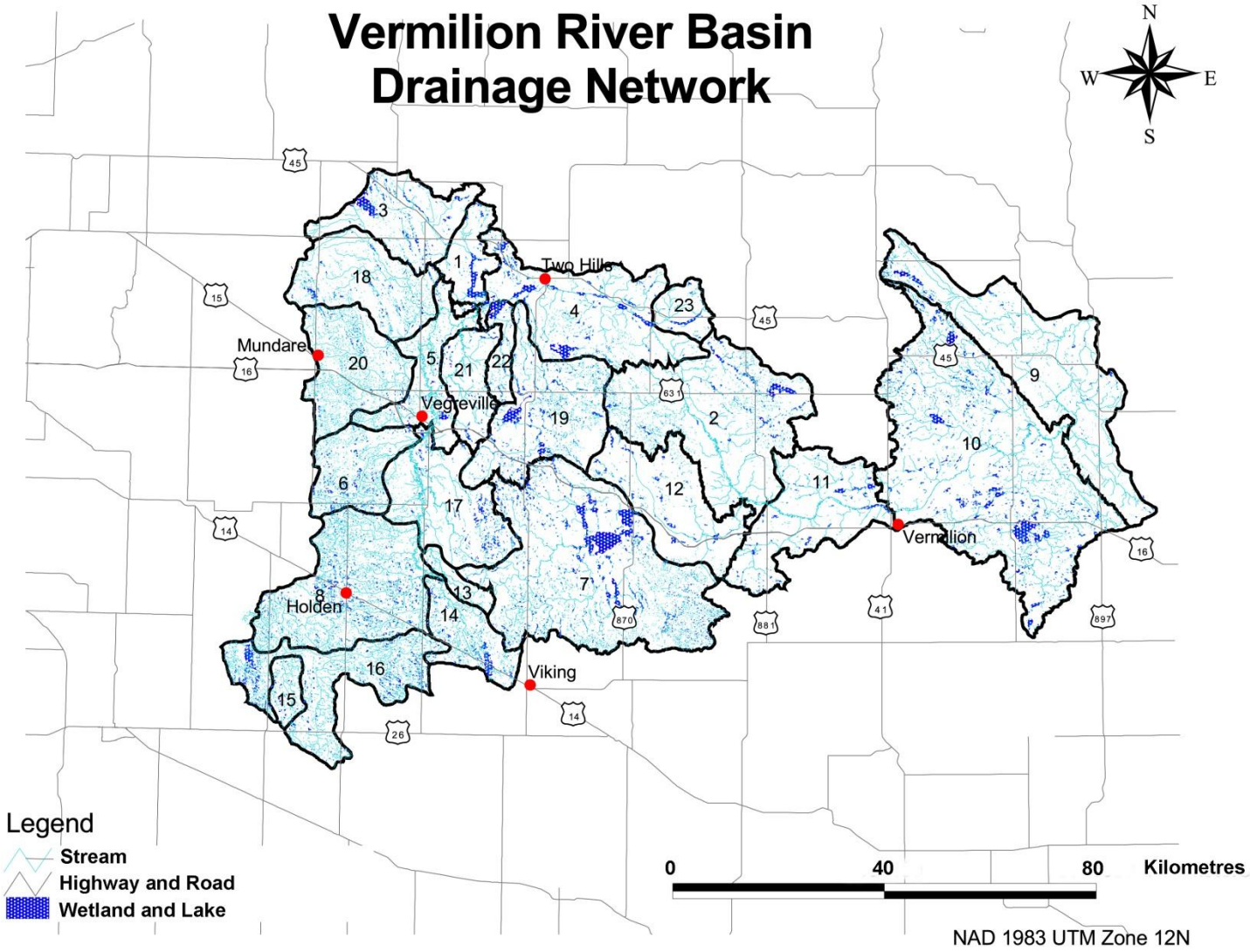

Figure 1. Vermilion River Basin drainage network.

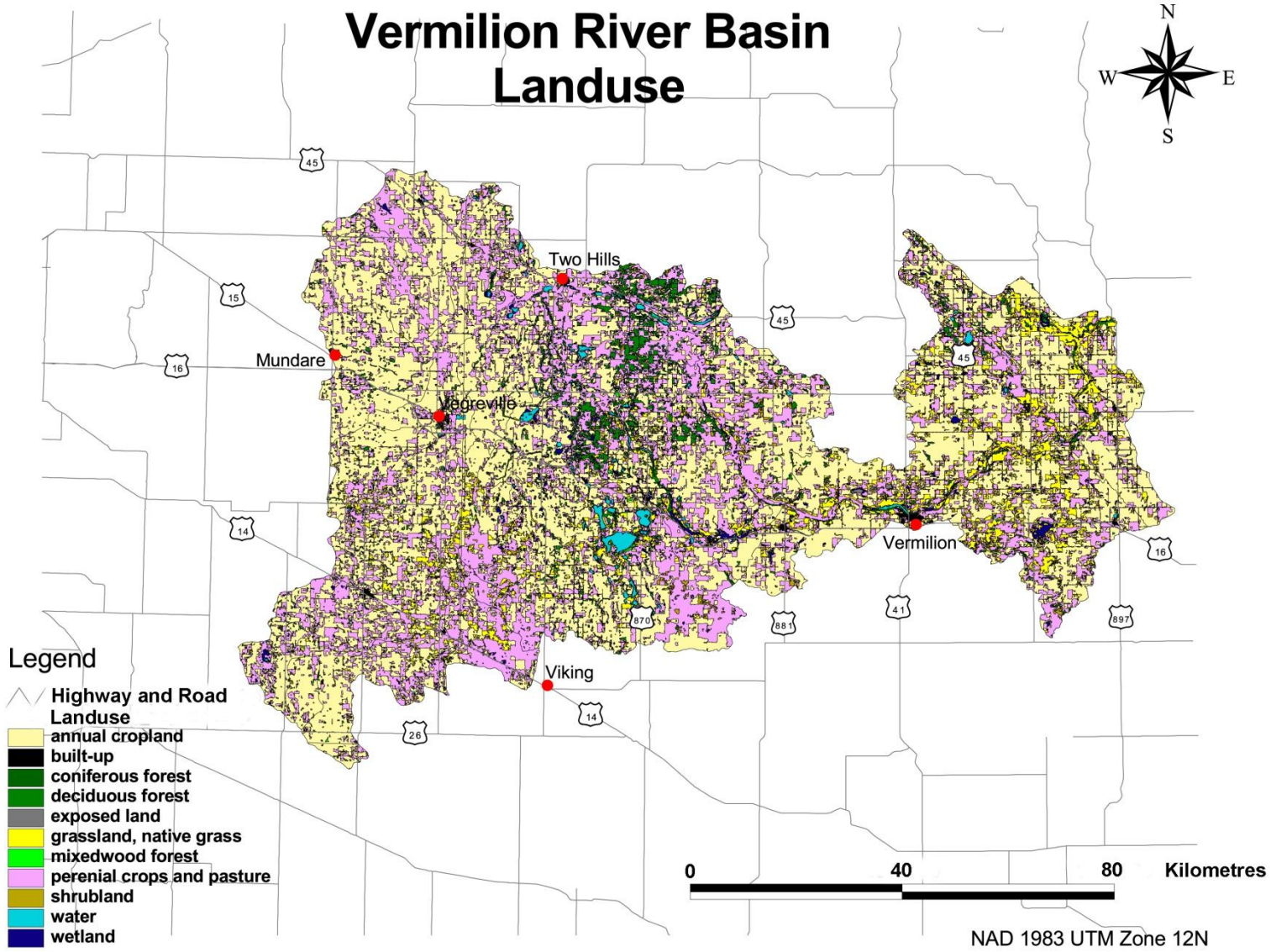

Figure 2. Vermilion River Basin land cover.

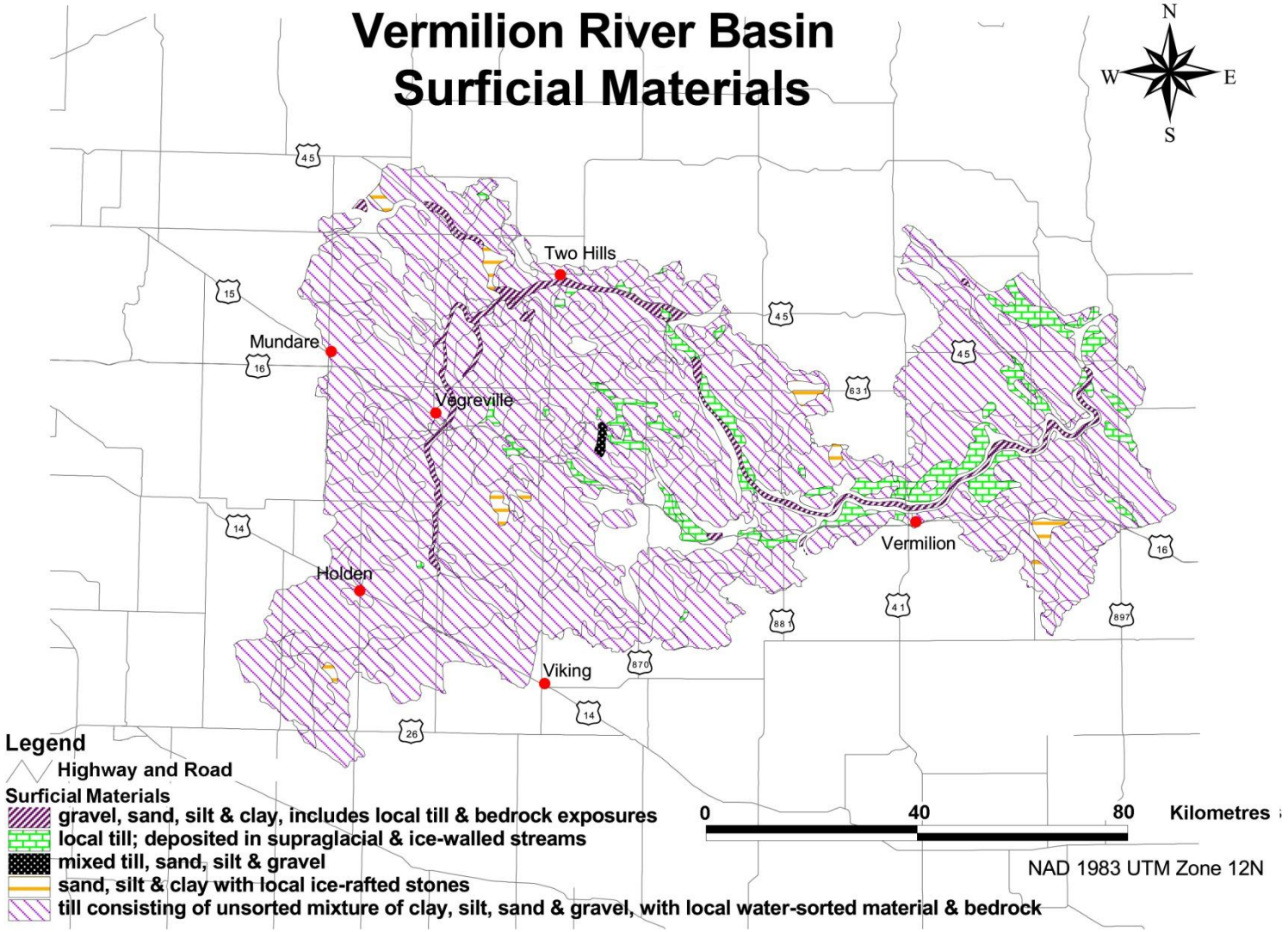

Figure 3. Vermilion River Basin surficial materials.

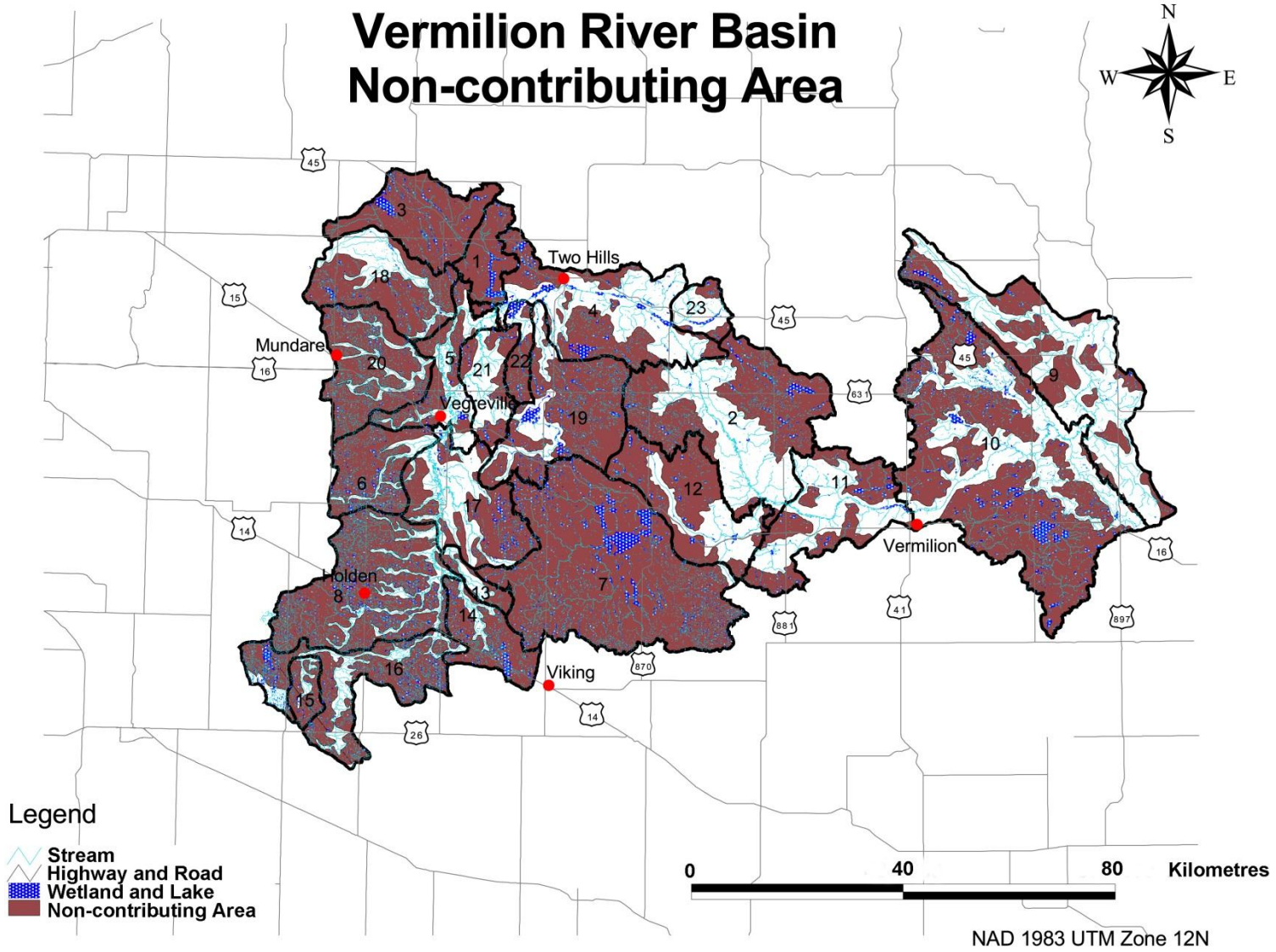

Figure 4. Vermilion River Basin non-contributing area.

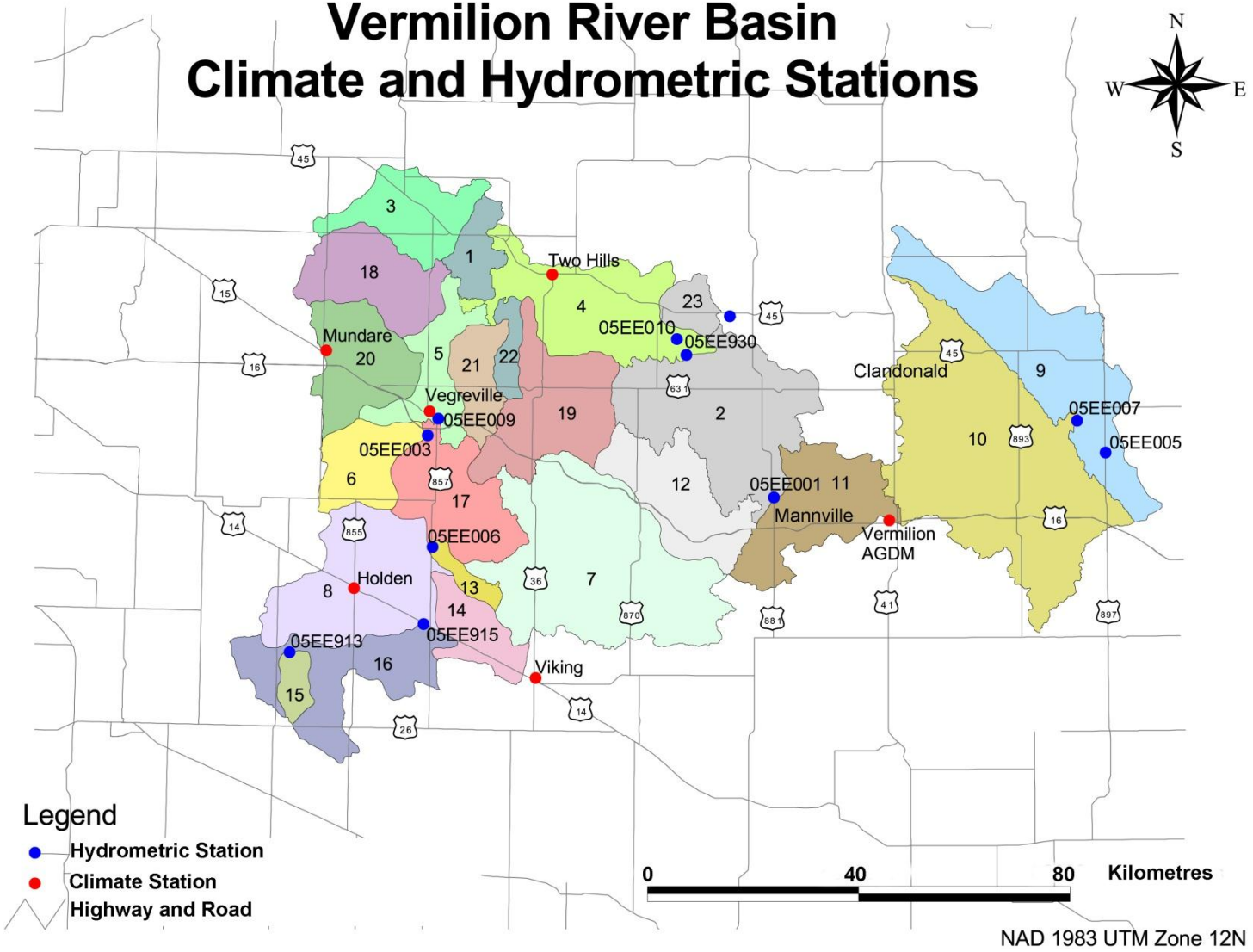

Figure 5. Vermilion River Basin climate and hydrometric stations.

Table 1. Sub-basins at the Vermilion River Basin.

Sub-basin	Area (km^2)	Mean Slope (%)	Mean Elevation (m)
1	108.86	2.317	630
2	631.73	2.780	663
3	249.23	1.395	632
4	457.90	2.630	642
5	197.96	1.041	637
6	194.26	1.044	675
7	900.20	2.045	679
8	505.19	0.986	688
9	602.86	2.189	618
10	1164.49	3.263	632
11	355.50	2.780	638
12	328.04	2.670	673
13	46.40	0.670	679
14	156.91	0.658	685
15	56.40	0.889	720
16	344.50	0.916	701
17	316.10	0.859	665
18	294.04	0.860	648
19	388.70	2.441	671
20	284.70	0.889	668
21	141.04	1.819	648
22	62.22	2.691	641
23	75.60	3.184	646

3.2.2 Meteorology Dataset

The dataset used in the HSPF model by Golder Associates, Ltd. (Golder Associates, 2009) consists of daily observed wind speed, dew point temperature, precipitation, and streamflow discharge for several towns including Vegreville, Holden, and Lloydminster during 1961-2008. Daily simulated evaporation and streamflow discharge during are also included in the dataset. For CRHM modeling, the meteorological forcing data requires hourly air temperature, relative humidity, wind speed, incoming solar radiation, and daily precipitation, thus the dataset developed for HSPF was not used. Archived hourly air temperature, relative humidity, and wind speed and daily precipitation during 2003-2009 were obtained through Environment Canada's National Climate Data and Information Archive website (http://climate.weatheroffice.gc.ca/climateData/canada_e.html) and used to force CRHM on an hourly time-step. The archived data were acquired for climate stations located in or adjacent to the Vermilion River Basin, including Holden, Viking, Vegreville, Mundare, Two Hills, and Vermilion from stations operated by Alberta Agriculture and Rural Development and Environment Canada (Figure 5). Table 2 describes the location of these climate stations. Missing data gaps during 2003-2009 were filled using a spatial interpolation technique based on the correlations between stations. The Environment Canada observed hourly incoming solar radiation at Stony Plain nearby Edmonton was not considered due to its distance from the basin; instead hourly incoming solar radiation was estimated using a simple temperature method based on Annandale *et al*. (2002) as implemented by Shook and Pomeroy (2011a).

Table 2. Meteorological data stations for CRHM modelling in the Vermilion River Basin

Station Name	Latitude	Longitude	Elevation	Station Identifier
Holden AGDM	53.19	-112.25	688	3013340
Viking NORTH 3	53.28	-111.77	675.8	3016845
Vegreville	53.51	-112.1	639.3	3016GF0
Mundare AGDM	53.57	-112.3	683	3014665
Two Hills AGDM	53.63	-111.68	678	3016655
Vermilion AGDM	53.34	-110.88	623	3016802

3.2.3 Hydrometric Dataset

In addition to the meteorological forcing data, archived hydrometric data were obtained from Environment Canada's Water Survey of Canada website:
http://www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm?cname=main_e.cfm
for the stations shown in Figure 5. Table 3 lists the details for these stations. The hydrometric data are used to evaluate model performance on simulating streamflow in the corresponding gauging sub-basins.

Table 3. Water Survey of Canada Hydrometric stations in the Vermilion River Basin.

Station Name	Station Number	Available Period
Vermilion River near Mannville	05EE001	1958-1983
Vermilion River near Vegreville	05EE003	1967-1986
Stretton Creek near Marwayne	05EE005	1978-2009
Vermilion River Tributary near Bruce	05EE006	1978-2009
Vermilion River near Marwayne	05EE007	1979-2009
Vermilion River at Vegreville	05EE009	1987-2009
Vermilion River at Range Road 105	05EE010	2006-2009
Vermilion River Drainage near Holden	05EE913	1981-1993
Vermilion River Drainage near Bruce	05EE915	1981-1983
Vermilion River near Beauvallon	05EE930	1997-2006

3.2.4 Soil Moisture Dataset

Daily soil moisture data at various depths (i.e. 5-cm, 20-cm, 50-cm, and 100-cm) were obtained from Alberta Agriculture and Rural Development website:
http://www.agric.gov.ab.ca/app116/stationview.jsp for Mundare, Two Hills, and Vermilion. The soil moisture data, which are only available for the period after May 2005, are used to set the fall soil moisture status in the model, as well as to evaluate the model's simulation of soil moisture.

3.2.5 Snow Survey Dataset

Snow survey data from the snow courses located at Mannville, Bruce, Two Hills, and Clandonald were acquired from Alberta Environment. The snow surveys were conducted twice a year (approximately March 1st and April 1st) by Alberta Environment by taking samples of depth and density of snow over the snow course to calculate the mean snow accumulation as snow water equivalent (SWE). The snow survey data were used for evaluating the model's predicted SWE, which is a state variable that is updated daily. Alberta Environment snow surveys do not describe the state of cropland, i.e. whether the underlying field was fallow or stubble. As fallow fields retain much less of their snowcover than stubble fields, and crop rotation was widely practiced, year-to-year comparison of these snow surveys on cropland is difficult, as is comparing the surveyed values to model simulations. Uncertainty in the exact date of the snow surveys, which can vary by one week before or after the first of the month, also created uncertainty in choosing the correct day of simulated SWE to compare to the snow survey observations. The brief description for these snow courses is as follows:

Mannville

The snow course is on open farmland between two rows of trees approx. 500 m apart running north-south.

Bruce

The snow course is located in a small aspen bluff, completely enclosed by trees, amid open farmland.

Two Hills

The snow course is on slightly rolling, open pasture land.

Clandonald

The snow course is also on pasture land, with about half the ten points in the open, and the other half protected by small aspen trees to the east and north.

4 Initial Model Setup and Tests

4.1 Initial Model Setup

4.1.1 Model Description

For the initial model setup in the Vermilion River Basin (VRB), the existing CRHM Prairie Hydrological Model (CRHM-PHM) formulation was adopted. The CRHM-PHM was developed from a modelling study conducted in the Smith Creek Research Basin (SCRB), located in east-central Saskatchewan (Fang *et al*., 2010; Pomeroy *et al*., 2010). Many similarities exist between two basins: dominant agricultural land use, many small depressional wetlands, wetland drainage and alteration, and large non-contributing areas. Thus, the modelling setup gained in the SCRB is thought to be appropriate for initial application in the VRB. The only difference between the initial model setup and existing CRHM-PHM is the replacing of the module representing Gray's snowmelt infiltration equation (Gray *et al*., 1985) and the Green-Ampt infiltration method (Ogden and Saghafian, 1997) with the module representing Gray's parametric snowmelt infiltration (Gray *et al*., 2001) and Ayers' unfrozen infiltration procedures (Ayers, 1959). This replacement was necessary as the Gray *et al*. (1985) infiltration module was found to estimate frozen soil infiltration poorly during early spring rainfall (Fang *et al*., 2010) and the Green-Ampt infiltration calculation underestimated infiltration at the field scale.

In summary, a set of physically based modules was linked in a sequential fashion to simulate the dominant hydrological processes for the VRB. Figure 6 shows the schematic of these modules, and these modules include:

1. Observation module: reads the meteorological data (temperature, wind speed, relative humidity, vapour pressure, precipitation, and radiation), calculates snowfall, rainfall, elevation-adjusted temperature and humidity and provides these variables to other modules.
2. Garnier and Ohmura's radiation module (Garnier and Ohmura, 1970): calculates the theoretical global radiation, direct and diffuse solar radiation, as well as maximum sunshine hours based on latitude, elevation, ground slope, and azimuth, providing radiation inputs to sunshine hour module, energy-budget snowmelt module, net all-wave radiation module.
3. Sunshine hour module: estimates sunshine hours from incoming short-wave radiation and maximum sunshine hours, generating inputs to energy-budget snowmelt module, net all-wave radiation module.
4. Interception module: this is a simple routine to read output of snowfall and rainfall from the Observation module to generate sub-canopy snowfall and rainfall.
5. Gray and Landine's albedo module (Gray and Landine, 1987): estimates snow albedo throughout the winter and into the melt period and also indicates the beginning of melt for the energy-budget snowmelt module.
6. PBSM module or Prairie Blowing Snow Model (Pomeroy and Li, 2000): simulates the wind redistribution of snow and estimates snow accumulation throughout the winter period.
7. Walmsley's windflow module (Walmsley *et al*., 1989): adjusts the wind speed change due to local topographic features and provides the feedback of adjusted wind speed to the PBSM module.

8. EBSM module or Energy-Budget Snowmelt Model (Gray and Landine, 1988): estimates snowmelt by calculating the energy balance of radiation, sensible heat, latent heat, ground heat, advection from rainfall, and change in internal energy.

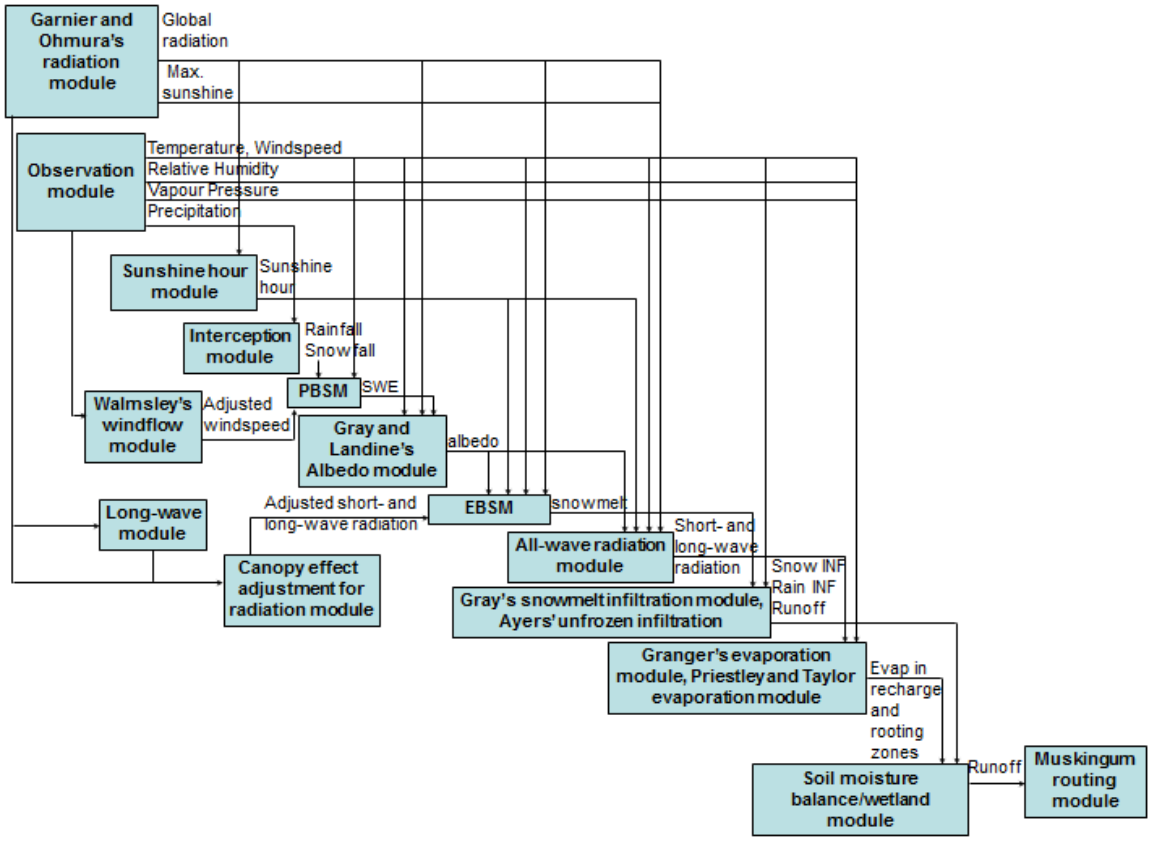

Figure 6. Flowchart of physically based hydrological modules for the initial model setup.

9. Canopy adjustment for radiation module (Sicart *et al*., 2004): adjusts the net all-wave radiation energy where woodland imposes effects of tree canopy on amount of radiation energy for melting snowpack underneath.

10. All-wave radiation module: calculates net all-wave radiation from the short-wave radiation and provides inputs to the evaporation module.

11. Infiltration module (two types): Gray's parametric snowmelt infiltration (Gray *et al*., 2001) estimates snowmelt infiltration into frozen soils and Ayers' unfrozen infiltration (Ayers, 1959) estimates rainfall infiltration into unfrozen soils. Both infiltration algorithms update moisture content in the soil column from soil moisture balance with wetland/depression component module.

12. Evaporation module (two types): Granger's evaporation expression (Granger and Gray, 1989) estimates actual evaporation from unsaturated surfaces, Priestley and Taylor evaporation expression (Priestley and Taylor, 1972) estimates evaporation from saturated

surfaces or water bodies, both update moisture content in the soil column, and Priestley and Taylor evaporation also updates moisture content in the wetland or depression from soil moisture balance with wetland or depression component module;

13. Soil moisture balance/wetland module: this is a newly developed module, specifically for prairie basins with prominent wetland storage and drainage attributes. This new module was modified (Dornes *et al*., 2008) from an original soil moisture balance routine developed by Leavesley *et al*. (1983). The soil moisture balance model divides the soil column into two layers; the top layer is called the recharge zone. Inputs to the soil column layers are derived from infiltration from both snowmelt and rainfall. Evapotranspiration withdraws moisture from both soil column layers. Evaporation only occurs from the recharge zone, and water for transpiration is taken out of the entire soil column. Excess water from both soil column layers satisfies groundwater flow requirements before being discharged to subsurface flow (representing flow in macropores that occurs in cracking clay, very coarse soils and in organic soils). The movement of runoff, subsurface discharge and groundwater discharge between HRUs is calculated by a routing module. This module also estimates the surface depression storage and its effect on the surface drainage, which is a specific hydrological character in the prairie pothole region (Fang *et al*., 2010). Detailed description of this new module is given by Pomeroy *et al*. (2010).

14. Muskingum routing module: the Muskingum method is based on a variable discharge-storage relationship (Chow, 1964) and is used to route the runoff between HRUs in the sub-basin. The routing storage constant is estimated from the average length of HRU to main channel and averaged flow velocity; the average flow velocity is calculated by Manning's equation (Chow, 1959) based on averaged HRU length to main channel, average change in HRU elevation, overland flow depth and HRU roughness.

4.1.2 Model Parameter Estimation

Basin physiographic parameters

A CRHM modelling structure termed "representative basin" (RB) was used to simulate the hydrological processes for each modelled sub-basin of the VRB. In a RB, a set of physically-based modules are assembled for a number of HRUs; the RB can be repeated as necessary in a basin, with each sub-basin possessing the same modules but varying their parameter sets and also varying the number of HRUs. The VRB was divided into 23 sub-basins that are represented by 23 RBs. These RBs are connected according to the sequence of flow downstream through the VRB. The streamflows from these 23 RBs are routed along the main channels, lakes, and wetlands using the Muskingum routing method (Figure 7).

Each RB, has up to nine HRUs: "Built-up and Exposed Land", "Fallow Cropland", "Stubble Cropland", "Grassland", "Woodland", "Shrubland", "Open Water", "Wetland", and "Channel". The area of each HRU is different in each RB. Not all HRUs are present in a given RB; the area of unused HRUs in a RB are set to zero.

The 30-m Landsat (data collected in 2000) classified landcovers shown in Figure 2 and the current (2004) detailed hydrography and wetlands shown in Figure 8 were utilized in the land use generalization process to determine the HRU (Figure 9). Fallow and stubble proportions of cropland land uses were differentiated using farm operation data presented in the Census of Agriculture by Statistics Canada (2006) for Beaver County, Minburn County, Two Hills County,

Lamont County, and Vermilion River County. The areas of the nine HRUs in each sub-basin were determined using both landcover and hydrography; the areas of the 23 sub-basins were also estimated using the sub-basin polygon GIS feature, which totals ~7,862.8 km^2 for the Vermilion River Basin. The 25-m ASTER DEM shown in Figure 10 was employed in the terrain preprocessing GIS analysis to determine the slope and elevation; the averaged values of slope and elevation were assigned to for the nine HRUs in each sub-basin. The averaged values of area, elevation and slope for these HRUs in the 23 sub-basins are presented in Appendix 1.

Albedo and canopy parameters

Albedo parameters for bare ground and snow as well as the canopy parameter LAI (leaf area index) was derived for the HRUs. The albedo parameters 0.17 and 0.85 were determined for bare ground and snow respectively, based on recommended values by Male and Gray (1981) for snow and Armstrong et al. (2008) for summer conditions. The canopy parameter, LAI, was used to model canopy effects on radiation for snowmelt. A minimal LAI (0.001) was set for "Builtup and Exposed Land", "Fallow Cropland", "Stubble Cropland", "Grassland", "Shrubland", "Open Water", "Wetland", and "Channel" HRUs, and a LAI of 0.4 was assigned to "Woodland" HRU, representing a typical value for aspen trees during winter (Pomeroy et al. 1999). The values of LAI are presented in Appendix 2.

Blowing snow parameters

Blowing snow fetch distance is the upwind distance without disruption to the flow of snow. 1000 m fetch distance was set for the large exposed sites: "Fallow Cropland", "Stubble Cropland", and "Grassland" HRUs. For other HRUs, a 300 m fetch length was assigned. These values are comparable to the estimated values for the prairie fields by Fang *et al*. (2010) using the computer program "FetchR" (Lapen and Martz, 1993). Values of vegetation height, stalk density and stalk diameter were set for these HRUs to represent them in the prairie environment during fall and winter. The distribution factor parameterizes the allocation of blowing snow transport from aerodynamically smoother (or windier) HRU to aerodynamically rougher (or calmer) ones and was decided according to the prairie landscape aerodynamic sequencing (Fang and Pomeroy, 2009). The values of the fetch distance, vegetation height, stalk density and stalk diameter as well as distribution factor are presented in Appendix 2.

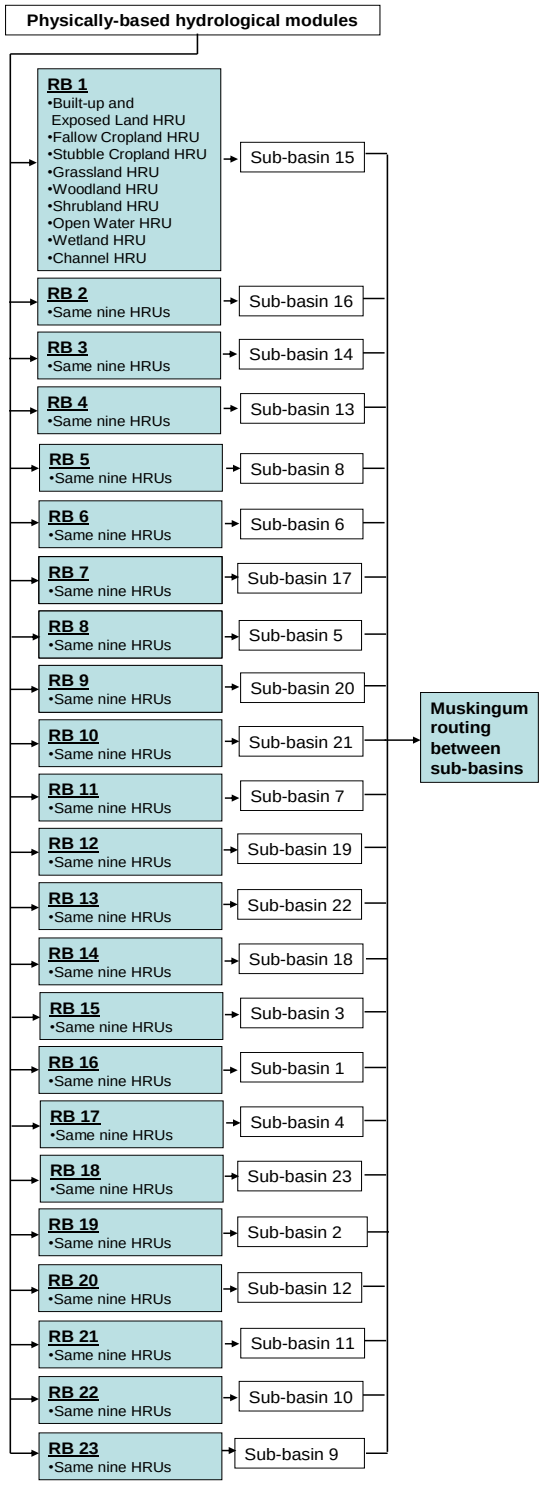

Figure 7. Initial CRHM modelling structure for the Vermilion River Basin.

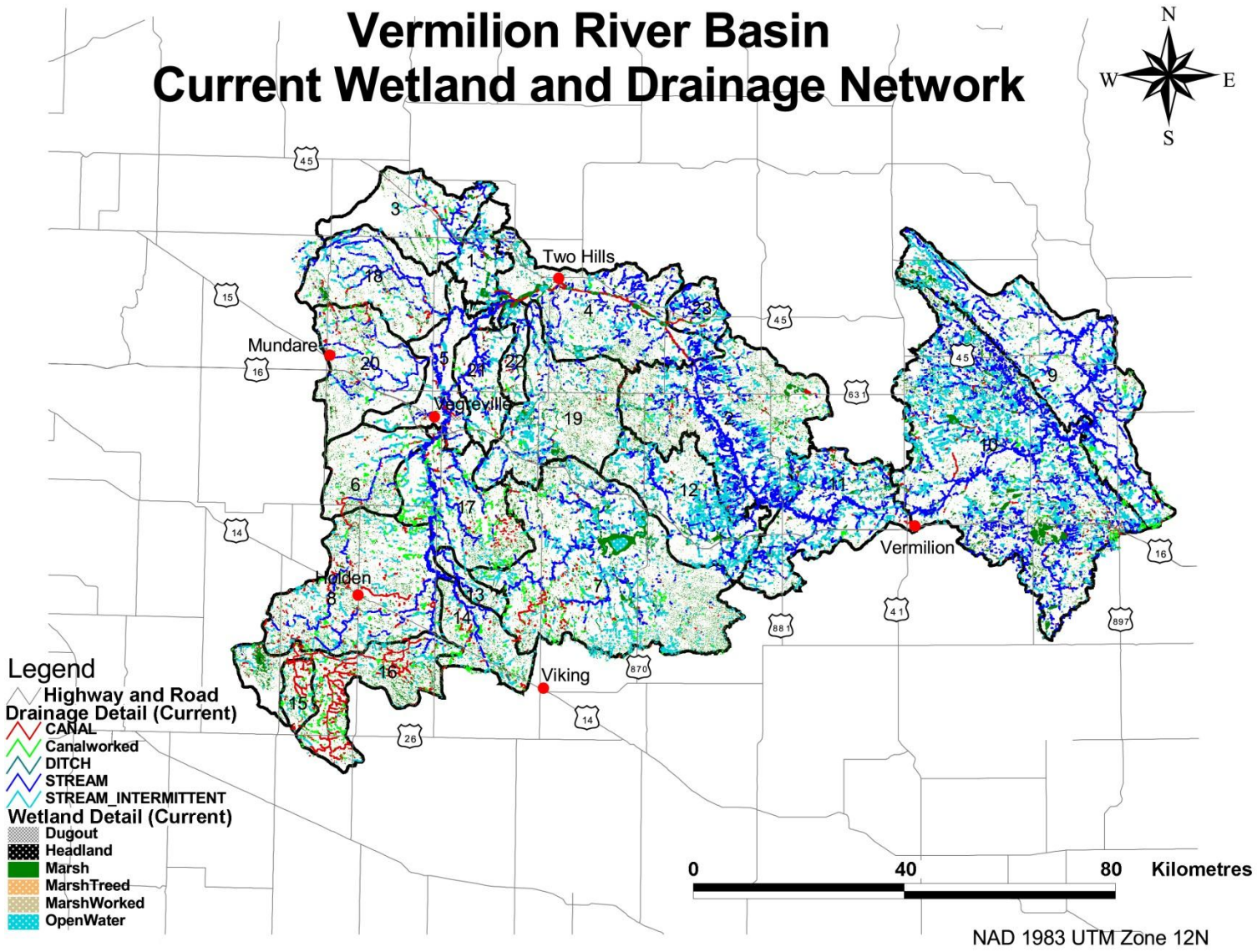

Figure 8. Vermilion River Basin current (as of 2004) wetland and drainage network/hydrography.

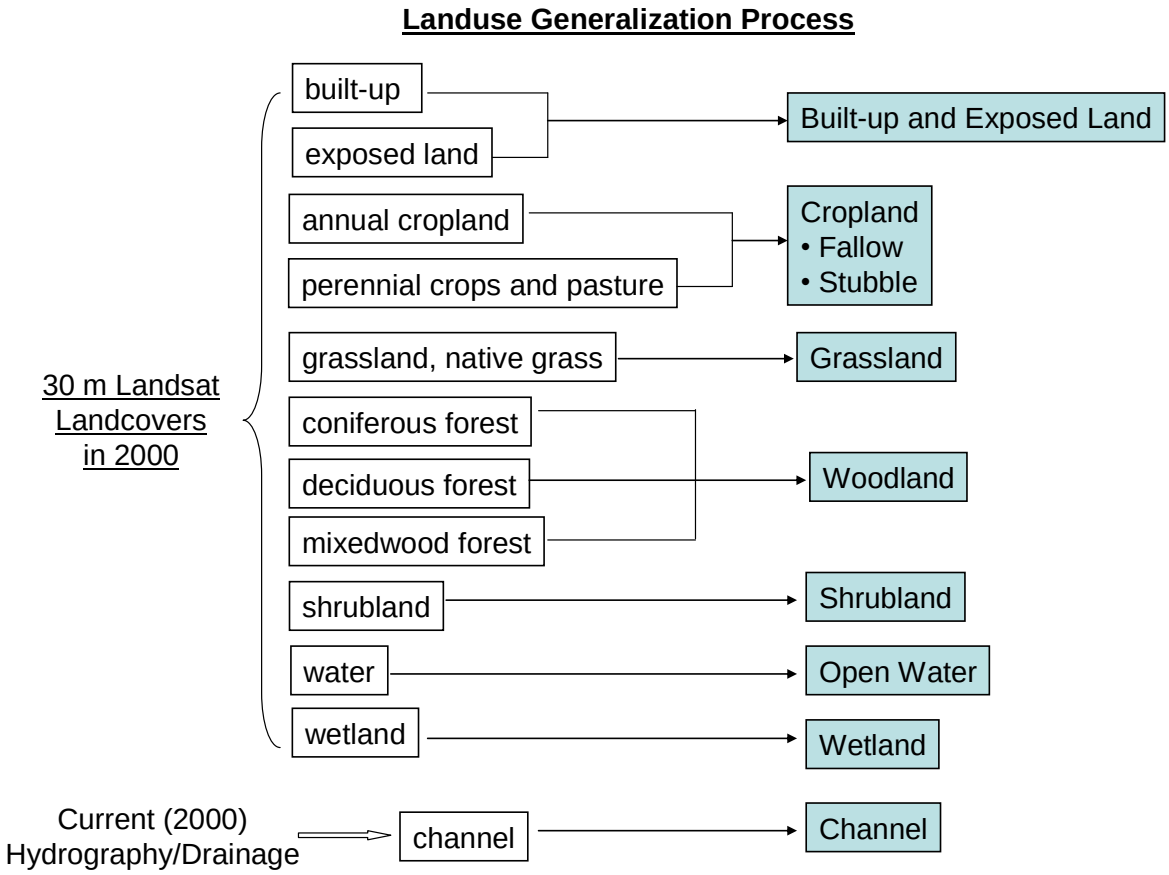

Figure 9. HRU generation from the landuse generalization process. HRUs are highlighted.

Frozen soils and wetland parameters

Because the model is run over the spring-fall period of each simulation year, the pre-melt soil moisture saturation and soil temperature for the "Fallow Cropland", "Stubble Cropland", "Grassland", "Woodland", and "Shrubland" HRUs are state variables (initial conditions) that must be set. Fall soil moisture before winter soil freeze-up is presumed to approximate the pre-melt soil moisture storage the following spring. The pre-melt soil saturation was estimated by dividing the pre-melt volumetric soil moisture by the soil porosity. Soil porosity was estimated from soil texture, which is mainly loam in this region. Measurements of volumetric soil moisture content 50 cm below surface at the Mundare, Two Hills, and Vermilion AGDM stations was used to determine the pre-melt soil moisture for all HRUs except the "Builtup and Exposed Land" HRUs which were assumed to be saturated due to the lack of vegetation and their high soil compaction. "Open Water" and "Wetland" and "Channel" HRUs do not have soil layers. The measured spring soil temperatures at 50 cm depth at these stations were used to set up the pre-melt soil temperature. The values of pre-melt soil saturation and temperature for the four simulation years: 2005-06, 2006-07, 2007-08, and 2008-09 are presented in Appendix 3.

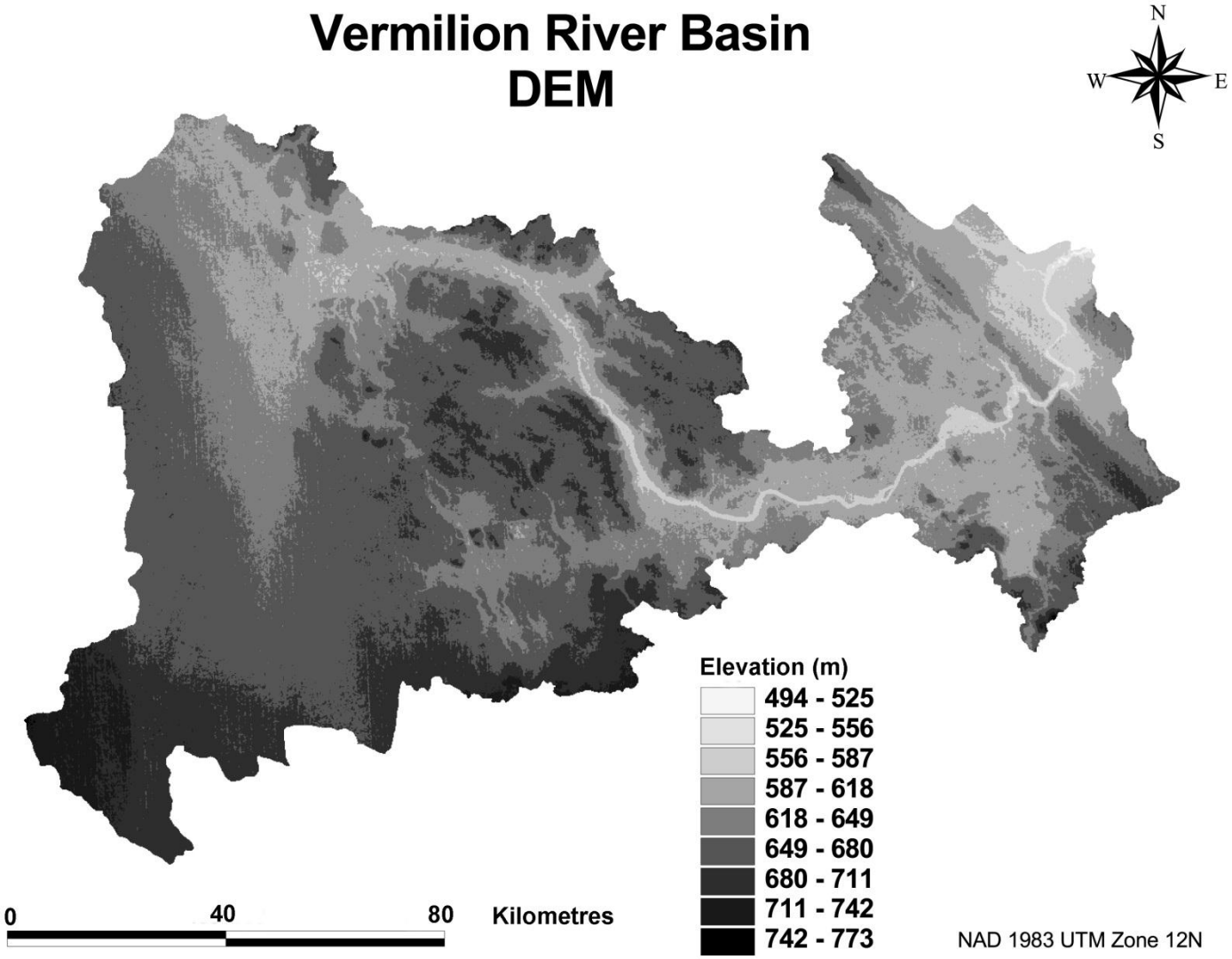

Figure 10. Vermilion River Basin 25-m ASTER DEM.

In the soil moisture balance and wetland module, the maximum water holding capacity for the soil column was determined from multiplying the rooting zone depth by soil porosity; 600 mm was set for the maximum water holding capacity of soil column. The initial value of available water in the soil column was estimated by multiplying the maximum water holding capacity by pre-melt soil saturation. The soil recharge layer is the shallow top layer of the soil column, approximately 60 mm in depth; the initial value of available water in the soil recharge layer was determined by multiplying the maximum water holding capacity and pre-melt soil saturation. It should be noted that the model treats "Channel", "Open Water", and "Wetland" HRUs as having no soil column, but permanent surface ponding. Subsurface and groundwater drainage factors control the rate of flow in the subsurface and groundwater domains; these rates are slow in the prairie environment (Hayashi *et al*., 1998) and were estimated from the saturated hydraulic conductivity based on soil texture. The values of the maximum water holding capacity for both soil column and recharge layer as well as their initial values for four seasons: 2005-06, 2006-07, 2007-08, and 2008-09 are presented in Appendix 4.

The automated procedure presented by Fang *et al*. (2010) was used to estimate the surface depression storage capacity (sd_{max}) for upland area HRUs (i.e. "Builtup and Exposed Land", "Fallow Cropland", "Stubble Cropland", "Grassland", "Woodland", and "Shrubland") and wetland area HRUs (i.e. "Open Water" and "Wetland"). For the initial model setup, only the 25-m ASTER DEM was available for the VRB and thus was used in the automated procedure, while a high quality LiDAR DEM is preferable for such procedure. The initial storage in the surface depressions (sd_{init}) in upland area HRUs was assumed to be zero due to their ephemeral nature and normally dry condition in the fall. The value of sd_{init} was assumed to be 30% of sd_{max} for the wetland HRUs. Averaged values of the surface depression storage capacity for the HRUs are presented in Appendix 4.

Routing Parameters

For routing amongst HRUs within a sub-basin (RB), the Muskingum routing method was used. Routing length for the non-channel HRUs (i.e. "Builtup and Exposed Land", "Fallow Cropland", "Stubble Cropland", "Grassland", "Woodland", "Shrubland", "Open Water", and "Wetland") was calculated using the modified Hack's law length-area relationship (Fang *et al*., 2010). The length-area relationship was derived from the CRHM-PHM modeling study conducted in the Smith Creek Research Basin (Pomeroy *et al*., 2010) and can be widely applied in the Prairie pothole region due to its fractal nature. Routing length for the channel HRUs was directly determined from the length of the secondary channel in the basin hydrography GIS dataset. The values of channel shape, Manning's roughness coefficient, longitudinal friction slope, hydraulic radius, and dimensionless weighting factor were decided using the same method present in the CRHM-PHM modeling study (Pomeroy *et al*., 2010). Figure 11 shows the routing sequence amongst HRUs within a sub-basin. This routing from the upland HRUs to the wetland HRUs and then to the channel HRUs is adopted from the sequence used in the in the CRHM-PHM modeling study (Pomeroy *et al*., 2010). The routing distribution parameter is used to partition amount of runoff amongst HRUs; the values of the routing distribution parameters were estimated by applying the Hack's law length-area relationship (Fang *et al*., 2010). The values for these routing parameters are presented in Appendix 5.

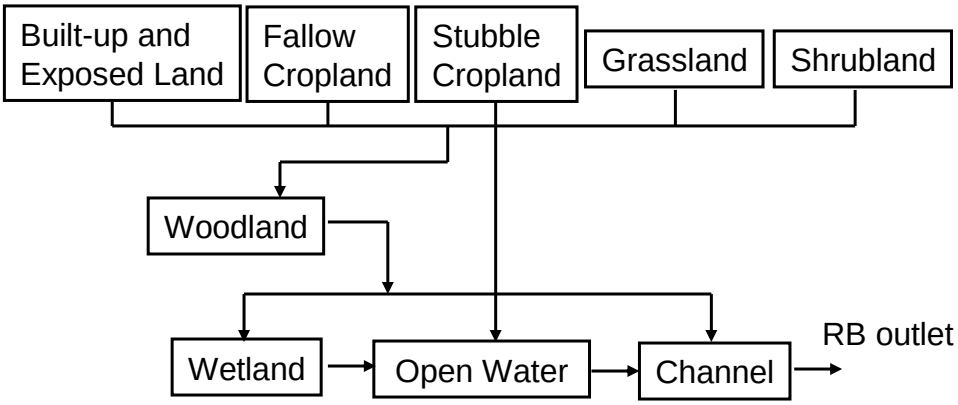

Figure 11. Routing sequence amongst HRUs within a sub-basin (RB).

For routing amongst sub-basins, also known as Representative Basins (RBs), the Muskingum routing method was used. Routing length amongst the sub-basins was determined from the length of the primary channel in the basin hydrography GIS dataset. The channel shape was assumed to be parabolic for channels in all sub-basins. Manning's roughness coefficient, longitudinal friction slope, hydraulic radius, and dimensionless weighting factor were decided using the same method as in the CRHM-PHM modeling study (Pomeroy *et al*., 2010). Runoff from each RB outlet flows to the primary channel, which is connected in the sequence shown in Figure 12; this sequence follows the channel flow order from the upstream part to the downstream part of the basin. The values for these routing parameters are presented in Appendix 5.

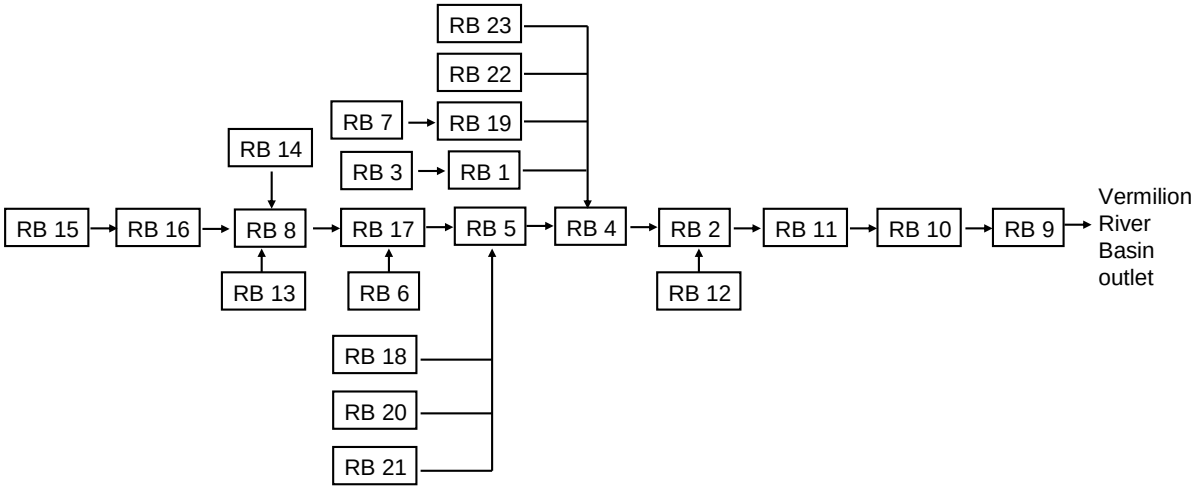

Figure 12. Routing sequence amongst sub-basins (RBs).

4.2 Test Results of Initial Model Setup

The purpose of the initial model tests is to evaluate how well the existing CRHM-PHM developed in the Smith Creek Research Basin can perform for prediction of various hydrological state variables and flows in the Vermilion River Basin. An evaluation of model performance compared to basin observations of snow accumulation, soil moisture, and streamflow discharge was conducted. The results are instructive for identifying what is lacking in the original CRHM-PHM formulation for application in the VRB and for informing an agenda of model improvements in the next stage of the study.

4.2.1 Evaluation of Snow Accumulation Prediction

Observations of snow accumulation (SWE) from the Alberta Environment's snow courses located at Mannville, Bruce, Two Hills, and Clandonald were used for the evaluation. The exact snow course locations could not be determined, but they are assumed to be mainly in cultivated fields and pasture as the accumulations are not consistent with forested locations despite the course descriptions listed in Section 3.2.5. Because the snow courses cover diverse landscape types, a direct comparison of mean SWE to model outputs is not straightforward, but was attempted using a single HRU type in the nearest sub-basins. The observed SWE at Mannville was used to test the simulated SWE in the stubble field HRU in sub-basin 11, the observed SWE at Bruce was used to test the simulated SWE in the stubble field HRU in sub-basins 8, 14, and 16, the observed SWE at Two Hills was used to test the simulated SWE in the stubble field HRU in sub-basin 4, and the observed SWE at Clandonald was used to test the simulated SWE in the stubble field HRU in sub-basin 10.

Figure 13 shows the evaluations of SWE predictions on 1st March and 1st April in each year of four-year (2006-09) period. The prediction of SWE is best for sub-basins 4 and 11 shown in Figure 13(a) and Figure 13(d), out of the six sub-basins tested. All the simulations performed poorly for the 1st April 2007 snow surveys. Model prediction errors can result from model errors, model parameter errors, meteorological data errors and test observation errors. It is difficult to draw a conclusion on what error or set of errors is causing the differences between model prediction and observation in this case. At the Vermilion River Basin steering committee meeting in June 2011, local landowners identified a major spring storm that was missing from the meteorological data record in March and April 2007, and which may account for some of the differences.

4.2.2 Evaluation of Soil Moisture Prediction

Observations of volumetric soil moisture at various depths from AGDM stations located near Mundare, Two Hills, and Vermilion were used for this evaluation. Model predictions of soil moisture in the top recharge layer as well as the entire soil column under stubble fields were tested against soil moisture observations at 5 cm and 50 cm below ground surface, respectively. The observed soil moisture near Mundare, Two Hills, and Vermilion was used to evaluate the simulated soil moisture in sub-basins 20, 4, and 11, respectively. Figures 14, 15, and 16 show volumetric soil moisture observation and prediction from May 1st to August 31st in each year of four-year (2006-09) period at the sub-basins 4, 11, and 20, respectively. The figures illustrate

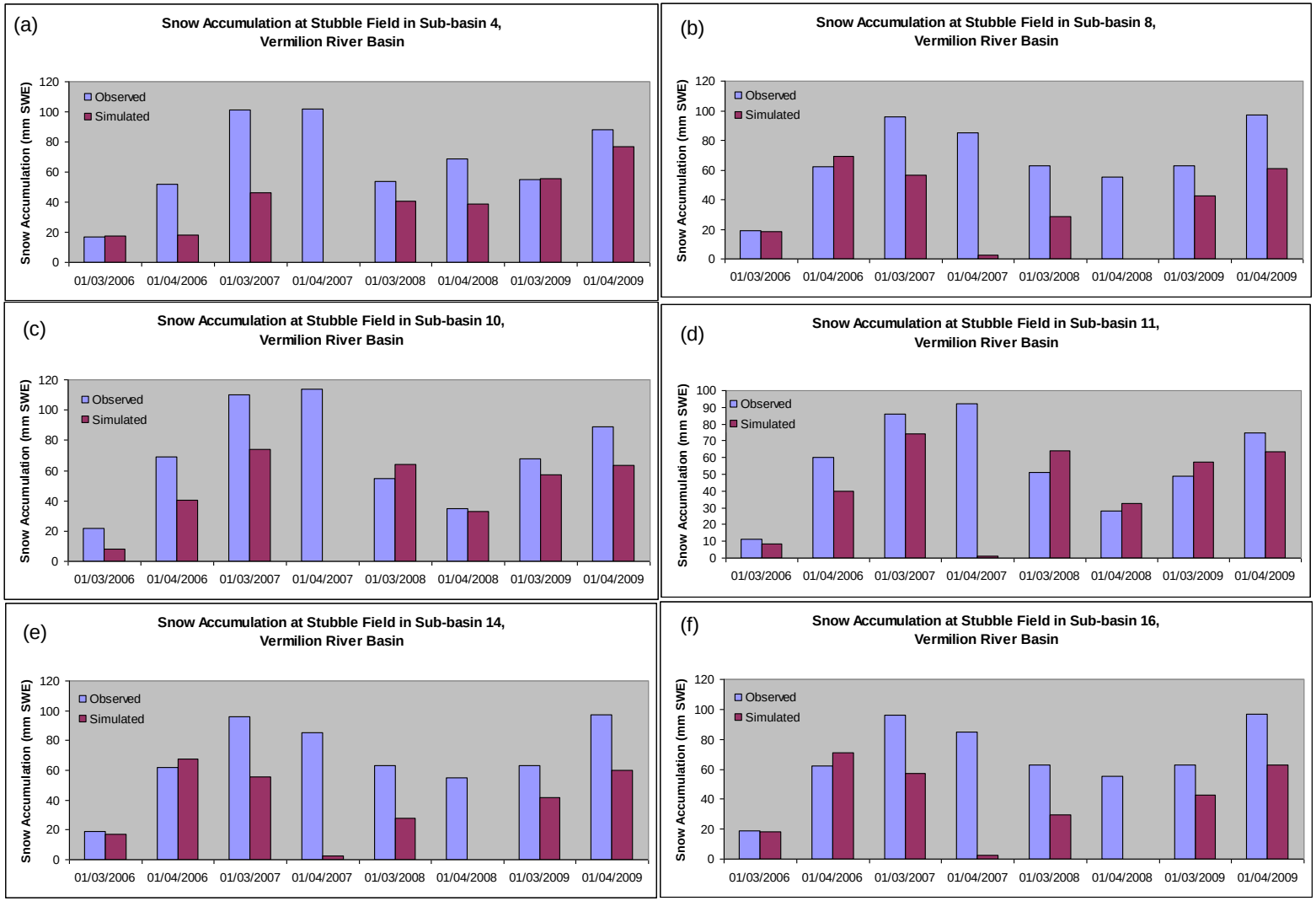

Figure 13. Evaluation of snow accumulation at the stubble field in (a) sub-basin 4, (b) sub-basin 8, (c) sub-basin 10, (d) sub-basin 11, (e) sub-basin 14, and (f) sub-basin 16.

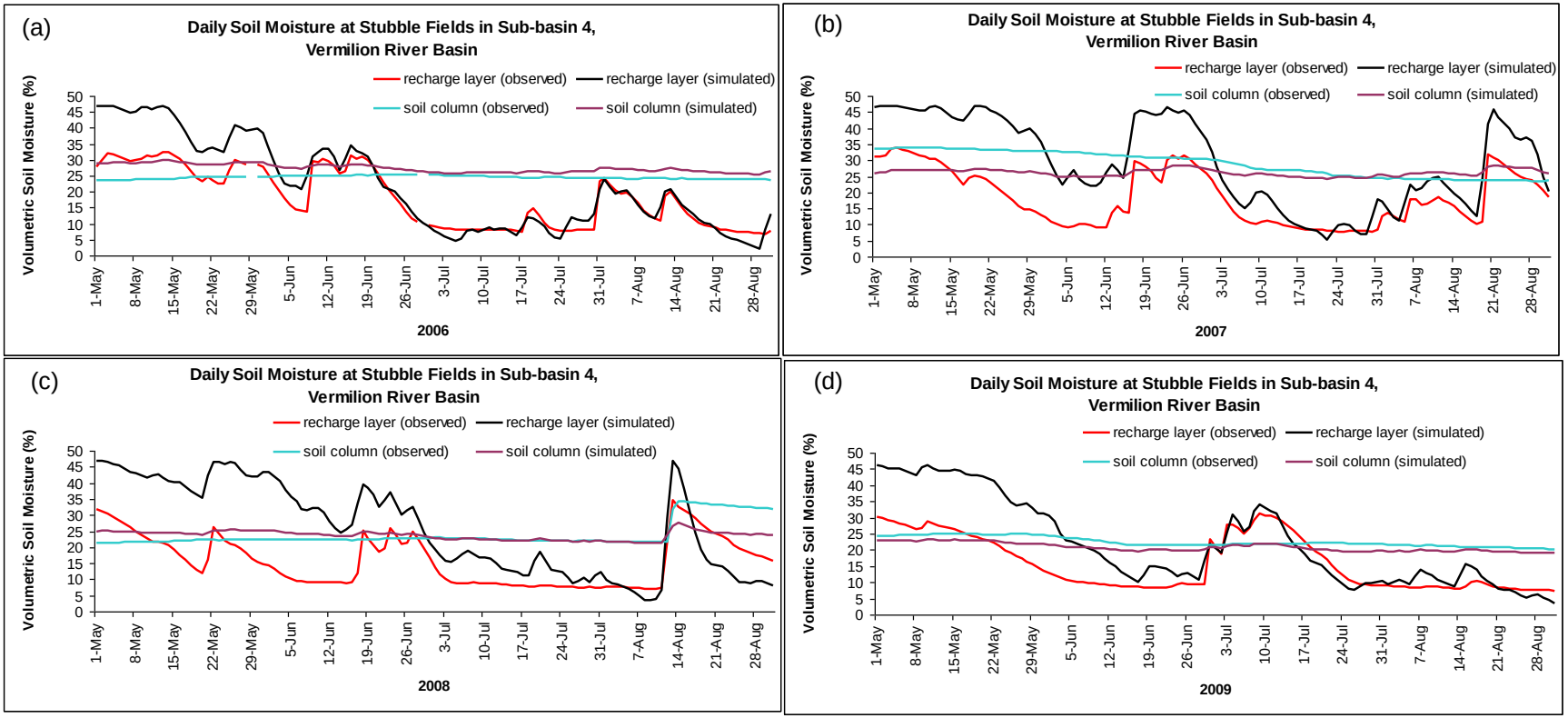

Figure 14. Evaluation of soil moisture at the stubble field in sub-basin 4 from 1st May to 31st August in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

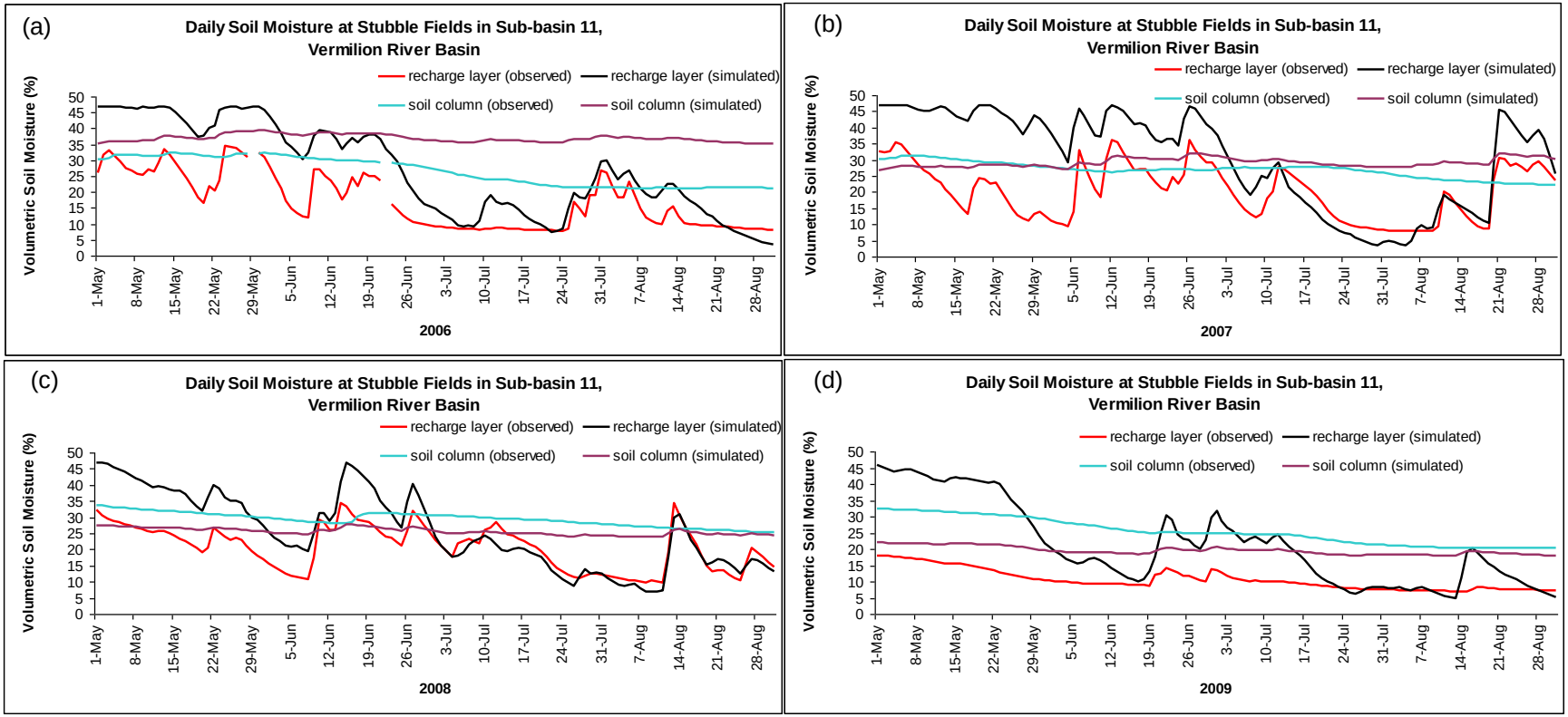

Figure 15. Evaluation of soil moisture at the stubble field in sub-basin 11 from 1st May to 31st August in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

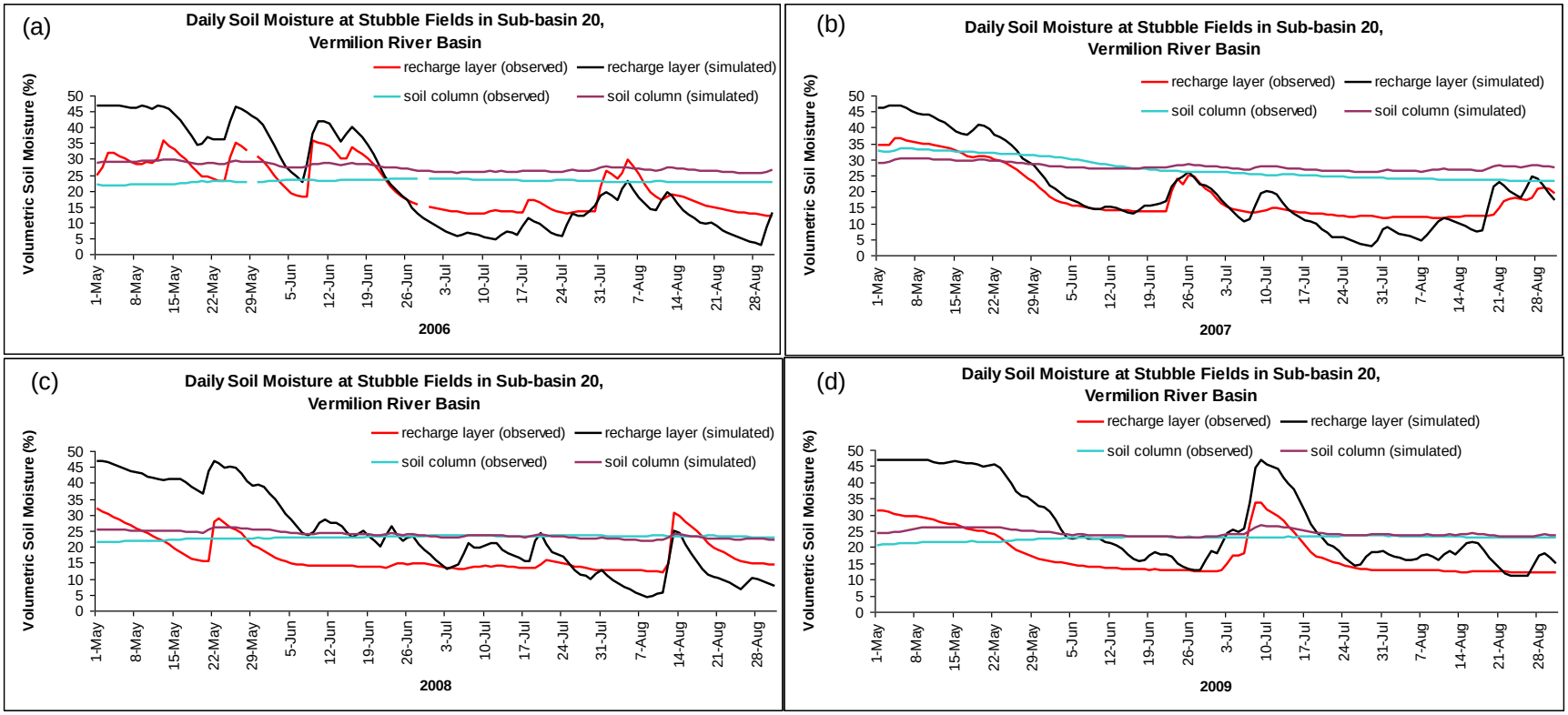

Figure 16. Evaluation of soil moisture at the stubble field in sub-basin 20 from 1st May to 31st August in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

that pattern of the model simulated soil moisture with the observed soil moisture for both the top shallow recharge layer and whole soil column. There are often notable discrepancies between the simulated and observed soil moisture in spring, but convergence in the middle of the growing season. The spring discrepancies may be due to inaccurate estimation of snowmelt infiltration, resulting from errors in the April snowpack prediction.

4.2.3 Evaluation of Streamflow Prediction

Estimations of streamflow (discharge) made from observations of stream stage and velocity at hydrometric stations operated by the Water Survey of Canada (WSC) were used for the evaluation. The simulated streamflow at the outlet of sub-basins 13, 10, 17, and 4 was compared to the estimated streamflow at the WSC stations 05EE006, 05EE007, 05EE009, and 05EE010, respectively. It should be noted that streamflow from a sub-basin includes the runoff from that sub-basin and all of the streamflow discharge from upstream sub-basins (see Fig. 12). Figures 17, 18, 19, and 20 show observed and predicted streamflow from 1st May to 30th September in each year of a four-year (2006-09) period at 05EE006, 05EE009, 05EE010, and 05EE007, respectively.

Figures 17 and 18 demonstrate that the model had some predictive ability for upstream sub-basins. That is, the simulated daily discharge at the outlet of sub-basins 13 and 17, which corresponds to the stations 05EE006 and 05EE009 in the upper Vermilion River Basin, better matches observations than the simulated daily discharge at the outlet of sub-basins 4 and 10, which correspond to the stations 05EE010 and 05EE007 in the lower basin. This is especially the case for the discharge in 2008 and 2009.

4.3 Discussion

The original CRHM-PHM used many parameterisations adapted directly from Smith Creek, Saskatchewan and so its operation with minimal modification in Vermilion River Basin was not expected to be successful. Nevertheless, the model predicted soil moisture in the growing season reasonably well. The model delivered fair performance in SWE prediction that was difficult to assess given the limited number and uncertain nature of snow accumulation observations to compare to. For streamflow prediction, the model showed better predictive capability for the upper part of Vermilion River Basin (sub-basins 13 and 17 and upstream) than the lower portion of the basin (sub-basins: 4 and 10 and upstream). There are several factors that need to be considered in evaluating this difference. Complicating streamflow prediction is: 1) the channelization of the middle section of Vermilion River, including sub-basins: 1, 2, 3, 4, 9, 10, and 11; and 2) operation of the Morecambe structure located near the outlet of sub-basin 4. The structure operation has many hydraulic and engineering guidelines and its simulation is better suited to water management models than hydrological ones like CRHM. Hence streamflow in the lower basin is controlled by water management rather than sub-basin hydrology. Although the model was able to simulate streamflow in the upper basin (sub-basins 6, 8, 13, 14, 15, 16, and 17), , it did so poorly. A more realistic representation of complexes of wetlands and contributing area dynamics would improve simulation.

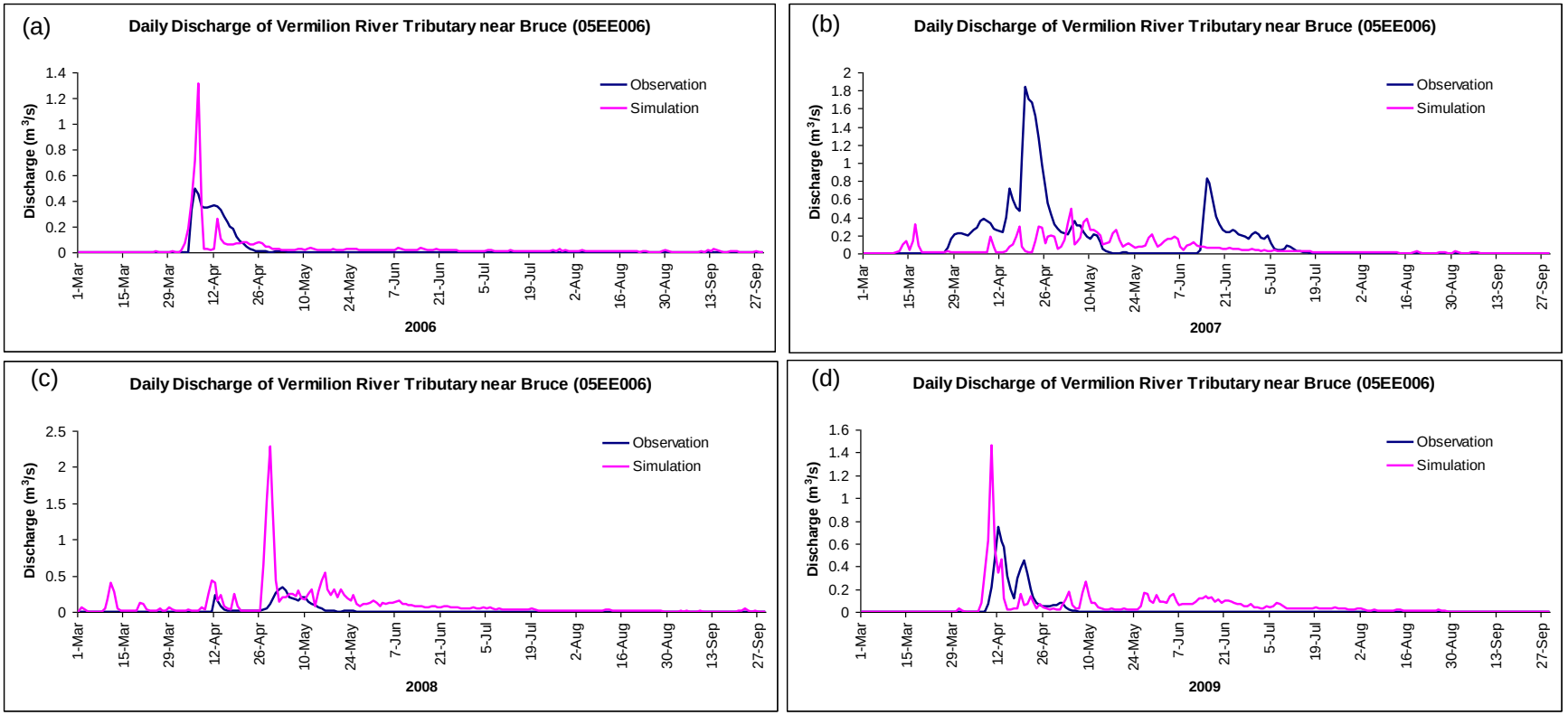

Figure 17. Observed and modelled daily discharge (streamflow) of the outlet of sub-basin 13, the Vermilion River Tributary near Bruce (WSC 05EE006) from 1st March to 30th September in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

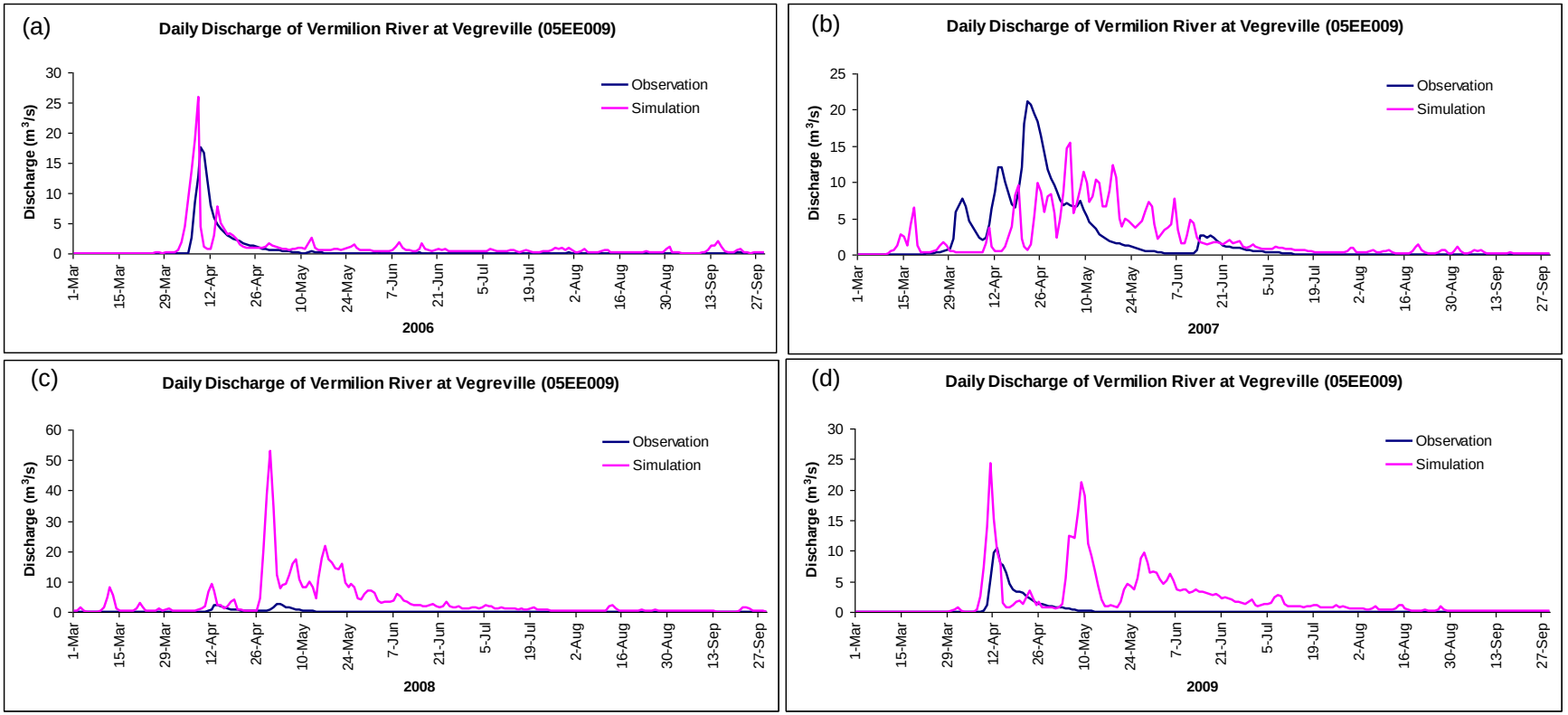

Figure 18. Observed and modelled daily discharge (streamflow) of the outlet of sub-basin 17, the Vermilion River at Vegreville (WSC 05EE009) from 1st March to 30th September in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

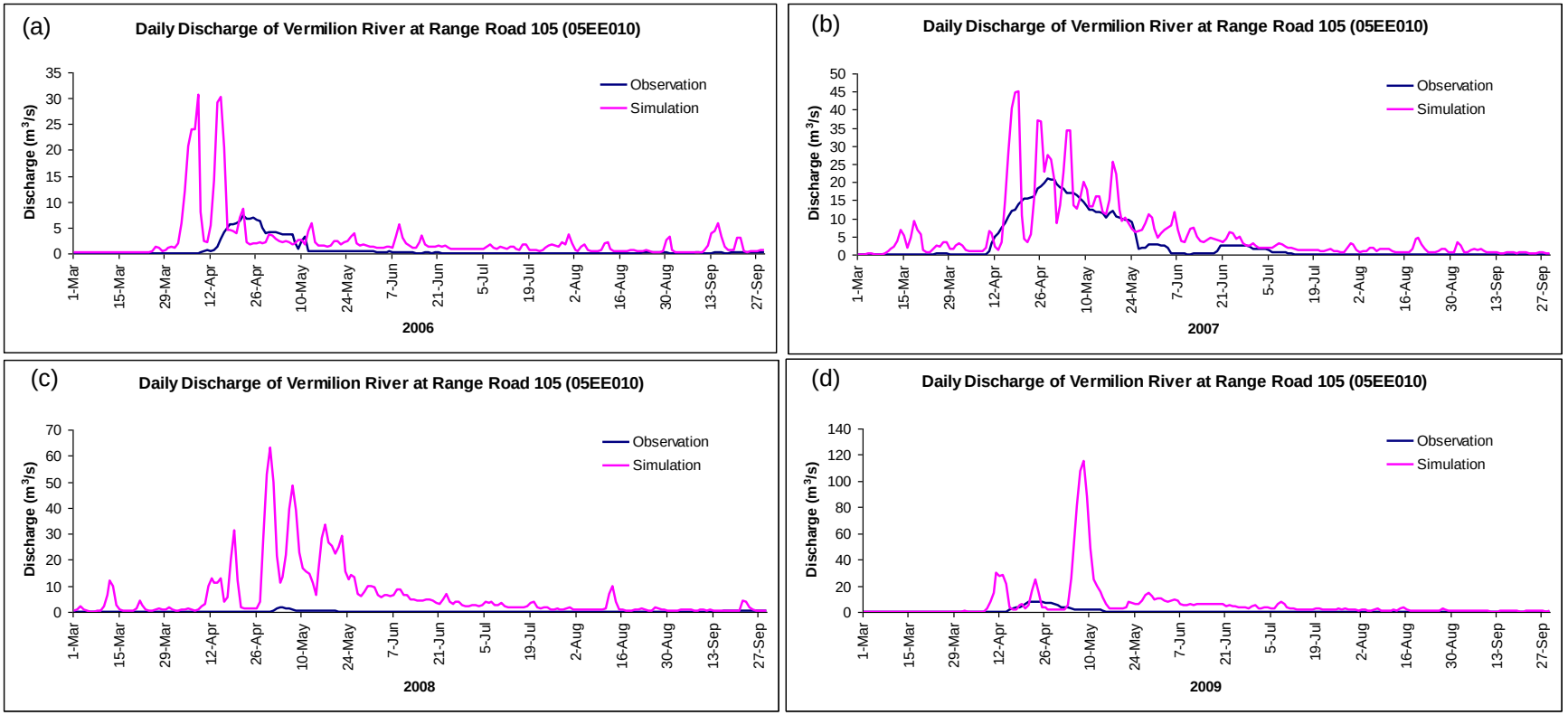

Figure 19. Observed and modelled daily discharge (streamflow) of the outlet of sub-basin 4, the Vermilion River at Range Road 105 (WSC 05EE010) from 1st March to 30th September in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

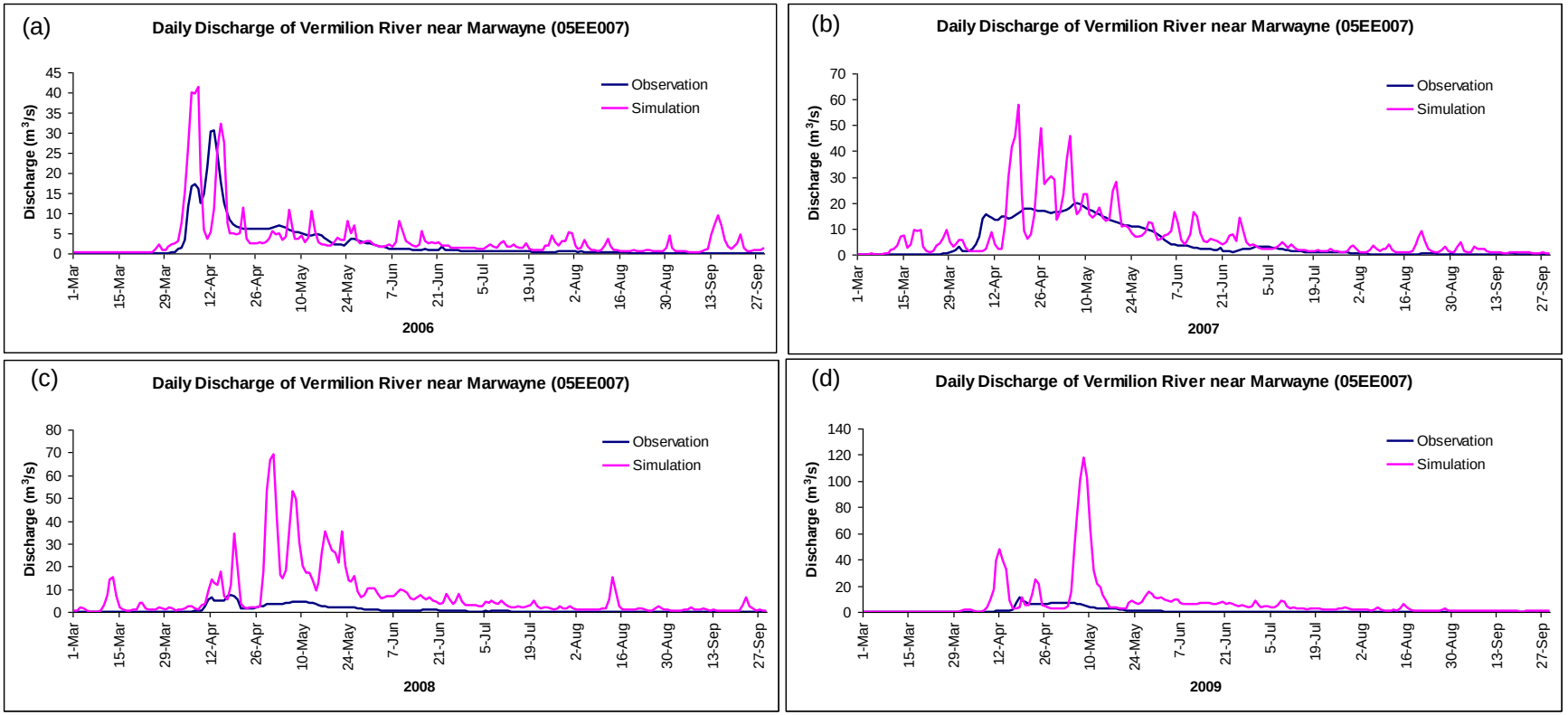

Figure 20. Observed and modelled daily discharge (streamflow) of the outlet of sub-basin 10, the Vermilion River near Marwayne (WSC 05EE007) from 1st March to 30th September in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

5 Improved Model Setup and Tests

5.1 Improvements to Model Setup

The streamflow response of the Vermilion River Basin at its mouth is dominated by channel hydraulics and control structures in the lower basin and so is influenced by wetlands only to the extent that the management regime of these control structures is affected by upstream hydrological behaviour of the tributaries with respect to volume and timing of streamflow inputs to the structures. The upstream tributaries that are much more sensitive to wetland extent and capacity were therefore the subject of further focussed study and model evaluation. Model improvements were made for simulations of the upstream sub-basins 6, 8, 13, 14, 15, 16, and 17.

5.1.1 Prairie Runoff Contributing Area and Wetland Storage

The inward draining of prairie hydrography has two major effects on prairie hydrology. Firstly, the contributing area of a basin which responds to hydrological events is dynamic, changing as wetlands connect and disconnect. This effect is well-documented and has prevented conventional hydrological models from being used successfully in the prairie pothole region, even if they are able to reproduce other cold-regions processes. Secondly, the storage within wetlands introduces "memory" effects to stream discharges. Because deep wetlands can store more water than can be evaporated during a single year, or can be filled during a single year's runoff, their initial state will persist from year to year. Recent research has shown that the connectivity of filled wetlands resembles the dendritic pattern found in more well-drained landscapes. Thus, the persistence of a single wetland will control the outflows of all of the wetlands upstream. Therefore, the discharge of a stream in a basin dominated by wetlands is influenced by conditions over several years previous.

Other important characteristics of the wetland depressional storage include:

- the connectivity between wetlands is ephemeral, occurring only when wetlands are full,
- the magnitudes of the depth, area and volume of water stored in wetlands vary tremendously as the wetlands range from transient puddles to semi-permanent lakes, and
- area of a wetland exposed to evaporation is a non-linear function of its depth.

These characteristics have been found to contribute to nonlinearity in the relationship between the fraction of a basin contributing runoff, and the water storage in the basin (Shook and Pomeroy, 2011b).

The relationships between the contributing area of prairie basins and the storage of water in wetlands has long been known to be complex (Stichling, 1957), and has recently been demonstrated to be nonlinear and hysteretic (Shook and Pomeroy, 2011). An example of this behaviour is shown by Figure 21, which plots the flows of WSC station 05EE006 (sub-basin 13, Vermilion Tributary at Bruce) along with rainfall computed from Environment Canada raingauges. The initial input of more than 50 mm of rain on June 5, 2007 resulted in zero runoff, while subsequent, smaller (and therefore less-intense) daily rainfalls resulted in gauged flows.

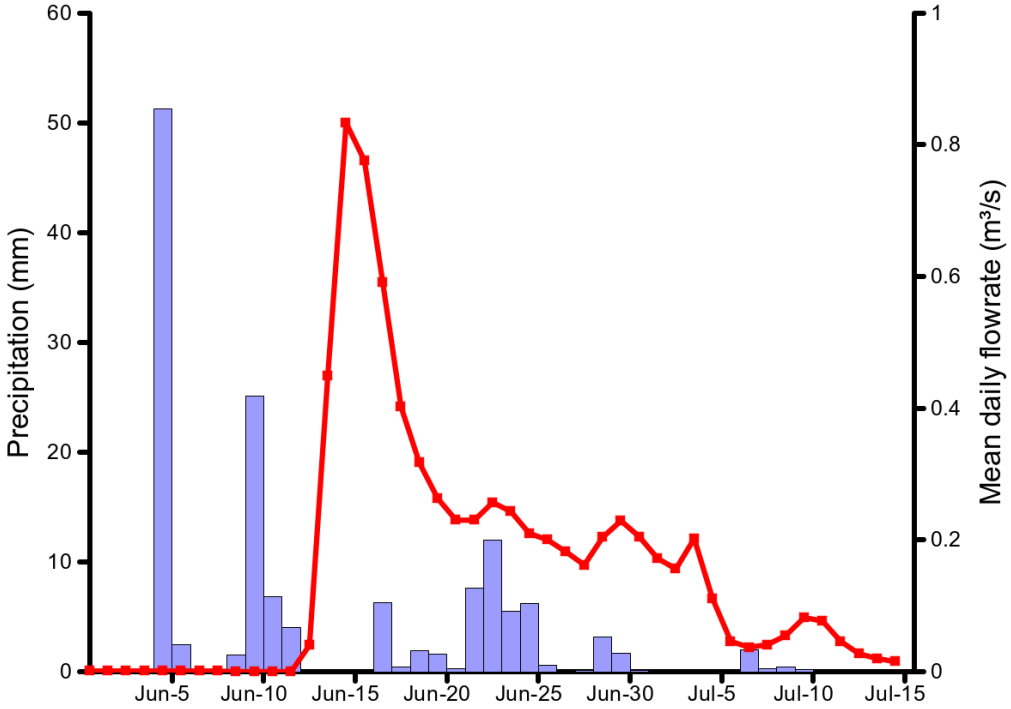

Figure 21. Flows of the Vermilion Tributary at Bruce (sub-basin 13) WSC 05EE006, June 1-15, 2007.

As a consequence of the hysteresis between wetland water storage and contributing area, the fraction of water running off from a given rainfall or snowmelt event cannot be predicted by the rainfall-runoff relationships present in conventional hydrological models.

Shook and Pomeroy (2011b) demonstrated that the cause of the hysteretic relations between water storage and contributing area is the connection amongst wetlands. The changes in the connections amongst the wetlands are demonstrated by the frequency distribution of water areas, which change differently for wetting (formation of connections) and drying (breaking of connections).

To demonstrate this, runoff from upland to the wetlands in a basin was simulated by applying simulated runoff to a high-resolution LiDAR DEM of a portion of sub-basin 8 (the only LiDAR DEM of the Vermilion River Basin available at the time). The simulated runoff was redistributed over the DEM using the iterative method of Shapiro and Westervelt (1992) as described by Shook and Pomeroy (2011b). Although this method provides detailed information about the spatial distribution of surface runoff, as shown in Figure 22, it cannot be used as a component of a hydrological model as it is too slow and does not accurately simulate the physics of runoff generation.

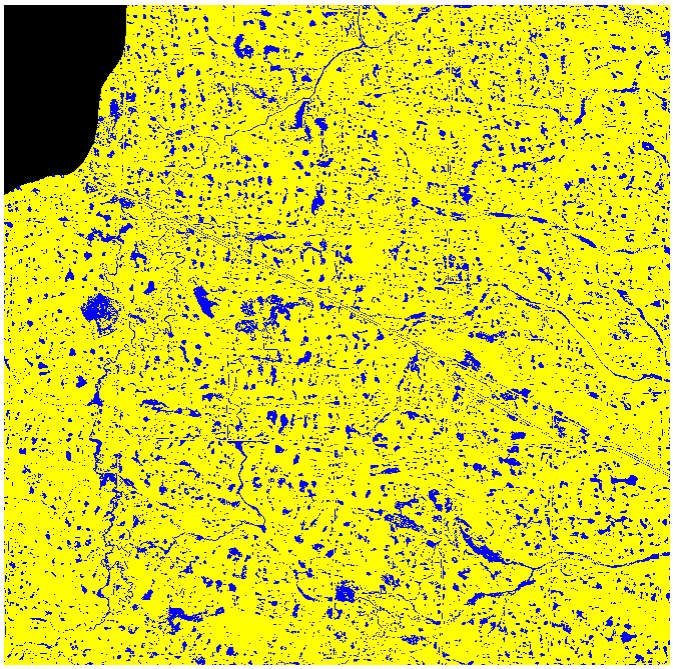

Figure 22. Simulated water accumulation caused by adding 10 mm of excess precipitation to the LiDAR data of a fraction of sub-basin 8. Water is plotted in blue, unwetted areas in yellow. The region outside the Vermilion River basin is black. Projection is UTM 13.

Shook and Pomeroy (2011b) showed that the changing connections among the wetlands could be simulated using a set of synthetic wetlands whose area-volume relationships were derived from high-resolution LiDAR DEM data. The connectivity of the wetlands was also inferred from the LiDAR data, by overlaying the conventional drainage network computed by an automatic drainage system delineation program "TOPAZ" (Garbrecht and Martz, 1993; 1997), and the number of wetlands intersecting streams of each Horton-Strahler stream order was calculated, as described by Shook and Pomeroy (2011b).

5.1.2 Dynamical Depressional Storage Network

The number of wetlands and other water-holding depressions in a prairie basin is very large; Figure 22 maps over 9000 depressions holding water in an area of approximately 90 km^2. As it is impossible to simulate each wetland in even a small basin, it was decided to simulate a small set of wetlands whose frequency distribution matched that of a basin, using the statistical connectivity established previously.

Unfortunately, determination of the parameters of the synthetic wetlands (areas, volumes, connectivity) requires the use of LiDAR data which was not available for most of the Vermilion River Basin for this phase of the study. Because a detailed LiDAR DEM was available for the Smith Creek Research Basin (SCRB) and because its topography is broadly similar to that of the Vermilion River Basin, the SCRB wetland parameters were copied directly. Previous work (Fang *et al.*, 2010) had delineated all wetlands greater than 100 m^2 within the sub-basin. As described above these wetlands were overlaid by the conventional drainage network computed

from TOPAZ and the number of wetlands intersecting streams of each order was computed. As shown in Table 4, the ratio of wetlands at each order to the next order is between 0.99 and 2.69. Accordingly, most of the modelled wetlands were assigned a branching ratio of 2, the only exception being for the first-order wetlands which had branching ratios of 3. The arrangement of HRUs in the model is depicted schematically in Figure 23. The size of each wetland was determined from the frequency distribution of wetlands at Smith Creek, and assigned randomly to HRUs (Figure 24). Detailed descriptions of the dynamical depressional storage network simulation of 46 wetlands and its results are provided by Shook and Pomeroy (2011b).

Table 4. Total number of sub-basin 5 wetlands at Smith Creek and bifurcation ratios for each Horton-Strahler stream order.

Horton-Strahler Stream Order	Wetland Count	Bifurcation Ratio
1	2837	1.96
2	1445	1.66
3	868	2.24
4	388	2.69
5	144	0.99
6	145	

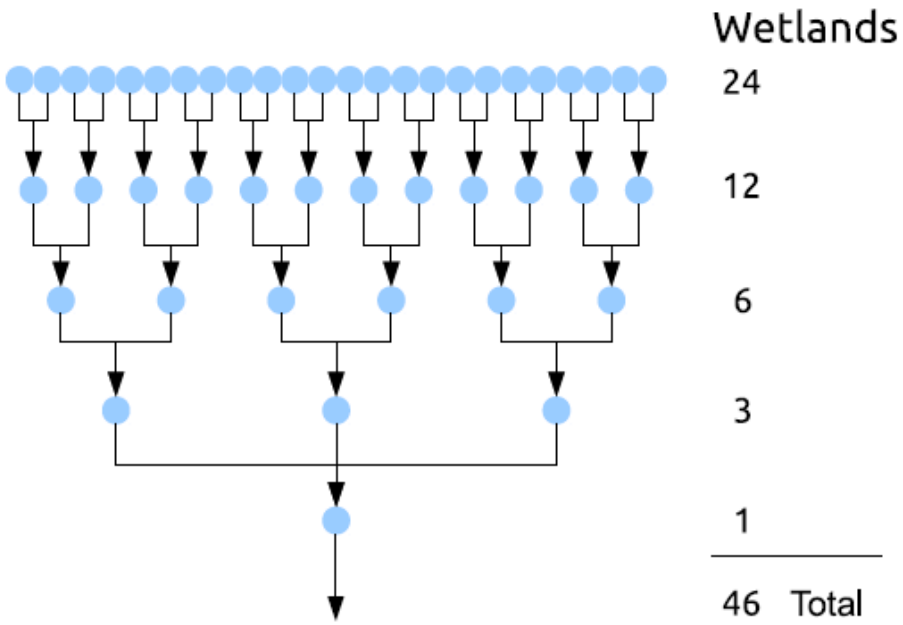

Figure 23. Schematic diagram of arrangement of dynamical depressional storage wetlands in model.

A minimum of 46 model wetlands are required to represent the SCRB connectivity as shown in Figure 25. The effects of using of more sets of wetlands to represent the behaviour of a basin were investigated using a simple Fortran 95 model of simulated wetlands. The model allows any number of wetlands to be connected in any configuration. As simulated water is added to model,

the wetlands fill and connect, spilling water in a cascade. Figure 25 plots the curves of contributing area vs. total volume of water stored in the wetlands for varying numbers of sets of wetlands. The use of multiple sets of wetlands results in a smoother curve, due to the reduction in the "gatekeeper" effect (Phillips et al., 2011) whereby large wetlands prevent downstream wetlands from receiving water until they are filled.

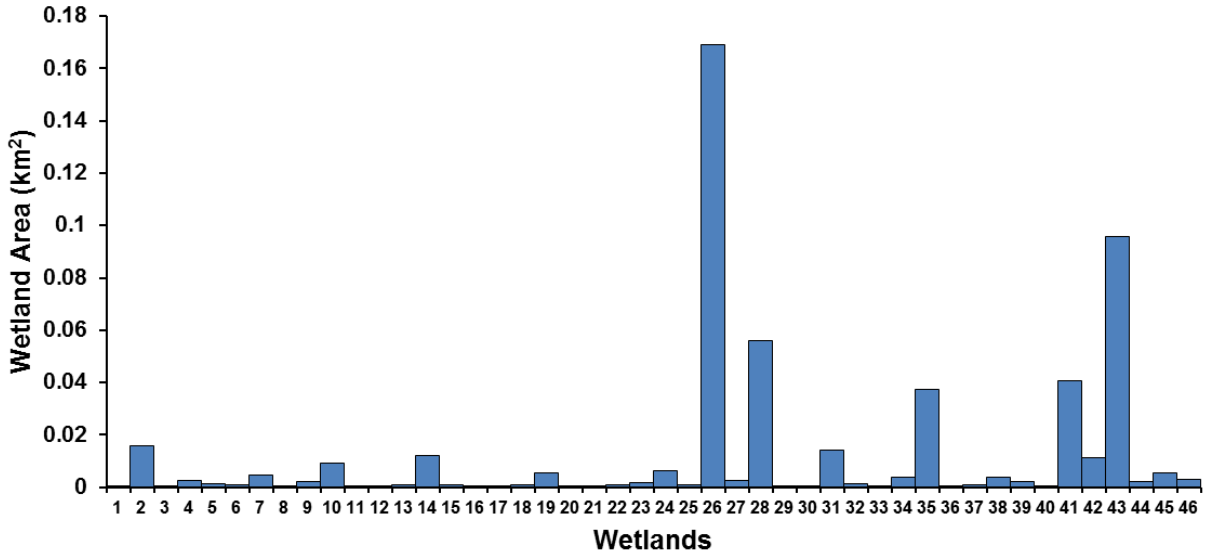

Figure 24. Size distribution of the dynamical depressional storage dynamical depressional storage network.

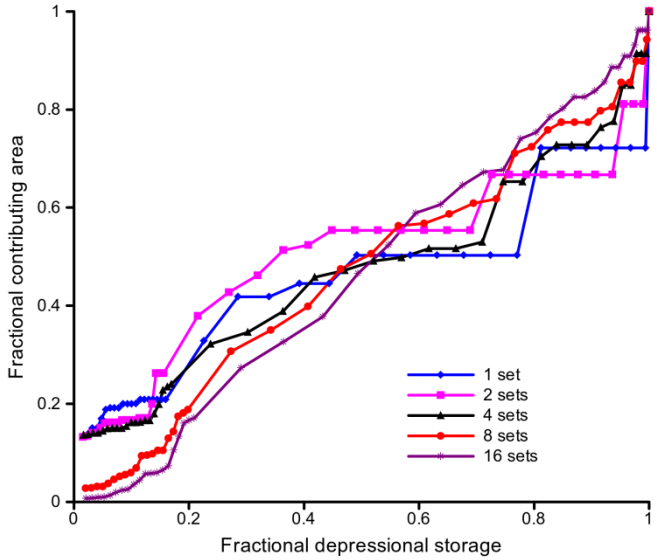

Figure 25. Fraction of simulated basin contributing flow vs. fraction of total water-holding capacity of wetlands. All simulations are purely filling.

The multiple-wetland simulations were incorporated in CRHM by creating a separate HRU for each of the 46 wetlands. Because wetlands can be present in any open prairie landscape, this required 46 HRUs to be added to many of the HRUs in all of the RBs, which greatly increased the complexity, memory requirements and execution time of the model.

To replace the single wetland HRU used in the initial model setup with the dynamical depressional storage HRUs, a simulated sub-region of upland and dynamical depressional storage network was used to represent the upland and wetland areas in an actual basin. In order for the sub-region to preserve the inheritance of its corresponding basin, the ratio between the upland and wetland in the sub-region must be same as the one in the actual basin. Moreover, streamflow output from the sub-region was scaled via a scaling factor to provide streamflow for the actual basin. Equations [1] to [3] were developed from the hydrography of Smith Creek sub-basin 5 (designated the representative wetland basin) to estimate the streamflow from the simulated sub-region.

$$Q_{RWB} = Q_s \times SR \qquad [1]$$

where: Q_{RWB} = streamflow output of the representative wetland basin,
Q_S = streamflow output of the simulated sub-region, and
SR = scaling ratio.

The scaling ratio is calculated as:

$$SRs = A_{RWB}/A_S \qquad [2]$$

where: A_{RWB} = the area of the representative wetland basin,
A_S = area of simulated sub-region in the representative wetland basin.

The area of simulated sub-region includes both simulated upland and wetland:

$$A_S = A_{su} + A_{sw} \qquad [3]$$

where: A_{su} = simulated upland area in the representative wetland basin,
A_{sw} = simulated wetland area in the representative wetland basin = 0.5209 km^2.

The same equations are applied and Equations [4] to [10] are used to calculate streamflow from the upstream sub-basins of Vermilion River:

$$Q_v = Q_{vs} \times SR_{vs} \qquad [4]$$

where: Q_v = streamflow output of an upstream Vermilion River sub-basin,
Q_{vs} = streamflow output of the simulated sub-region in the upstream Vermilion River sub-basin, and

SR_{vs} = scaling ratio for the upstream sub-basin.

The scaling ratio is calculated as:

$$SRvs = \frac{Avs}{Av} \quad [5]$$

where: A_v = the area of an upstream Vermilion River sub-basin,
A_{vs} = area of a simulated sub-region in the upstream Vermilion River sub-basin.

The area of an upstream Vermilion River sub-basin is the sum of both upland and wetland:

$$A_v = A_{vu} + A_{vw} \quad [6]$$

where: A_{vu} = upland area of an upstream Vermilion River sub-basin,
A_{vw} = wetland area of an upstream Vermilion River sub-basin. Assume that wetland areas do not change in moving from Smith Creek sub-basin to Vermilion River sub-basin. This requires that $A_{vw} > A_{sw}$.

The area of a simulated sub-region at the upstream Vermilion River sub-basin is:

$$A_{vs} = A_{vsu} + A_{vsw} \quad [7]$$

where: A_{vsu} = upland area in the simulated sub-region at the upstream Vermilion River sub-basin,
A_{vsw} = wetland area in the simulated sub-region in the upstream Vermilion River sub-basin = 0.5209 km^2.

The ratio between the upland and wetland must be preserved in both the actual basin area and the simulated sub-region:

$$\frac{Avsu}{Avsw} = \frac{Avu}{Avw} \quad [8]$$

Rearranging the Equation [8] provides estimation for the upland area in the simulated sub-region:

$$Avsu = \frac{Avu}{Avw} \times Avsw \quad [9]$$

Applying the Equation [9] into the Equation [7] gives the estimates for the area of a simulated sub-region in an upstream Vermilion River sub-basin:

$$Avs = Avsw \times (1 + \frac{Avu}{Avw}) \quad [10]$$

As A_{vu}/A_{vw} changes in different Vermilion River upstream sub-basins, so does A_{vs}, which is input in the Equation [5] to calculate the scale ratio.

Before estimating the scaling ratio, the areas for "Wetland" and "Open Water" HRUs as well as upland HRUs were updated. Areas for these HRUs shown in the Table A1 were defined from a land use classification using a Landsat image (2000) and are too low for both "Wetland" and "Open Water" HRUs. For all 23 sub-basins, "Wetland" ranged from 0.008% to 3.33% of the basin area and "Open Water" ranged from 0% to 3.46%. The more current (2004) DUC wetland inventory of impact class was used to update the HRU area, giving ranges of 1.76-8.62% and 0.006-3.56% for "Wetland" and "Open Water" HRUs, respectively. The updated HRU area is shown in the Appendix 6. After updating HRU area, the area of sub-basin, area of simulated sub-region at the sub-basin, and the scaling ratio for the upstream Vermilion River sub-basins were estimated using Equations [5] to [10] and are shown in Table 5. In addition, replaced the single wetland HRU in the initial model setup by the dynamical depressional storage network, the routing sequence between HRUs shown in Figure 11 was revised and is illustrated in Figure 26. Values for HRU area and routing length for the upstream Vermilion River sub-basins in the dynamical depressional storage mode setup are summarized in the Appendix 7.

Table 5. Sub-basin area, simulated sub-region, and scaling ratio for the upstream Vermilion River sub-basins.

	Sub-basin						
	15	16	14	13	8	6	17
Total sub-basin (A_v)	56.40	344.50	156.91	46.40	505.19	194.26	316.10
Total Simulated Sub-region (A_{vw})	8.73	7.86	6.69	8.05	10.02	10.12	30.36
Scaling Ratio	6.46	43.81	23.46	5.76	50.42	19.20	10.41

5.1.3 Updated Wetland Storage Capacity

With the updated HRU area from the current (2004) DUC wetland inventory of impact class, the depressional storage capacity was also re-calculated for the dynamical depressional storage model setup. Firstly, portions of area previously classified as upland using the Landsat image (2000) was "erased" by the DUC wetland impact class polygons and re-defined as "Wetland" and "Open Water". Then, the automated procedure presented by Fang *et al*. (2010) was used to estimate the depressional storage capacity (sd_{max}) for the revised upland HRUs (i.e. "Builtup and Exposed Land", "Fallow Cropland", "Stubble Cropland", "Grassland", "Woodland", and "Shrubland") and "Open Water" HRU. Values of sd_{max} for the randomly selected dynamical depressional storage HRUs were adopted from those at Smith Creek sub-basin 5 defined by the Smith Creek LiDAR DEM (Fang *et al*., 2010). The updated values of depressional storage capacity for the upstream Vermilion River sub-basins in the dynamical depressional storage mode setup are shown in the Appendix 8.

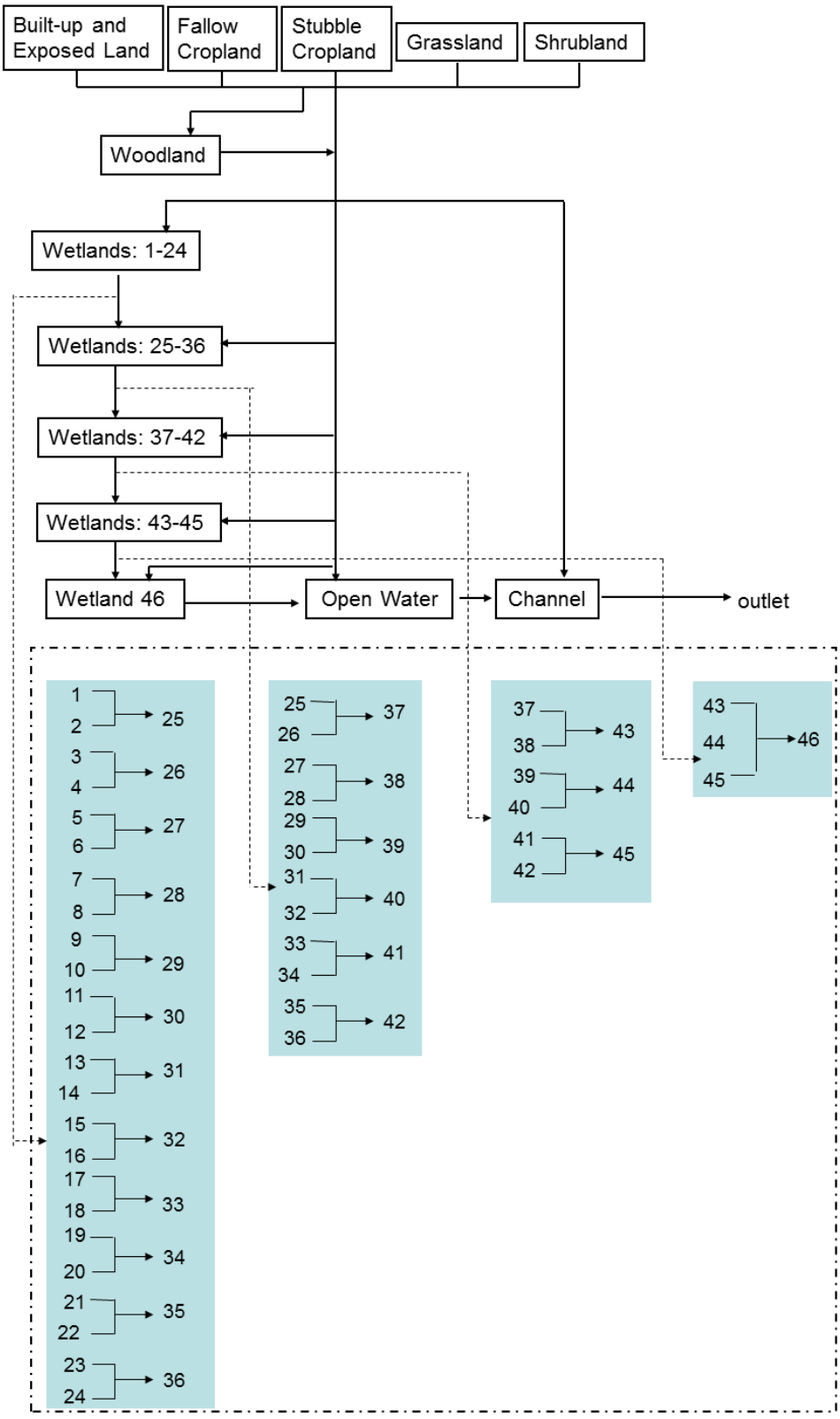

Figure 26. Routing sequence between HRUs within sub-basin with dynamical depressional storage network.

5.1.4 Sub-basin Precipitation Data

When model forcing data were generated from only six weather stations (Figure 5) to make predictions for the large size basin such as VRB, one of the uncertainties is the input meteorological data, with the precipitation being the most variable and most important to hydrological prediction and therefore of the greatest concern. Figure 27 demonstrates this uncertainty; model predictions of streamflow out of sub-basin 13 were quite different depending on which of two nearby stations (Holden or Viking) provided meteorological data. To reduce this uncertainty, precipitation was calculated for each sub-basin using the inverse-distance weighting spatial interpolation method. The weighting ratios of nearby stations were estimated for each sub-basin based on the distance between the stations and the centroid of the sub-basin. The estimated weight ratios are listed in Table 6 and give the partitioning values for nearby stations to assign precipitation to a given sub-basin. For instance, precipitation for the sub-basin 13 uses 29% of precipitation from Holden and 71% from Viking according to the ratios in Table 6.

Table 6. Inverse-distance weighting ratios of precipitation for the Vermilion River sub-basins.

	Station Name					
Sub-basin	Holden	Viking	Vegreville	Mundare	Two Hills	Vermilion
1	0	0	0.28	0.24	0.48	0
2	0	0.21	0.12	0	0.40	0.28
3	0	0	0.31	0.41	0.28	0
4	0	0	0	0	1	0
5	0	0	0.81	0.13	0.06	0
6	0.14	0	0.55	0.31	0	0
7	0	1	0	0	0	0
8	1	0	0	0	0	0
9	0	0	0	0	0	1
10	0	0	0	0	0	1
11	0	0	0	0	0	1
12	0	0.66	0	0	0	0.34
13	0.29	0.71	0	0	0	0
14	0.38	0.62	0	0	0	0
15	1	0	0	0	0	0
16	1	0	0	0	0	0
17	0.18	0.40	0.42	0	0	0
18	0	0	0.29	0.59	0.12	0
19	0	0.19	0.22	0	0.59	0
20	0	0	0	1	0	0
21	0	0	0.72	0	0.28	0
22	0	0	0.30	0	0.70	0
23	0	0	0	0	1	0

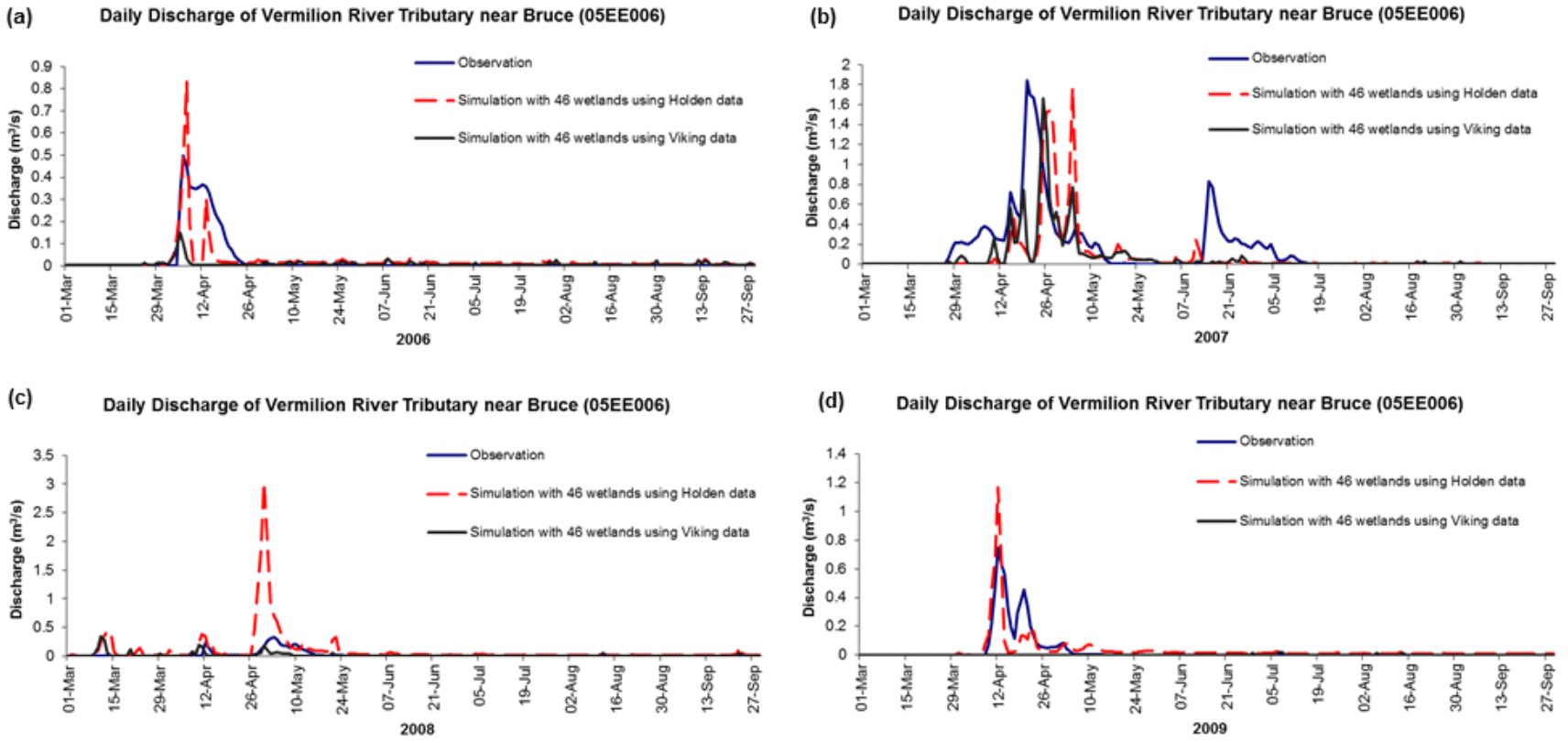

Figure 27. Comparisons of the simulated streamflow for sub-basin 13 with data from Holden and Viking stations in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

5.1.5 Continuous Simulations and Spin-up Simulation Data

For simulations using the initial model setup (Section 4), the initial depressional storage each fall was assumed to be zero for the upland HRUs and 30% of the storage capacity for the wetland HRUs. Without annual measurements of depressional storage, actual values are unknown. These assumptions can introduce errors in evaluating the impact of depressions on hydrology as there are "memory" effects on hydrology introduced by depressions/wetlands, such that streamflow is influenced by depressional storage that itself is influenced by the water balance over several years previous (Shook and Pomeroy, 2011b). Thus, a 'spin-up' meteorological dataset was created for the improved model simulations with the dynamical depressional storage model setup. During the 'spin-up' period the model is run to calculate changes to state variables such as depressional storage so that a realistic initial depressional storage is used. The depressional storage calculated for the end of each summer is then used the subsequent fall as the new initial condition in what are now continuous simulations. Observational data from 1st October 2003 to 30th September 2009 were used, and the first two seasons, 1st October 2003 to 30th September 2005, were used for spinning up the depressional storage. 50% of the storage capacity was assigned to the initial condition on 1st October 2003 to start off the spin-up. Values of the initial storage are shown in Table A20 of the Appendix 8 for the upstream Vermilion River sub-basins.

5.1.6 Updated Modules

Forest interception and soil infiltration modules were updated for the improved model simulations. The initial model setup used the "NeedleLeaf" module, which has subsequently been replaced by the latest forest snow mass- and energy-balance module called "CanopyClearing" (Ellis *et al*., 2010; Pomeroy et al., 2012). This new module estimates the snowfall and rainfall intercepted by forest canopy and updates the under-canopy snowfall and rainfall; it also provides estimation for the adjusted short-wave and long-wave radiation underneath the forest canopy. In the "CanopyClearing" module, a canopy was specified for "Woodland" HRUs. Values of 0.4 and 3 kg/m^2 were used as the LAI and canopy snow interception capacity parameters, respectively, for the "Woodland" HRU.

The infiltration module named "frozenAyers" includes both Gray's parametric snowmelt infiltration to frozen soils (Gray *et al*., 2001) and Ayers' unfrozen maximum infiltration rate (Ayers, 1959) algorithms and was used in the initial model setup. This module is not suitable for continuous multiple-year runs required by the spin-up model simulations. Thus, another infiltration module called "PrairieInfiltration" was used as its replacement. The "PrairieInfiltration" module has Gray's prairie snowmelt infiltration to frozen soils (Gray *et al*., 1985) and Ayers' unfrozen maximum infiltration rate (Ayers, 1959) algorithms and is suitable for the multiple-year simulations in the prairie environment. The revised flowchart of the hydrological processes with the updated modules is shown in Figure 28.

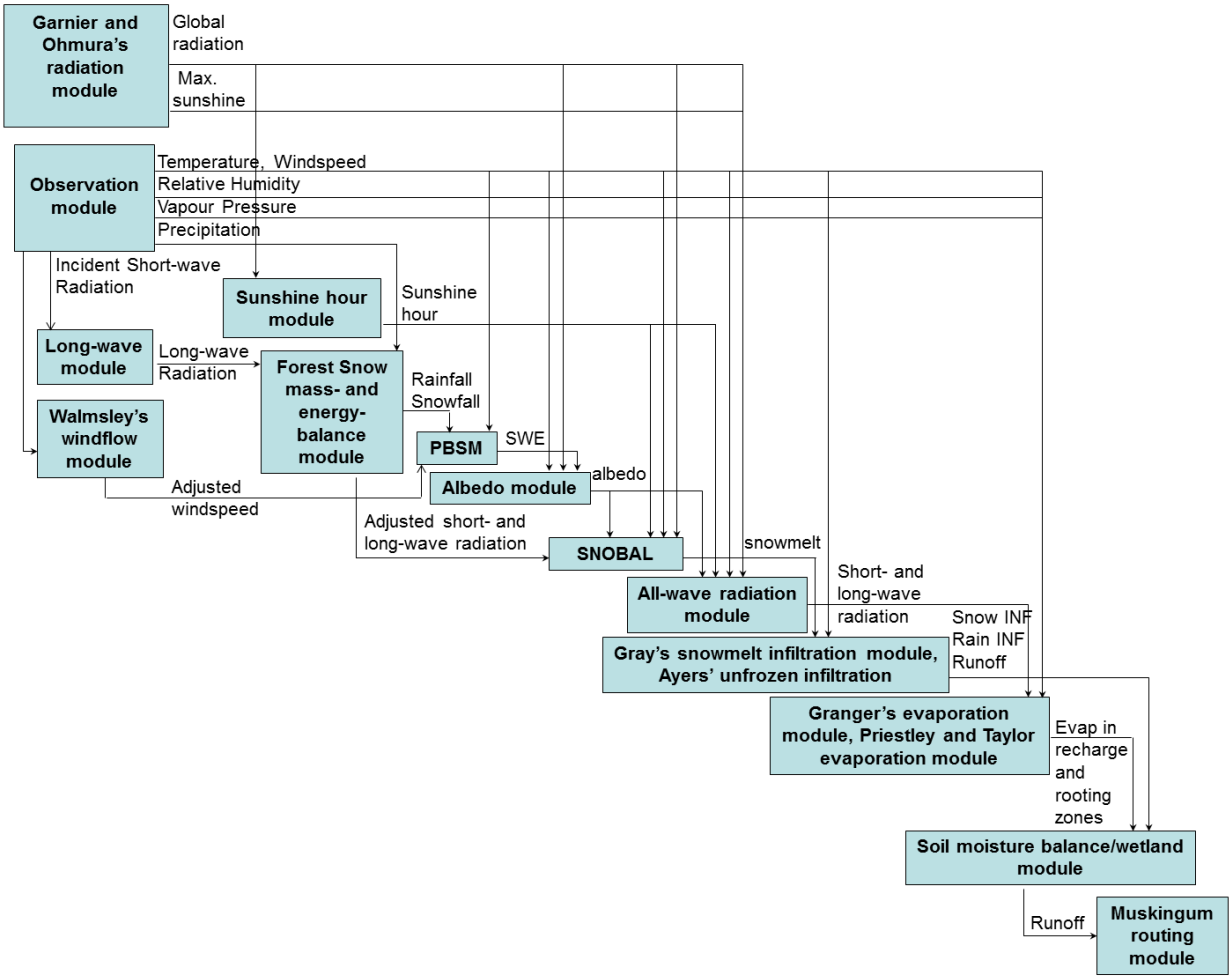

Figure 28. Flowchart of physically based hydrological modules for the improved model setup.

5.2 Evaluation of Improved Model Setup

Simulations incorporating improved model setup were conducted continuously from 1st October 2003 to 30th September 2009, with the first two seasons: 1st October 2003-30th September 2005 for spinning up the wetland storage. The improved model setup simulations included the dynamical depressional storage network, revised depressional storage capacity values, updated modules, and interpolated meteorological data as described in Section 5.1. The initial model setup had reasonable predictions for the snow accumulation and soil moisture; hence, the focus

of evaluation for the improved model setup is on the streamflow predictions for the upstream Vermilion River sub-basins.

5.2.1 Daily Streamflow Hydrograph

Figures 29 and 30 show the observed and simulated daily discharge hydrographs for sub-basins 13 and 17, respectively. Comparisons among the observation and two simulations (i.e. initial and improved model setups) in both figures demonstrate that the improved model simulations more closely match observations than do the initial simulations, but can still deviate from observed values. In some years (2006 and 2007), improved model simulated hydrographs get slightly more flashy in the summer, exact reason is not yet fully understood, but the accuracy of depressional storage capacity defined by the ASTER DEM and the simplified routing between wetland HRUs are suggested as possible reasons. It is highly likely that calibration of routing parameters would result in improved daily hydrograph simulation – but as this would not improve the physical realism of the model, calibration was not used to develop the improved model setup and its parameterisations.

5.2.2 Cumulative Seasonal Discharge

Compared to the daily streamflow hydrographs, cumulative seasonal discharge is of greater interest to the watershed managers and local farmers, as it provides information about total amount of water available for various uses. Thus, additional comparisons of seasonal discharge among the observation and two simulations were conducted. Figure 31 shows the comparison of cumulative discharge from 1st March to 30th September in four seasons: 2006-2009 for sub-basins 13 and 17. Out of all the comparisons, initial simulations are slightly better than the revised simulation in 2006 for sub-basin 13 and 2007 for sub-basin 17. For other years there are substantial improvements in model performance with the revision.

5.2.3 Peak Discharge

Peak annual discharge is useful information for land owners and watershed managers to plan flood prevention. Comparisons of peak discharge among the observation and two simulations were also conducted and are shown in Figure 32. Peak discharge during four seasons: 2006-2009 was generally overestimated by the initial model setup except for 2007; the improved model setup reduced these estimations of peak discharge so that they are closer to the observed ones. Figure 32(a) shows that improvement was made to the previously underestimated peak discharge in 2007 for sub-basin 13 by the initial model setup.

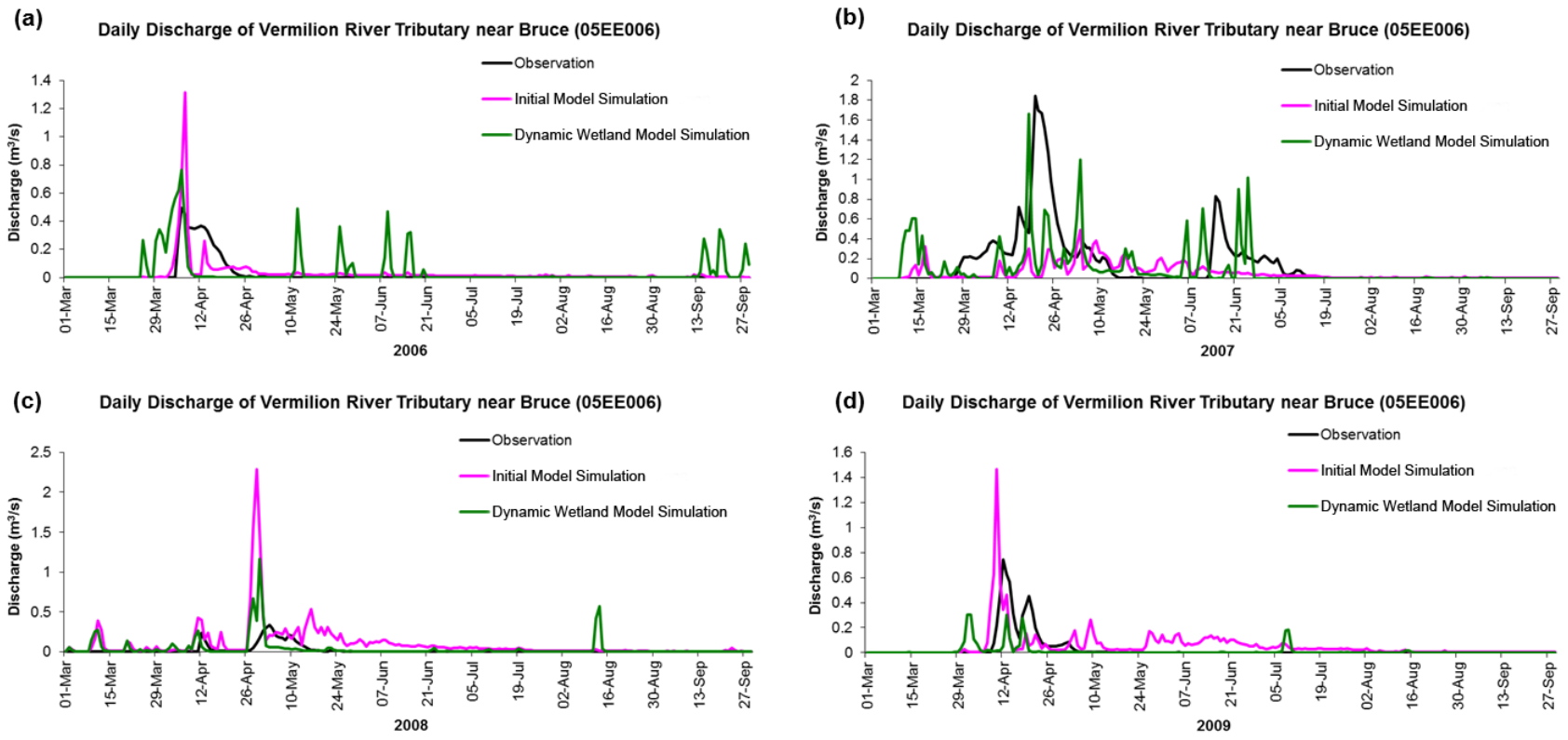

Figure 29. Observed and simulated (both initial and improved model setups) daily discharge out of sub-basin 13, the Vermilion River tributary near Bruce (WSC 05EE006), from 1st March to 30th September in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

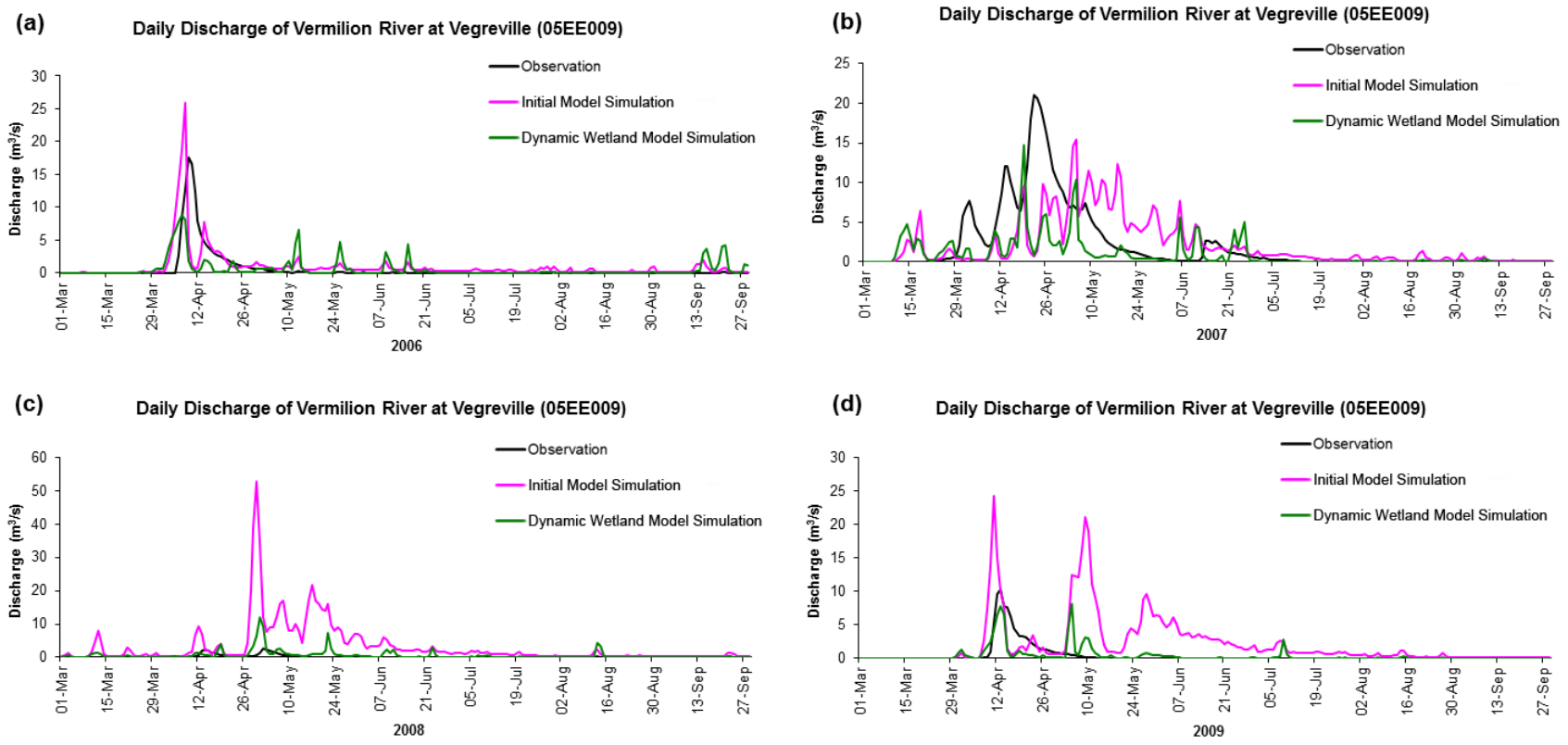

Figure 30. Observed and simulated (both initial and improved model setups) daily discharge out of sub-basin 17, the Vermilion River at Vegreville (WSC 05EE009), from 1st March to 30th September in (a) 2006, (b) 2007, (c) 2008, and (d) 2009.

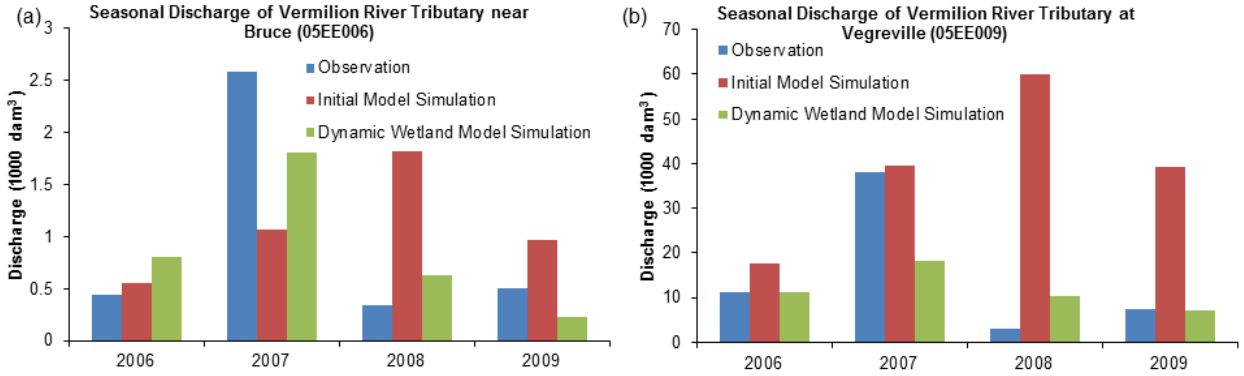

Figure 31. Comparisons of observed and simulated (both initial and improved model setups) seasonal discharge from 1st March to 30th September of (a) sub-basin 13, the Vermilion River tributary near Bruce (WSC 05EE006) and (b) sub-basin 17, the Vermilion River at Vegreville (WSC 05EE009).

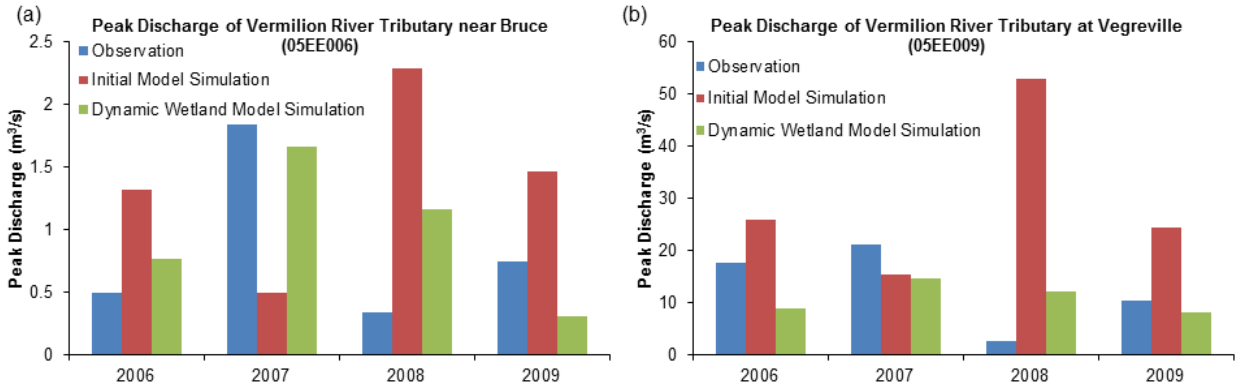

Figure 32. Comparisons of observed and simulated (both initial and improved model setups) peak discharge of (a) sub-basin 13, the Vermilion River tributary near Bruce (WSC 05EE006) and (b) sub-basin 17, the Vermilion River at Vegreville (WSC 05EE009).

5.3 Discussion

Improvement to the initial CRHM prairie hydrological model setup for Vermilion River Basin was made by including a dynamical wetland network in each sub-basin, improving maximum depressional storage parameterisation, estimating annual initial conditions for depressional storage, interpolating precipitation amounts and updating forest canopy and soil infiltration modules. The dynamical depressional storage network is an improved parameterisation because it captures the dynamics of wetland storage and fill-and-spill drainage interaction between wetlands. This also improves the model capability to deal with the "memory" effects introduced by the wetlands (Shook and Pomeroy 2011). Other improvements to the initial model setup include revision of the depressional storage capacity for upland areas using DUC current (2004)

wetland inventory, spin-up observation data for each sub-basin, continuous simulations, interpolated precipitation to sub-basins and updated modules. The improved model setup generally provided better simulations of daily streamflow hydrographs for two upstream Vermilion River sub-basins, though the hydrographs in some years had a flashier appearance. This flashiness might be caused by using the ASTER DEM to estimate wetland storage capacity or to routing of flow from wetland to wetland. Although the upland area and its associated depressional storage capacity were updated using DUC's 2004 wetland inventory impact class, the ASTER DEM might not be accurate enough for defining the small storage capacities typical of wetlands in the upland area. Moreover, the depressional storage values for the 46 wetlands were adopted from a sub-basin at Smith Creek, which was originally estimated using the high quality Smith Creek LiDAR DEM. Future work should derive depressional storage capacity for the Vermilion River using similar high quality DEMs. A 15-m high resolution LiDAR DEM was recently acquired for the west and middle parts of the Vermilion River Basin and should provide better estimates for the depressional storage capacity and consequently, should improve model simulations.

The improved model setup generally provided better predictions of seasonal and peak discharges, which are the primary concerns of watershed managers and land owners. Whilst model predictions could be better matched to observations by parameter calibration, this would not improve the physical basis of the simulation nor necessarily its ability to predict under changing land use and drainage conditions. Therefore parameter calibration was avoided in developing the improved model setup. The improved model setup is considered a suitable tool to analyze the effect of changing land cover and wetland drainage/restoration on streamflow discharge (seasonal, peak and duration) for upstream sub-basins of the Vermilion River.

6 Hydrological Sensitivity of Wetland Drainage and Restoration in the Upper Vermilion River Basin

6.1 Description for the Sensitivity Simulations

Based on discussions with the Vermilion River Watershed Management Project Steering Committee, six types of sensitivity were created for the upstream Vermilion River sub-basins 6, 8, 13, 14, 15, 16, and 17. This is to demonstrate the relative change in the basin hydrology due to draining or restoring wetlands. Another purpose is to provide guidelines to formalize basin hydrology and wetland scenario tests that are based on the sensitivity simulations results. The following lists the details for the six types of sensitivity.

1) Wetland Restoration. Open water and all 46 wetland HRUs at were progressively (i.e. 25%, 50%, 75%, and 100%) restored from the current (2004) level to the historical level according to the 1949 DUC wetland inventory. Also, the channel HRU was progressively reduced from current (2004) hydrography to the historical 1949 hydrography, and cropland area was accordingly reduced as wetland area increased. Consequently, the areas of cropland (fallow and stubble), channel, open water, and 46 wetland HRUs were recalculated for each level of wetland restoration, and the routing length for these HRUs and the dynamical depressional storage outflow scaling ratio were adjusted for the new geometries.

2) Wetland Drainage. Open water and all 46 wetlands at the current (2004) level were progressively (i.e. 25%, 50%, 75%, and 100%) drained. Cropland area was increased accordingly. Consequently, the area and routing length of cropland (fallow and stubble), open water, and 46 wetland HRUs were recalculated for each level of wetland drainage, and the dynamical depressional storage outflow scaling ratio were adjusted for the new geometries.

3) Spatial Wetland Drainage. This considers the effect of location of wetland drainage within each sub-basin; the upper basin is compared to the lower basin. For upper wetland drainage, only the upper wetlands (i.e. wetlands 1 to 24) were progressively (i.e. 25%, 50%, 75%, and 100%) drained from the current (2004) level. In contrast, for lower wetland drainage, only the lower wetlands (i.e. wetlands 25 to 46) were progressively drained. Area and routing length of cropland and drained wetland HRUs as well as the dynamical depressional storage outflow scaling ratio were adjusted for each level of wetland drainage.

4) Wetland Size Drainage. This takes the effects of wetland size into consideration for drainage impacts. For large wetland drainage, only those wetlands that are larger than 0.01 km^2 (i.e. wetland HRUs 2, 14, 26, 28, 31, 35, 41, 42, and 43) were progressively (i.e. 25%, 50%, 75%, and 100%) drained. For small wetland drainage, only those wetlands that are smaller than 0.01 km^2 (i.e. wetlands 1, 3, 8, 11, 12, 13, 16, 17, 20, 21, 22, 25, 29, 30, 33, 36, 37, and 40) were progressively (i.e. 25%, 50%, 75%, and 100%) drained. The area and routing length of cropland and drained wetland HRUs as well as the dynamical

depressional storage outflow scaling ratio were adjusted for each level of wetland drainage.

5) Spatial Wetland Restoration. This considers the effect of the location of wetland restoration within each sub-basin: the upper basin is compared to the lower basin. For upper wetland restoration, only the upper wetlands (i.e. wetlands 1 to 24) at current (2004) level were progressively (i.e. 25%, 50%, 75%, and 100%) restored to the 1949 level from current levels. For lower wetland restoration, only the lower wetlands (i.e. wetlands 25 to 46) were progressively restored from the current to the 1949 level. The area and routing length of cropland and restored wetland HRUs as well as the dynamical depressional storage outflow scaling ratio were adjusted for each level of wetland restoration.

6) Wetland Size Restoration. This takes the effects of wetland size into consideration for restoration impacts. For large wetland restoration, only those wetlands that are larger than 0.01 km^2 (i.e. wetlands 2, 14, 26, 28, 31, 35, 41, 42, and 43) were progressively (i.e. 25%, 50%, 75%, and 100%) restored from the current to the 1949 level. For small wetland restoration, only those wetlands that are smaller than 0.01 km^2 (i.e. wetlands 1, 3, 8, 11, 12, 13, 16, 17, 20, 21, 22, 25, 29, 30, 33, 36, 37, and 40) were progressively (i.e. 25%, 50%, 75%, and 100%) restored from the current to the 1949 level. The area and routing length of cropland and those wetland HRUs as well as the dynamical depressional storage outflow scaling ratio were adjusted for each level of wetland restoration.

In total, 40 sensitivity simulations and one simulation for the current level were conducted for the period of 1st October 2003-30th September 2009. These 41 simulations all used the period of 1st October 2003-30th September 2005 for spinning up depressional storage, and the simulations results generated in the succeeding four seasons from 1st October 2005 to 30th September 2009 were used for the sensitivity analysis. The calculated area, routing length, and scaling ratio for the 40 sensitivity simulations were present in the tables in the Appendix 9.

6.2 Results of Sensitivity Simulations

6.2.1 Water Balance Components

Full water balance components were produced for the sub-basin 6 from all 40 sensitivity simulations as well as the simulation for the current level. The water balance components include not only the streamflow but other key hydrological processes: snowmelt, snowmelt infiltration, rainfall infiltration, blowing snow sublimation, actual evapotranspiration, depressional storage fluctuation, and soil moisture fluctuation. These hydrological processes are important in the runoff generation for the streamflow in Vermilion River, so outputs of these processes are instructive for assessing how the system responds to the wetland drainage and restoration. Sub-basin 6 is a small headwaters (first order) basin near Vegreville that is expected to have changes in water balance that are representative of much of the rest of the VRB. For this section, only the responses of the water balance components except streamflow are analyzed; the response of streamflow is shown in the next section.

Blowing Snow Sublimation

Figure 33 demonstrates the four-season (1st October 2005 to 30th September 2009) average percent change in blowing snow sublimation loss for 40 sensitivity simulations. The percent change is between sublimation in sensitivity simulations and that for a simulation using current wetland area. Blowing snow sublimation increased as wetlands were drained; this is because as wetlands (with tall brush vegetation) are drained it is assumed that they are replaced with cropped lands (with short vegetation) which permit more blowing snow transport and sublimation. In contrast, less snow was lost to blowing snow sublimation when wetland restoration occurred; this is due to greater suppression of blowing snow occurrence as wetland area increases. Sublimation responded more to wetland drainage (7% increase) than to restoration (5% decrease) because of the relatively small amount of restoration possible on sub-basin 6 given the estimated 1949 wetland extent. Drainage or restoration of larger and lower wetlands was effective in changing sublimation, whilst change to smaller and upper wetlands had a negligible impact. Figures 33(b) and (c) show that the responses of larger and lower wetlands are 4.8% for 100% drainage and 2.9% for 100% restoration, whereas the maximum responses of smaller and upper wetlands drainage or restoration are less than 0.7%.

Snowmelt

Figure 34 shows the four-season (1st October 2005 to 30th September 2009) average percent change in cumulative snowmelt for 40 sensitivity simulations. The percent change is between the seasonal snowmelt in sensitivity simulations and the snowmelt using current wetland levels. Snowmelt increased as wetlands were restored; this is because wetlands restrict wind redistribution and subsequently more snow is accumulated and subsequently melted in a basin as result of increased wetland coverage. In contrast, there was less snowmelt when wetland drainage occurred; this is due to reduced snow accumulation from increased blowing snow sublimation losses when wetlands are converted to agricultural land. In sub-basin 6, cumulative snowmelt is not very sensitive to either wetland drainage or restoration, mainly due to the small current and previous wetland coverage in the basin and because snowmelt is responding to changes in blowing snow sublimation which is a fraction of total snowfall. Figure 34(a) demonstrates that total snowmelt dropped by 1.6% when all wetlands were drained, and that the snowmelt increased by 1.3% when all wetlands were restored to the 1949 level. Figures 34(b) and (c) show the effects of the spatial and wetland size drainage or restoration; snowmelt responded more effectively to changes in the larger and lower wetlands than in the smaller and upper wetlands, but the responses at 100% drainage or restoration to these selective modifications in wetland area are less than 1% of current snowmelt and are considered negligible.

Infiltration

Figures 35 and 36 show the four-season (1st October 2005 to 30th September 2009) average percent changes in snowmelt infiltration and rainfall infiltration for 40 sensitivity simulations. The percent change is between infiltration in sensitivity simulations and the snowmelt using current wetland levels. For both types of infiltration, there were increases as the wetland drainage occurred and decreases as wetlands were restored. With wetland drainage, previously saturated soils (zero infiltration) under wetlands become unsaturated and develop an increased

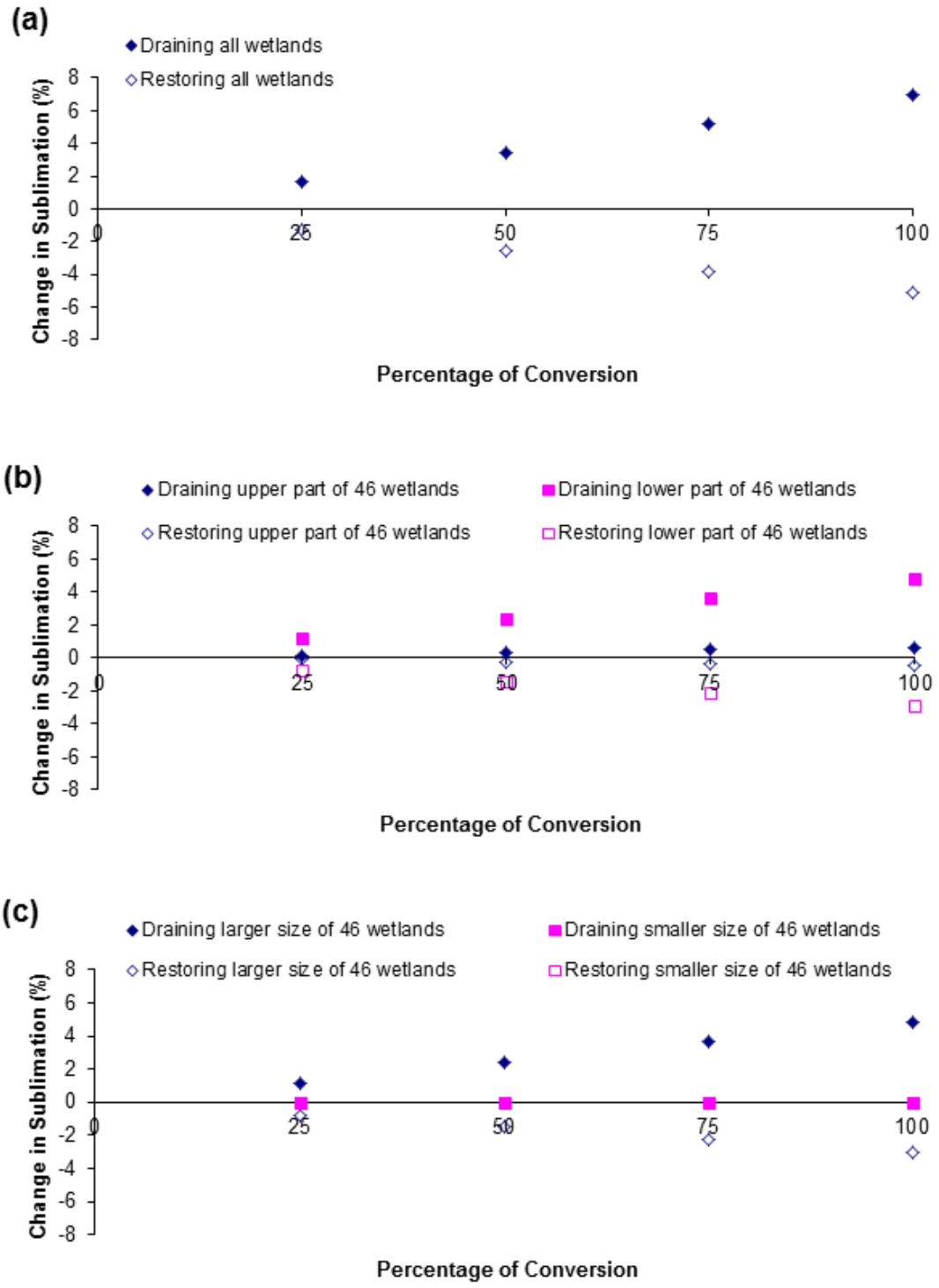

Figure 33. Four-season (1st October 2005 to 30th September 2009) average change in blowing snow sublimation (%) in Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetland drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

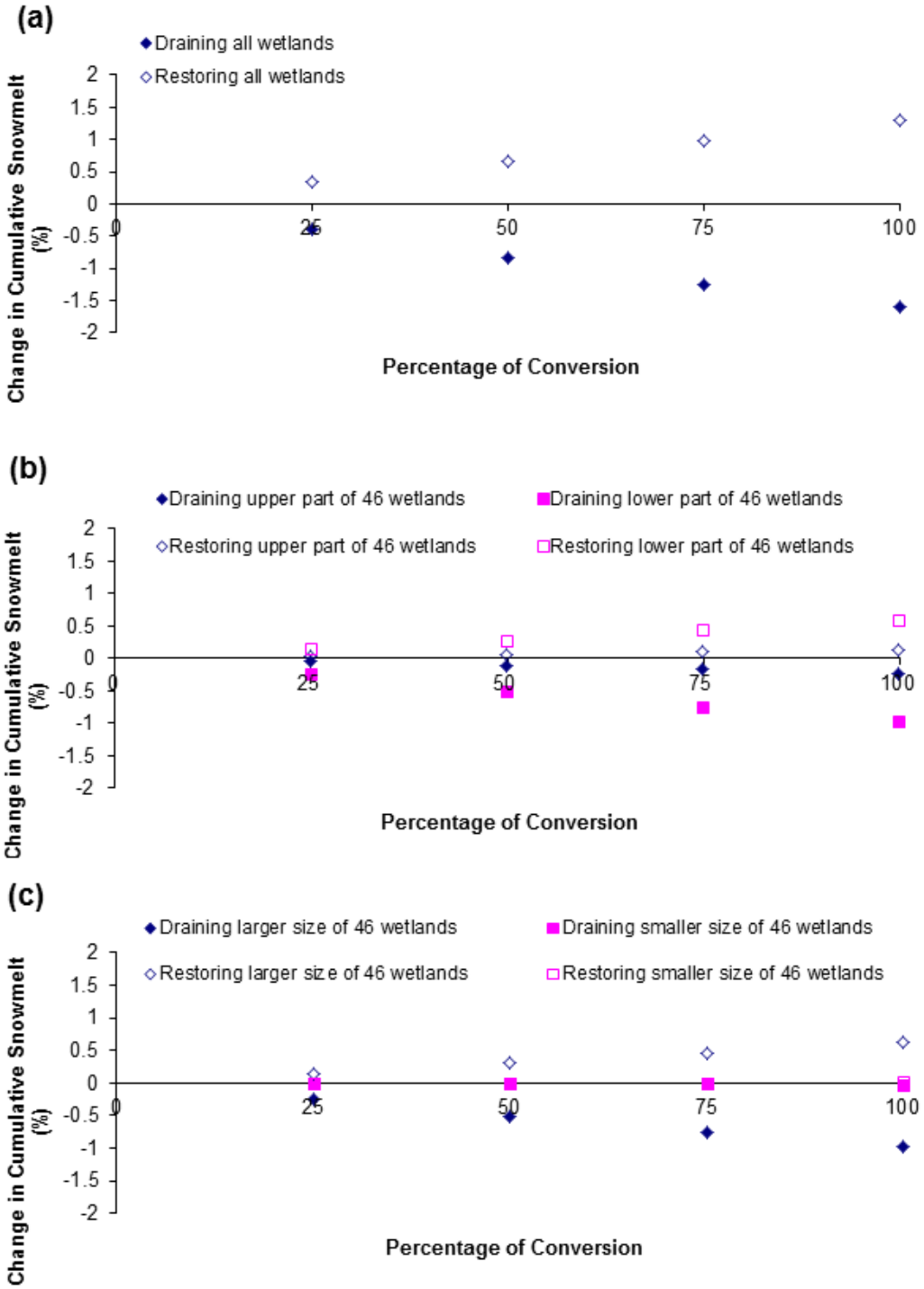

Figure 34. Four-season (1st October 2005 to 30th September 2009) average change in cumulative snowmelt (%) at Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetland drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

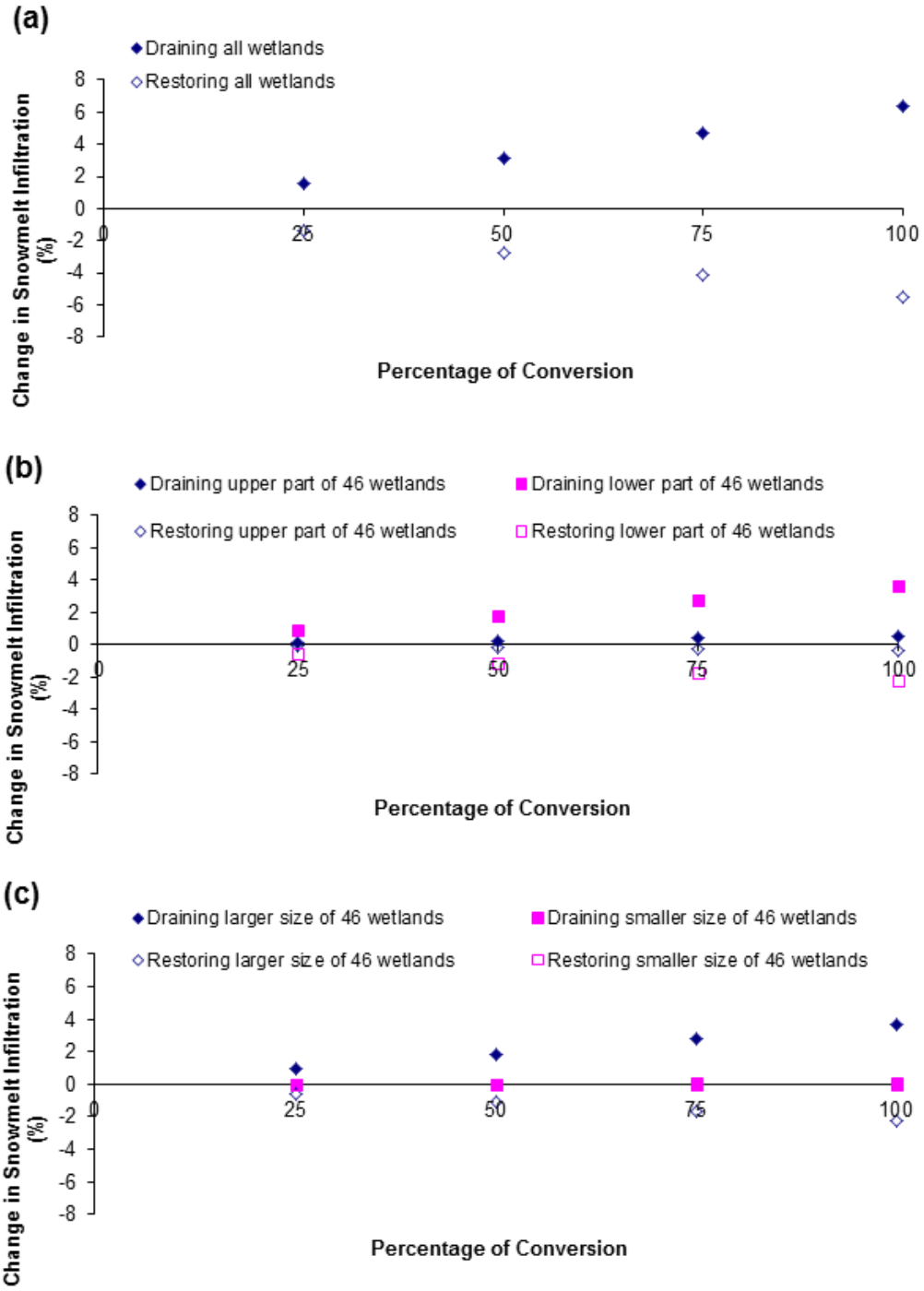

Figure 35. Four-season (1st October 2005 to 30th September 2009) average change in snowmelt infiltration (%) at Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetlands drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

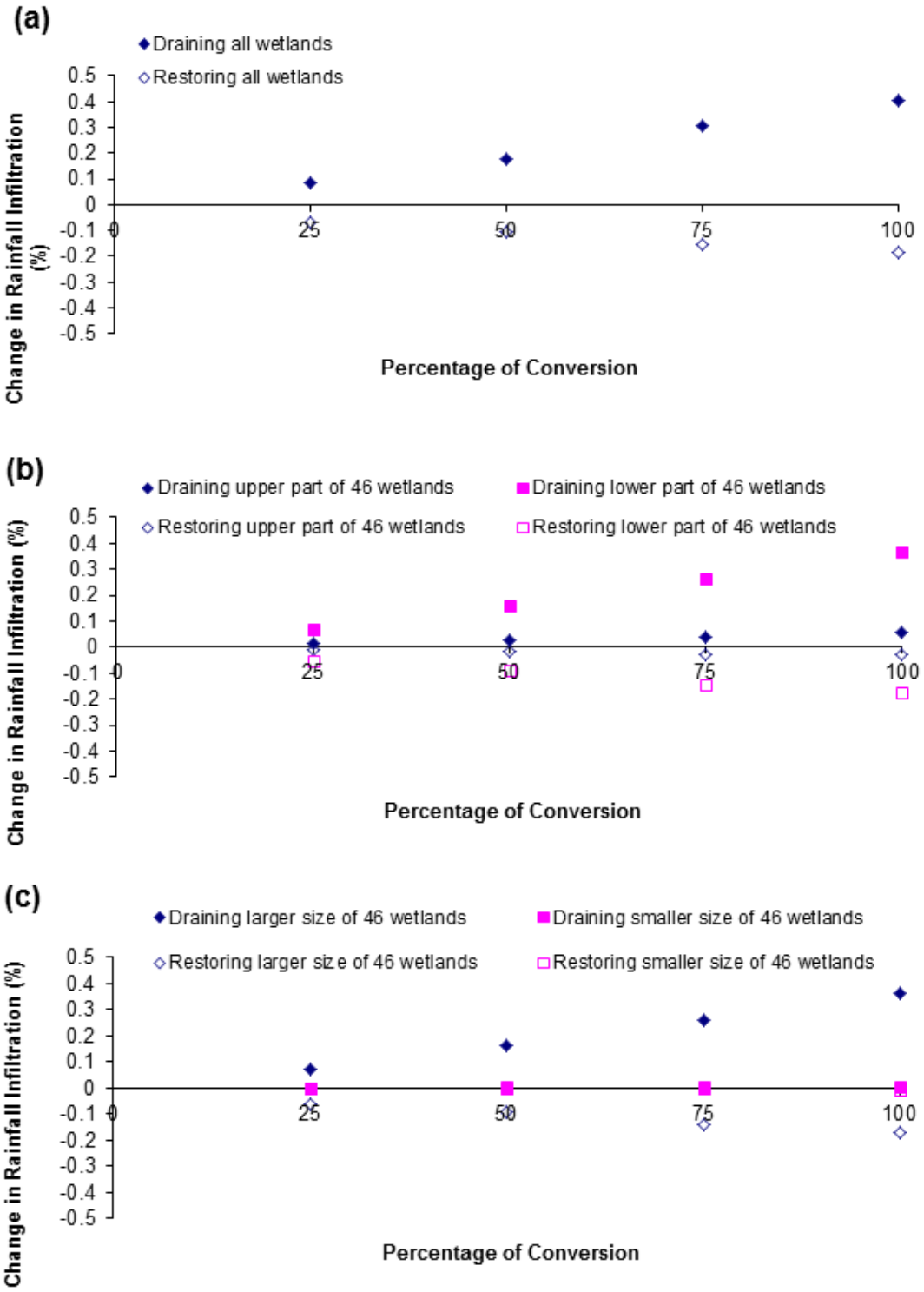

Figure 36. Four-season (1st October 2005 to 30th September 2009) average change in rainfall infiltration (%) at Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetlands drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

infiltration capacity and with restoration the opposite occurs. Figure 35(a) shows that snowmelt infiltration rose by about 6.3% when all wetlands were drained and declined by about 5.5% when all wetlands were restored to the 1949 level. Much smaller responses, less than 0.5%, were found for rainfall infiltration, showing the sensitivity of fall soil moisture status in controlling spring snowmelt infiltration (and runoff). Both types of infiltration responded more to the drainage or restoration of the larger and lower portion of wetlands than to the smaller and upper portion.

Actual Evapotranspiration

Figure 37 demonstrates the (1st October 2005 to 30th September 2009) average percent change in actual evapotranspiration (ET) for the 40 sensitivity simulations. Each of these changes is the difference in ET between a sensitivity simulation and the simulation for current wetland extent. Compared to agricultural lands, wetlands store more moisture and consequently have greater moisture available for ET, thus ET increases when wetlands are restored and decreases when wetlands are drained. The largest responses are found in the full wetland drainage or restoration; when all wetlands were drained, ET decreased by about 7% and increased by about 5.5% when all wetlands were restored to the 1949 level. Drainage and restoration of the larger and lower wetlands was effective whilst manipulation of the smaller and upper wetlands had negligible impacts on evapotranspiration.

Soil Moisture Fluctuation

Figure 38 shows the (1st October 2005 to 30th September 2009) average percentage changes in seasonal soil moisture fluctuation for 40 sensitivity simulations. Each of these changes is the difference in seasonal soil moisture fluctuation between a sensitivity simulation and the simulation for current wetland extent. There is less seasonal soil moisture fluctuation in the wetlands compared to agricultural lands; thus soil moisture fluctuates less when wetlands are restored and fluctuates more when wetlands are drained. Figure 38(a) shows that soil moisture fluctuation increased by about 7.8% when all wetlands were drained and diminished by about 6.5% when all wetlands were restored to the 1949 level. Drainage and restoration of the larger and lower wetlands was effective whilst manipulation of the smaller and upper wetlands had negligible impacts on soil moisture fluctuation.

Depressional Storage Fluctuation

Figure 39 shows the (1st October 2005 to 30th September 2009) average percent changes in seasonal depressional storage fluctuation for 40 sensitivity simulations. Each of these changes is the difference in seasonal storage fluctuation between a sensitivity simulation and the simulation for current wetland extent. There is greater depressional storage when wetlands are restored; thus the depressional storage fluctuation increases when there are more wetlands and decreases when wetlands are drained. Figure 39(a) shows a very strong response from depressional storage fluctuation to wetland drainage or restoration. The depressional storage fluctuation dropped by about 157% when all wetlands were drained and increased by about 122% when all wetlands were restored to the 1949 level. This is the largest percent change of any water balance component, but is expected as it is a direct consequence of wetland manipulation. Interestingly, due to network dynamics, a much reduced response was found when only the upper or lower

wetlands were manipulated, with the largest impact on restoring upper wetlands or draining lower wetlands or draining larger or restoring smaller wetlands.

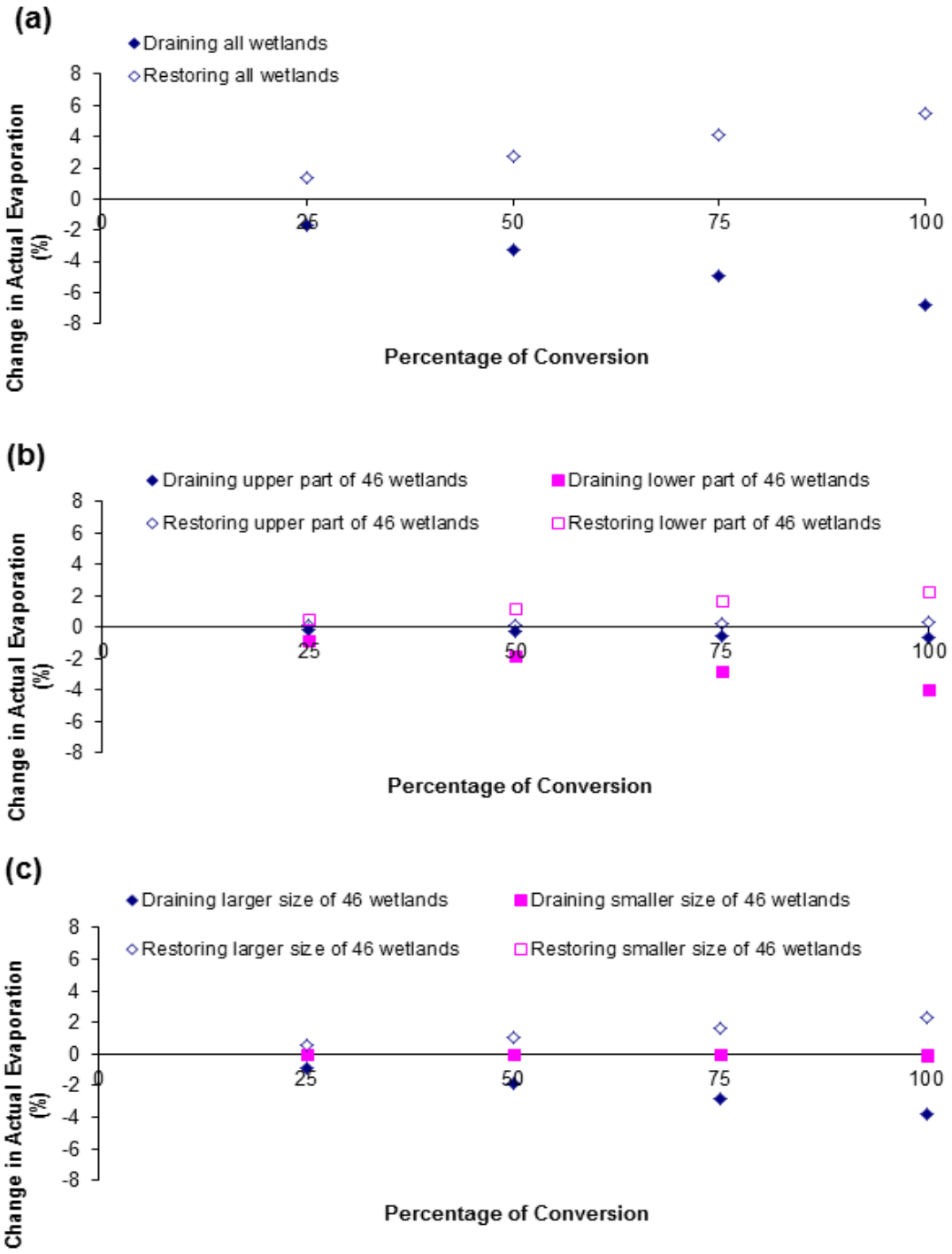

Figure 37. Four-season (1st October 2005 to 30th September 2009) average change in actual evaporation (%) at Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetlands drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

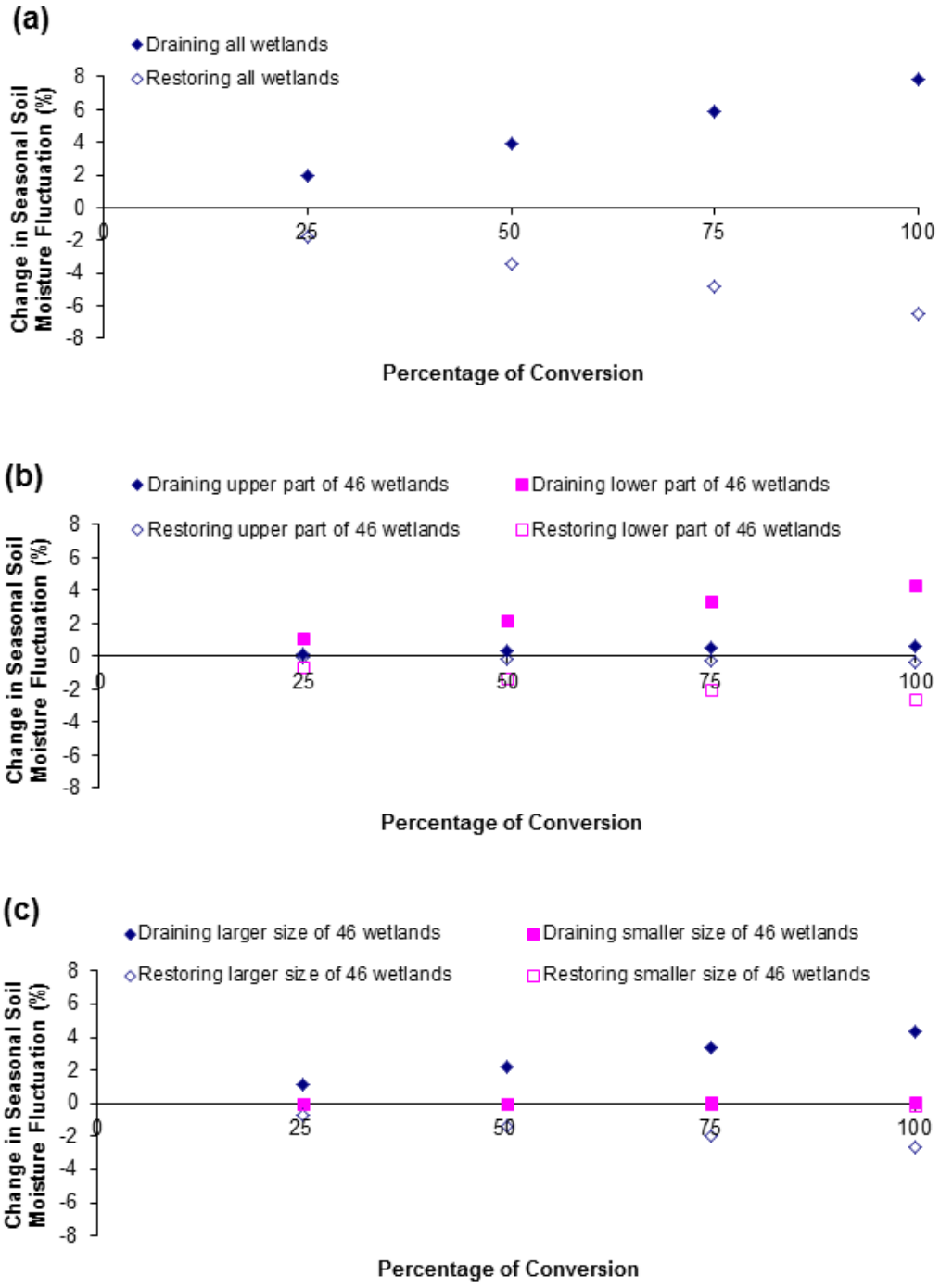

Figure 38. Four-season (1st October 2005 to 30th September 2009) average change in seasonal soil moisture fluctuation (%) at Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetlands drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

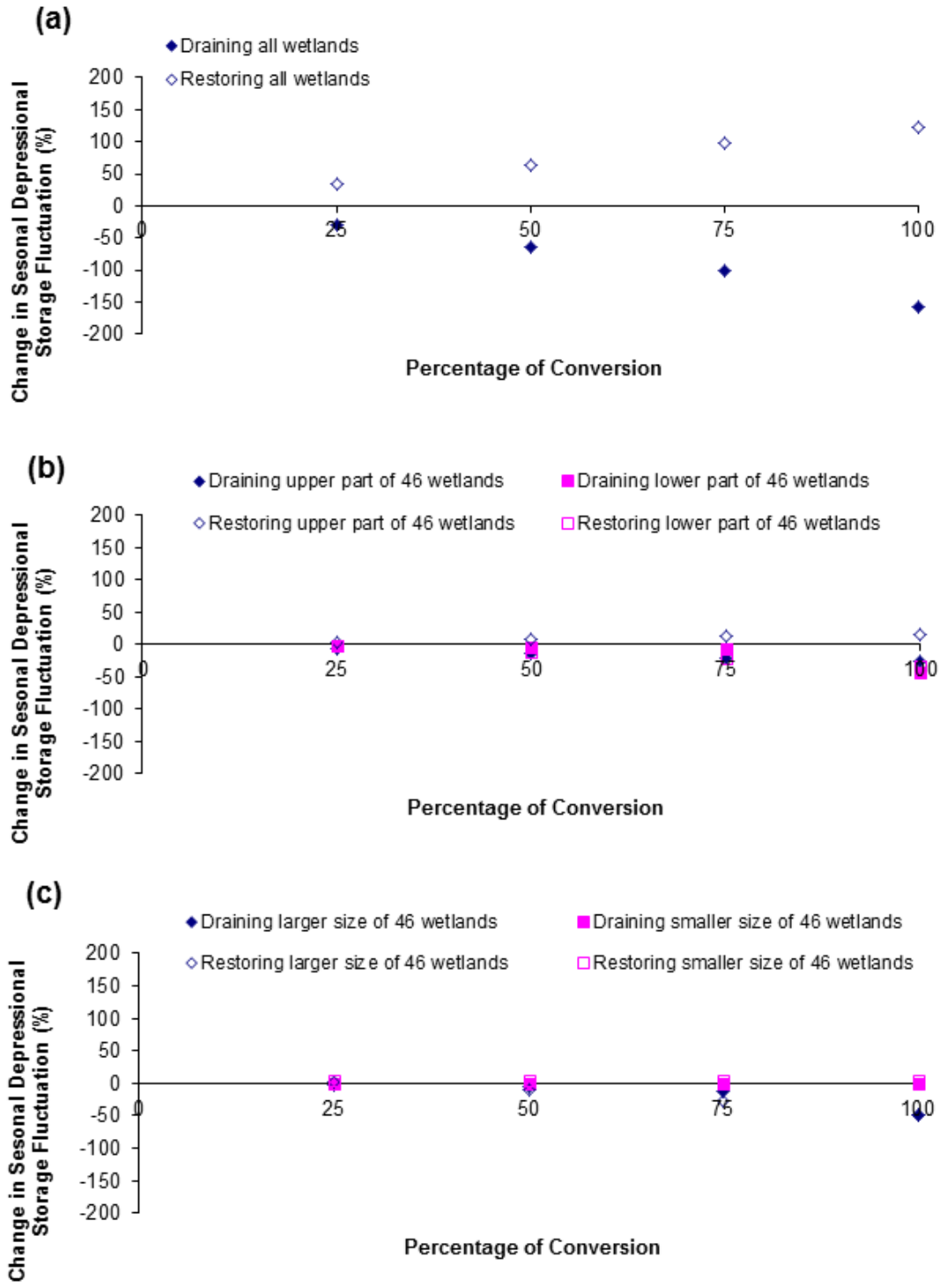

Figure 39. Four-season (1st October 2005 to 30th September 2009) average change in seasonal depressional storage fluctuation (%) at Vermilion River sub-basin 6 for the sensitivity simulations of: (a) all wetlands drainage and restoration, (b) spatial wetland drainage and restoration, and (c) wetland size drainage and restoration.

6.2.2 Sub-basin Streamflow

Streamflow discharge was calculated for all upstream Vermilion River sub-basins (i.e. sub-basins 6, 8, 13, 14, 15, 16, and 17) from all 40 sensitivity simulations as well as the simulation for the current wetland extent. Streamflow from an individual sub-basin is the sum of runoff produced from the sub-basin and that routed through the sub-basin from upstream sub-basins. Figure 40 shows the routing sequence for these upstream Vermilion River sub-basins and indicates that sub-basins 6, 13, 14, and 15 are the first stream order sub-basins, with sub-basins 16, 8, and 17 being the second, third, and fourth stream order sub-basins, respectively. Discharge from the higher-order sub-basins is at a much larger scale than from the first order headwater sub-basins and so comparison yields a scaling analysis of wetland impacts on streamflow as well as a spatial analysis. Sensitivity analysis for the simulated streamflow outputs were conducted and focused on annual discharge, peak discharge, and flow duration. The annual and peak discharges are the cumulative and daily maximum streamflow during the hydrological year (1st October to 30th September). For this study, flow duration is defined as the length of time (days) when the daily streamflow is greater than 5% of average annual discharge.

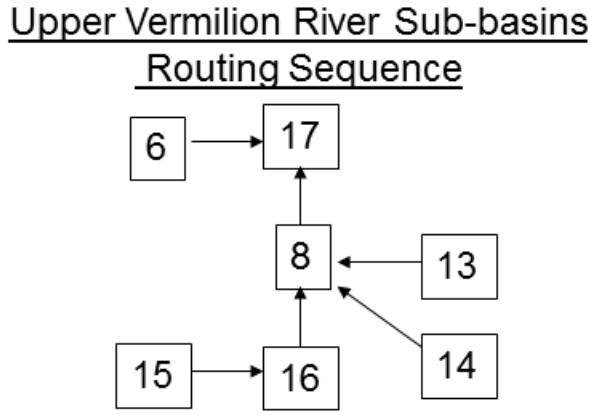

Figure 40. Routing sequence for the upstream Vermilion River sub-basins.

Annual Discharge

Figure 41 shows the four-season (1st October 2005 to 30th September 2009) average percent change in annual discharge for 40 sensitivity simulations conducted for all upstream Vermilion River sub-basins compared to that with current wetland extent. Draining wetlands (Fig. 41a) led to a linear increase in annual discharge from all sub-basins. Discharge from some first order sub-basins was very sensitive to complete drainage, with a 13% increase for sub-basin 13 and 10% increase for sub-basin 14, but other first order sub-basins showed a more modest increase, such as a 2.5% increase for sub-basin 6. At larger scales the responses were more moderate than at smaller scales, with a less than 5% increase for 2nd to 4th order basins – this suggests that the impact of wetland drainage on streamflow is not a strongly emergent at larger scales and that the large scale impacts of drainage are dampened compared to the small scale impacts. Draining the lower wetlands (Fig. 41d) in each sub-basin was five times more effective than draining the upper wetlands (Fig. 41c) and accounted for most of the basin-wide response. Draining the larger wetlands (Fig. 41g) accounted for almost all of the response and draining smaller wetlands (Fig. 41h) had an insubstantial impact on streamflow.

The impact of restoring wetlands (Fig. 41b) was not as dramatic as that of wetland drainage because restoration was limited by the wetland extent (7.5%-9%) estimated for 1949 and so the increase was modest and at most 2.5% of the sub-basin areas. There was a linear decrease in annual discharge with wetland restoration, ranging from 1 to 2.25% for first order basins. The sub-basin that responded most to drainage (13) could not be evaluated for restoration as its current wetland extent is estimated to be *greater* than that in 1949; however sub-basin 14 responded strongly to both drainage and restoration compared to other sub-basins. Decreases in discharge increased with increasing scale and so discharge from the 4th-order sub-basin decreased 3.5% for a wetland restoration of less than 2% of the sub-basin areas. This suggests that the impact of wetland restoration on reducing streamflow is emergent at larger scales. Restoration of the upper wetlands in the sub-basins (Fig. 41e) was very ineffective in reducing annual streamflow (<0.5% reduction), whilst that of lower wetlands (Fig. 41f) was effective and became more important at the largest scales, though it still did not account for the impact of restoring all wetlands (decrease < 2%). Large wetland restoration (Fig. 41i) accounted for almost all decreases in annual discharge with a negligible contribution from restoration of smaller wetlands (Fig 41j).

Peak Discharge

Figure 42 illustrates the four-season (1st October 2005 to 30th September 2009) average percent changes in peak discharge for 40 sensitivity simulations conducted for all upstream Vermilion River sub-basins compared to simulations at current wetland extent. As wetlands were drained, peak discharge increased linearly by up to 10%) for first-order sub-basins, and did not change or decreased linearly by up to 2%) for higher order sub-basins (Fig 42a). The impact of drainage on peak flows at small scales was proportionately smaller than that on annual flows and disappeared or reversed at larger scales; the greatest decrease in peak flow was associated with drainage of the largest higher order sub-basin (17). This is an interesting example of a reverse in the nature of impact with increasing spatial scale – in contrast to that on annual flows which only decreased at larger scales. As with annual discharge, most of the impact on peak discharge was from drainage of lower wetlands in the sub-basins (Fig.42d), rather than upper wetlands (Fig. 42c). Large scale reversal (upper wetlands) or dampening (lower wetlands) of this effect was evident for drainage of higher order sub-basins. Drainage of larger wetlands produced most of the impact (Fig. 42g) with negligible effects from drainage of smaller wetlands (Fig. 42h).

The impact of wetland restoration on peak discharge was highly variable (Fig. 42b) with some first order sub-basins showing an increase of up to 15% (e.g. 14) and some a decrease of up to 10% (e.g. 6). The impact decreased with increasing scale and was small (<2% decrease) at the largest scales suggesting that restoration has a non-emergent impact on peak discharge. The impacts of restoring larger and lower wetlands was clearer – peak discharge from all sub-basins declined with wetland restoration for the lower (Fig. 42f) or larger wetlands (Fig. 42i), but in both cases the impact was smaller at larger spatial scales (<2% decline). The impact on peak discharge of restoring upper (Fig. 42e) and smaller (Fig. 42j) wetlands was mixed and very small.

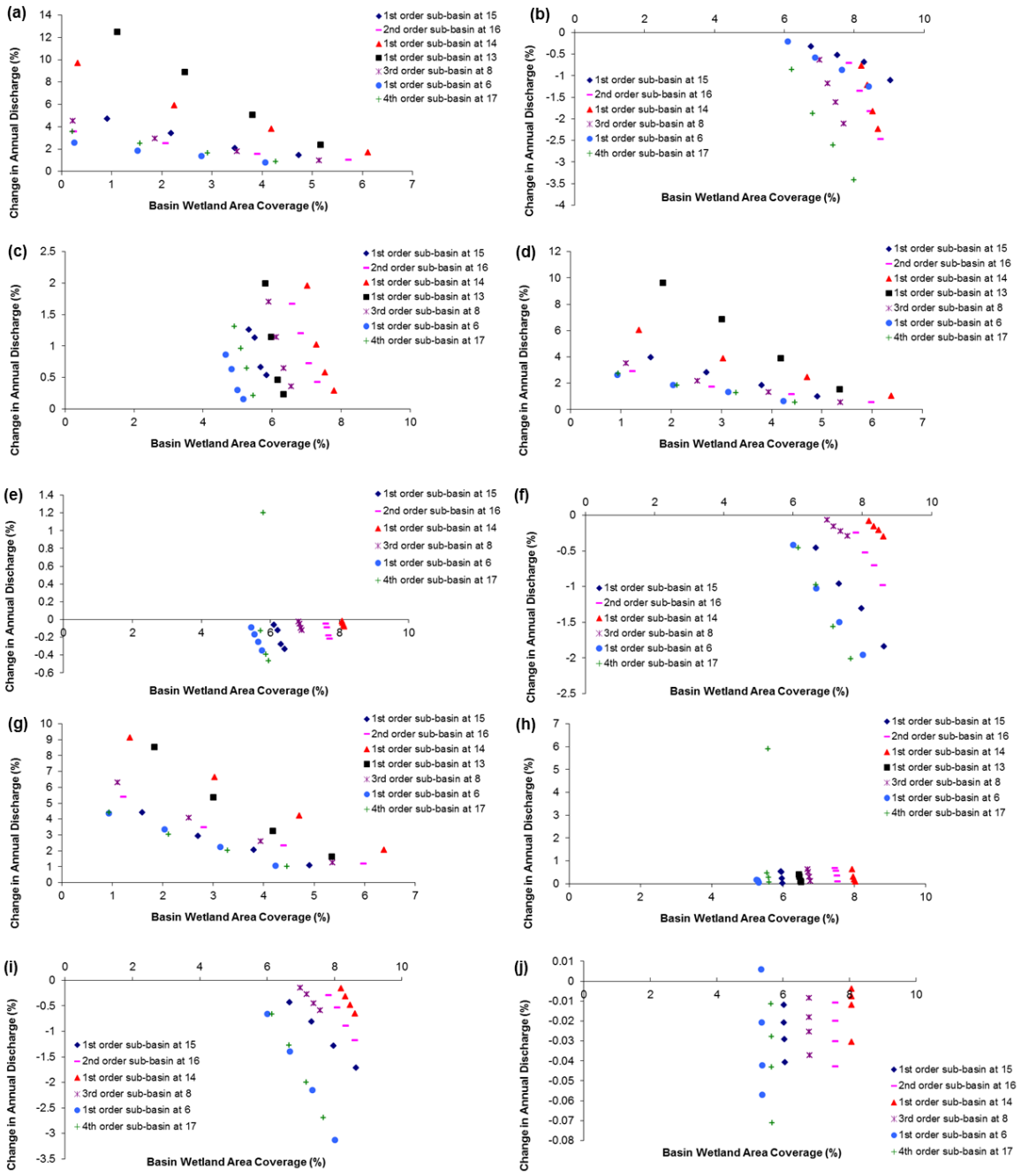

Figure 41. Four-season (1st October 2005 to 30th September 2009) average change in annual discharge (%) from upstream Vermilion River sub-basins for the sensitivity simulations of: (a) draining all wetlands, (b) restoring all wetlands, (c) draining upper part of 46 wetlands, (d) draining lower part of 46 wetlands, (e) restoring upper part of 46 wetlands, (f) restoring lower part of 46 wetlands, (g) draining larger size of 46 wetlands, (h) draining smaller size of 46 wetlands, (i) restoring larger size of 46 wetlands, and (j) restoring smaller size of 46 wetlands.

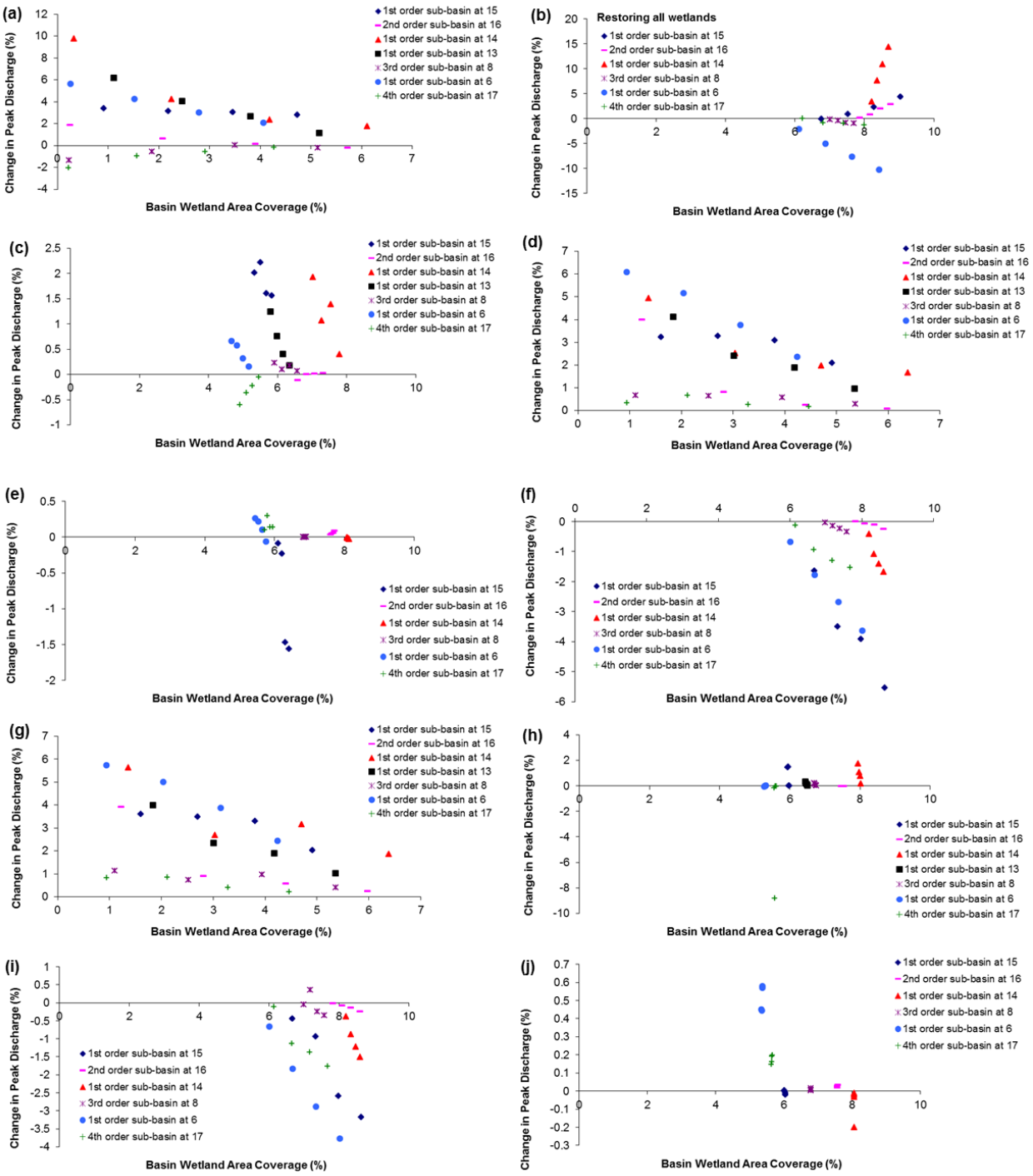

Figure 42. Four-season (1st October 2005 to 30th September 2009) average change in peak discharge (%) for upstream Vermilion River sub-basins for the sensitivity simulations of: (a) draining all wetlands, (b) restoring all wetlands, (c) draining upper part of 46 wetlands, (d) draining lower part of 46 wetlands, (e) restoring upper part of 46 wetlands, (f) restoring lower part of 46 wetlands, (g) draining larger size of 46 wetlands, (h) draining smaller size of 46 wetlands, (i) restoring larger size of 46 wetlands, and (j) restoring smaller size of 46 wetlands.

Flow Duration

Figure 43 illustrates the four-season (1st October 2005 to 30th September 2009) average percent changes in flow duration for 40 sensitivity simulations conducted for all upstream Vermilion River sub-basins compared to simulations with current wetland extent. For this study, flow duration is defined as length of time when the daily streamflow is greater than 5% of average annual discharge. Flow duration was expected to increase with wetland drainage because of the increase in streamflow with drainage. Flow duration increased up to 10% with wetland drainage of the first order sub-basins (Fig. 43a) but this impact decreased with increasing spatial scale and was less than 3% for the largest higher order sub-basin (17) and so may be considered non-emergent with increasing scale. Draining the lower (Fig. 43d) or larger wetlands (Fig. 43g) was found to cause a greater increase in flow duration than draining upper (Fig. 43c) or smaller wetlands (Fig. 43h). In contrast, flow duration for most, but not all, of the first order sub-basins decreased with wetland restoration and this decrease was emergent at larger spatial scales. Restoring all wetlands (Fig. 43b) had the largest impact but restoring the lower (Fig. 43f) or larger wetlands (Fig. 43i) resulted in a greater decrease in flow duration than did restoring the upper (Fig. 43e) or smaller wetlands (Fig. 43j).

6.3 Discussion

Various sensitivity simulations were conducted for the upstream VRB sub-basins. The four-season (1st October 2005 to 30th September 2009) average results for sub-basin 6 indicate that draining wetlands leads to decreases in cumulative snowmelt, actual evaporation, and seasonal depressional storage fluctuations and increases in blowing snow sublimation, infiltration, and seasonal soil moisture fluctuations. The opposite occurs when wetlands are restored. The hydrological cycle, especially streamflow, was particularly sensitive to wetland drainage or restoration. The four-season (1st October 2005 to 30th September 2009) average results for all upstream VRB sub-basins suggest that wetland drainage can increase annual discharge and flow duration. Conversely, wetland restoration can decrease annual discharge and flow duration. The large impact of drainage on reducing the seasonal filling of depressional storage and reducing evapotranspiration means that more water is available for streamflow generation despite reduced snowmelt, increased sublimation, infiltration and soil moisture storage change. Mixed results were found for the impact of wetland manipulation on peak discharge, but, in general, drainage increased it and restoration decreased it at the sub-basin level. The increases in annual discharge, peak discharge and flow duration with wetland drainage declined (or reversed for peak flow) as the spatial scale increased from first order sub-basins, indicating non-emergent behaviour with increasing basin size. These non-emergent impacts are anticipated to be even smaller at the scale of the whole VRB. The effect of wetland restoration on decreasing annual flow and flow duration was retained or even slightly enhanced at larger scales, suggesting emergent behaviour at the scale of the whole VRB.

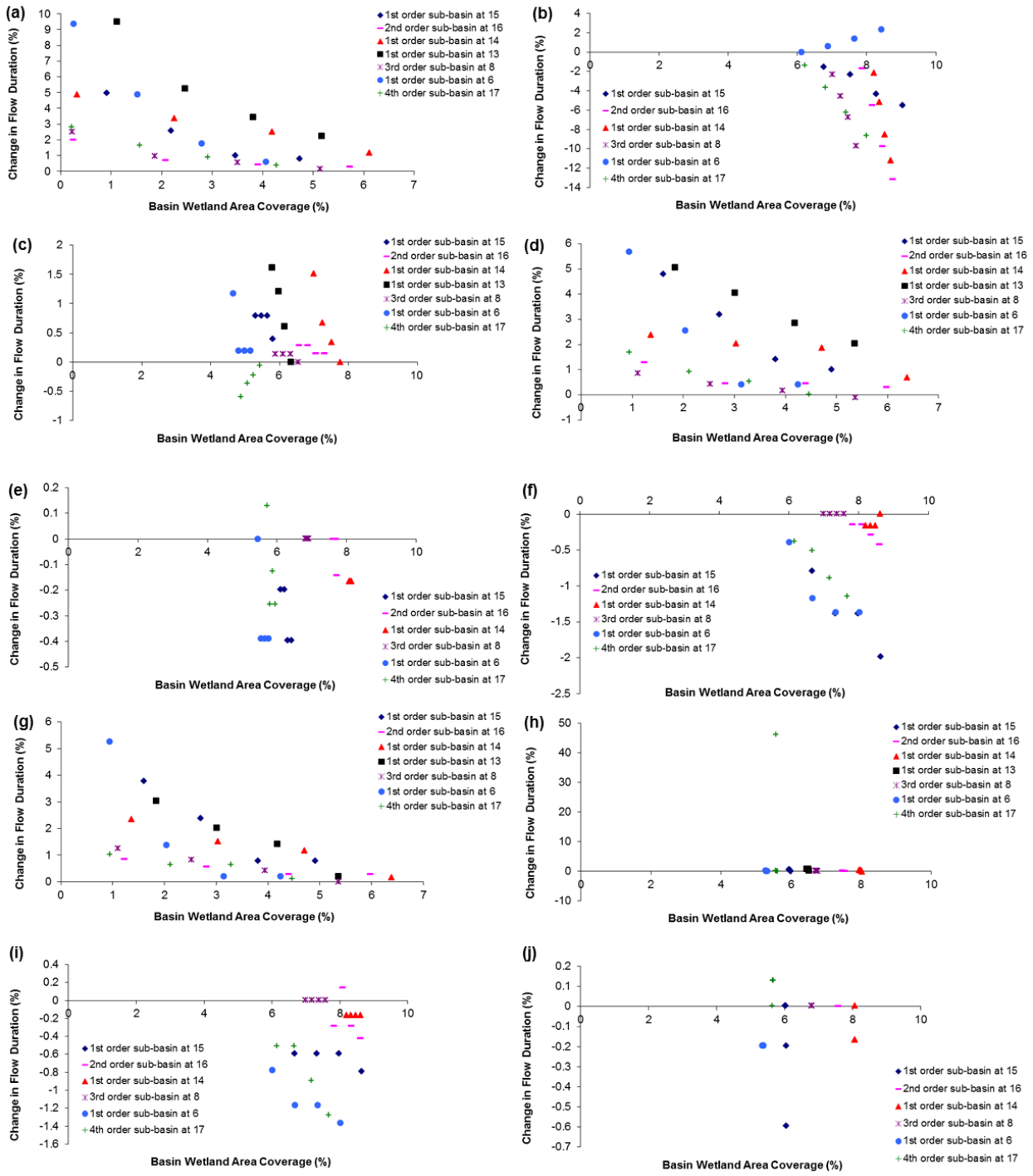

Figure 43. Four-season (1st October 2005 to 30th September 2009) average change in flow duration (%) for upstream Vermilion River sub-basins for the sensitivity simulations of: (a) draining all wetlands, (b) restoring all wetlands, (c) draining upper part of 46 wetlands, (d) draining lower part of 46 wetlands, (e) restoring upper part of 46 wetlands, (f) restoring lower part of 46 wetlands, (g) draining larger size of 46 wetlands, (h) draining smaller size of 46 wetlands, (i) restoring larger size of 46 wetlands, and (j) restoring smaller size of 46 wetlands.

Selective drainage and restoration with respect to wetland size and location was very instructive. Manipulation of larger wetlands in the lower section of each sub-basin caused greater changes (both positive and negative) in annual and peak streamflow and streamflow duration compared to manipulation of smaller wetlands in the upper section of sub-basin. This is partly due to larger wetlands occupying a greater area than smaller wetlands, but also to an apparent gatekeeper function of large wetlands in the lower part of the basin – if they were not filled then they would not pass on inflows received from upstream wetlands (Phillips et al., 2011). The hydrological function of smaller and upper wetlands was small to negligible, but the impact of manipulating only the larger, lower wetlands was less than the impact of manipulating all wetlands in a sub-basin. Clearly, manipulating the gatekeeper wetland function alone is less effective than whole basin wetland manipulation. If upstream flows remain unchanged, then there is much less multiplier effect from manipulating the action of the gatekeeper wetlands.

For the majority of the upstream Vermilion River sub-basins, the increases in annual and peak discharge and flow duration from draining all wetlands in 2004 are less than 13%, and the decreases in annual discharge, peak discharge and flow duration induced by restoring all wetlands (from the number in 2004 to that in 1949) are ~14%. These changes are relatively moderate compared to Smith Creek Research Basin (SCRB) in Saskatchewan (Pomeroy *et al*., 2010) due to the relatively small coverage and drainage of wetlands in the VRB. Figure 44 shows the historical and current levels of basin wetland coverage for VRB and SCRB. Historical (1949) and current (2004) wetland coverage are 7.4% and 6% of VRB, while wetland coverage are 16.6% historically (1958) and 8.9% currently (2007) of SCRB. Although the wetland coverage data for both basins were acquired from DUC, the very low historical level of wetland coverage in VRB triggered an investigation into data quality. The VRB historical and current DUC wetland inventories made available for this study are interim products, and so it would be useful to incorporate the DUC final wetland inventory in future studies.

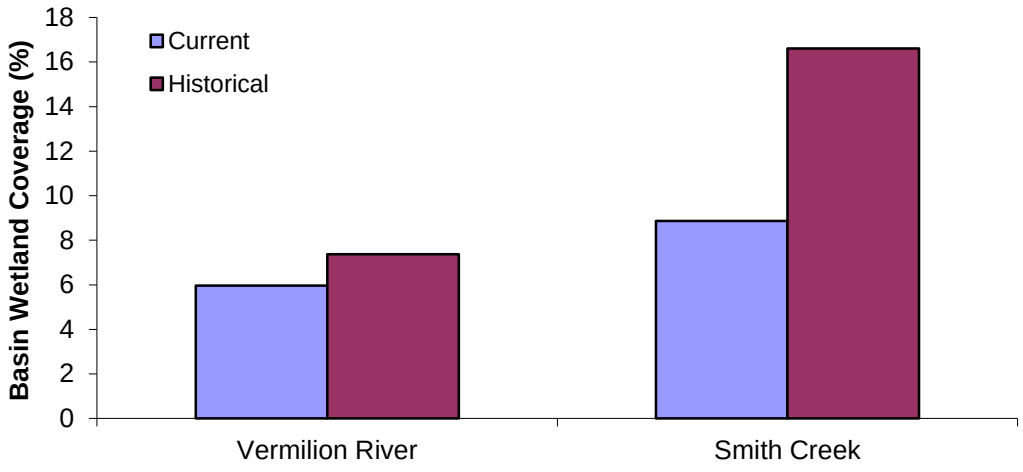

Figure 44. Historical and current levels of basin wetland coverage for Vermilion River Basin, AB and Smith Creek Research Basin, SK.

7 Scenario Simulations for the Upper Vermilion River Basin

7.1 Description of the scenario simulations

The sensitivity simulations conducted for the upper Vermilion River Basin in the previous section used a range of changes in wetland area coverage deriving from various levels and patterns of wetland drainage or restoration. For this section, specific scenarios were selected from the range of sensitivity analyses and corresponding simulations were carried. The scenario simulations used the same improved model setup of CRHM as did the sensitivity simulations. Four scenarios were developed in consultation with the Vermilion Watershed Management Project Steering Committee and are described as follows.

1) Enlarged Gatekeeper Wetland. The sensitivity simulations showed that manipulation of larger wetlands in the lower section of basin was more effective in affecting streamflow. Scenarios were created to explore the effectiveness of manipulating one large wetland in the lower basin (a gatekeeper wetland) to manage streamflow. Wetland #43 was identified as the largest wetland in the lower part (i.e. from Wetland #25 to #46) of the dynamical depressional storage network shown in Figs. 23 and 26. The depressional storage capacity for Wetland #43 was enlarged four times from its current depressional storage capacity. Other parameters remained unchanged.

2) Extremely Wet Condition. There was no significant flooding during the simulation period of 1st October 2003 to 30th September 2009 and so extremely wet conditions were not simulated. To examine the basin response to wet conditions, precipitation during this period was tripled, using a multiplier on all measured precipitation events. No parameters values were altered.

3) Extremely Wet Condition with Enlarged Gatekeeper Wetland. This combines the Scenarios 1) and 2): depressional storage capacity for the gatekeeper wetland #43 was enlarged four times from its current value and precipitation during 1st October 2003 to 30th September 2009 was tripled.

4) Draining Gatekeeper Wetland. The gatekeeper wetland, #43, was drained, and its depressional storage capacity was reduced to zero from 1st November to 1st March of each season. Outflow from the gatekeeper wetland #43 was restricted using two culverts of 1.5 m diameter and maximum 2 m ponding depth.

In total, four scenario simulations and one simulation for the current wetland extent and climate were conducted for the period of 1st October 2003-30th September 2009. These simulations all used the period of 1st October 2003-30th September 2005 for spinning up initial conditions of depressional storage, and the simulations results generated in the succeeding four seasons from 1st October 2005 to 30th September 2009 were used for the analysis.

7.2 Results and Discussion

For the scenario simulations, streamflow outputs (i.e. annual discharge, peak discharge, and flow duration) were produced and analyzed for upstream Vermilion River sub-basins: 6, 8, 13, 14, 15, 16, and 17. Figure 44 shows the four-season (1st October 2005 to 30th September 2009) average changes in streamflow (as a %) for the scenarios of enlarged and drained gatekeeper wetland. Each change is the difference between a scenario simulation and the simulation for current wetland extent. For the scenario where the depressional storage capacity of gatekeeper wetland was enlarged four times, annual discharge, peak discharge, and flow duration decreased for the 1st stream order sub-basins (6, 13, and 14), with sub-basin 13 having the largest impact (-4% for annual discharge and -9% for peak discharge). Interestingly, there were increases in the annual discharge, peak discharge, and flow duration for the 1st stream order sub-basin 15 under this scenario. As sub-basin size increased, there was <1% increase in annual discharge and peak discharge and <0.3% decrease in flow duration for the 2nd stream order sub-basin 16. But, this trend reversed at larger spatial scales. There was a <1% decrease in annual discharge and peak discharge and ~0.3% increase in flow duration for the 3rd stream order sub-basin 8. The trend was not apparent at the largest scale; at the sub-basin 17 (i.e. the 4th stream order sub-basin) there was little change in streamflow as a result of enlarging the gatekeeper wetland. These results suggest that the decreases in streamflow, peak and duration with gatekeeper enlargement sometimes found in small basins are not evident at larger scales, and therefore non-emergent with increasing scale.

For the scenario of draining the gatekeeper wetland, there was a <2% decrease in the annual discharge from the sub-basins 8, 13, 14, 15, and 16 and a 1% increase in the annual discharge from sub-basin 6. Draining the gatekeeper wetland resulted in ~2% increase in peak discharge for sub-basin 15, a <1.2% decrease in peak discharge for sub-basin 6, 8, 14, 16, and a decrease of 7.5% for sub-basin 13. Draining the gatekeeper wetland had little effect on flow duration. For the streamflow from all upper Vermilion River sub-basins outlet at the sub-basin 17, draining the gatekeeper wetland led to very small changes: ~0.1% increase in annual discharge, 0.7% decrease in peak discharge and 0.5% rise in flow duration. Overall, the effect of draining the gatekeeper wetland was inconsistent across sub-basins; cumulatively, it had an insignificant impact on streamflow at larger scales.

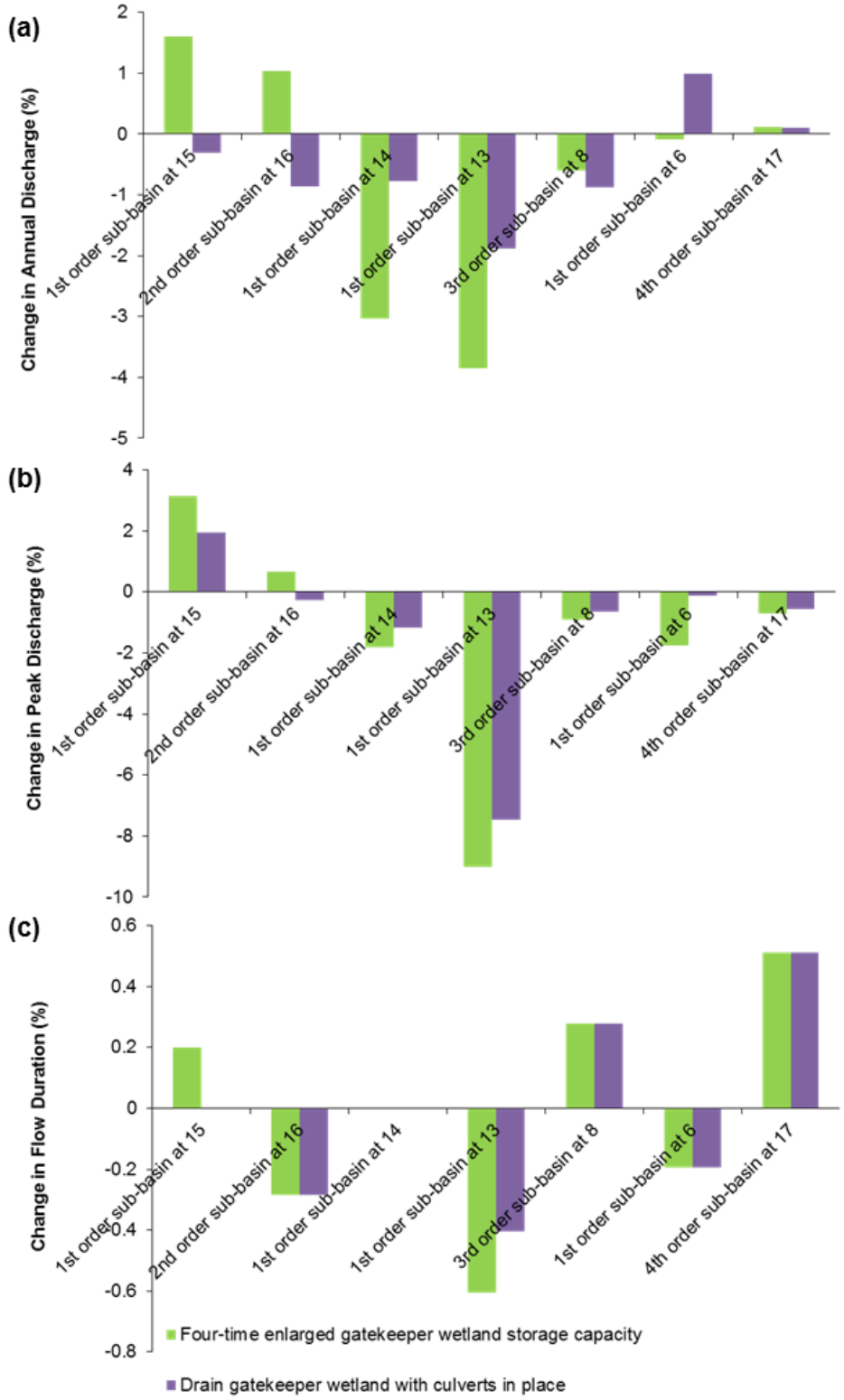

Figure 45. Four-season (1st October 2005 to 30th September 2009) average change (%) in upstream Vermilion River sub-basins for the scenarios of enlarged gatekeeper wetland and drained gatekeeper wetland: (a) annual discharge, (b) peak discharge, and (c) flow duration.

Figure 46 shows the four-season (1st October 2005 to 30th September 2009) average change in streamflow for the scenarios of extreme wet condition with and without enlarging the gatekeeper wetland. Tripling precipitation created an extreme wet condition, which caused drastic increases in streamflow. Increases in annual discharge from the upstream Vermilion River sub-basins ranged from 425% for sub-basin 15 to 565% for sub-basin 13. Large increases were also found in the peak discharge as result of the extreme wet condition, ranging from 250% for sub-basin 15 to 480% for sub-basin 13. Much smaller changes to flow duration occurred from the extreme wet condition; <1% increase for sub-basin 14 to a 21% increase for sub-basin 13. When enlarging the depressional storage capacity of gatekeeper wetland four times under the extreme wet condition, Figure 44 shows that identical increases occur to annual discharge, peak discharge and flow duration. This implies that the single gatekeeper wetland is not sufficient to influence the hydrology of extremely wet condition and its storage capacity is simply overwhelmed.

The gatekeeper wetland functions as a dam to reduce the volume and peak streamflow in most cases. The scenario results confirm that the single gatekeeper wetland can reduce streamflow volume and peak for smaller sized sub-basins if its storage capacity is increased. The effect of the enlarged gatekeeper wetland on reducing streamflow is lessened (or even reversed) as basin size increases. Also shown was that the single gatekeeper wetland does not effectively reduce streamflow under extremely wet conditions, as its storage capacity is overwhelmed by the available runoff. Though ineffective for extremely wet conditions, the enlarged gatekeeper is effective in reducing flows at small scales under moderate and dry conditions.

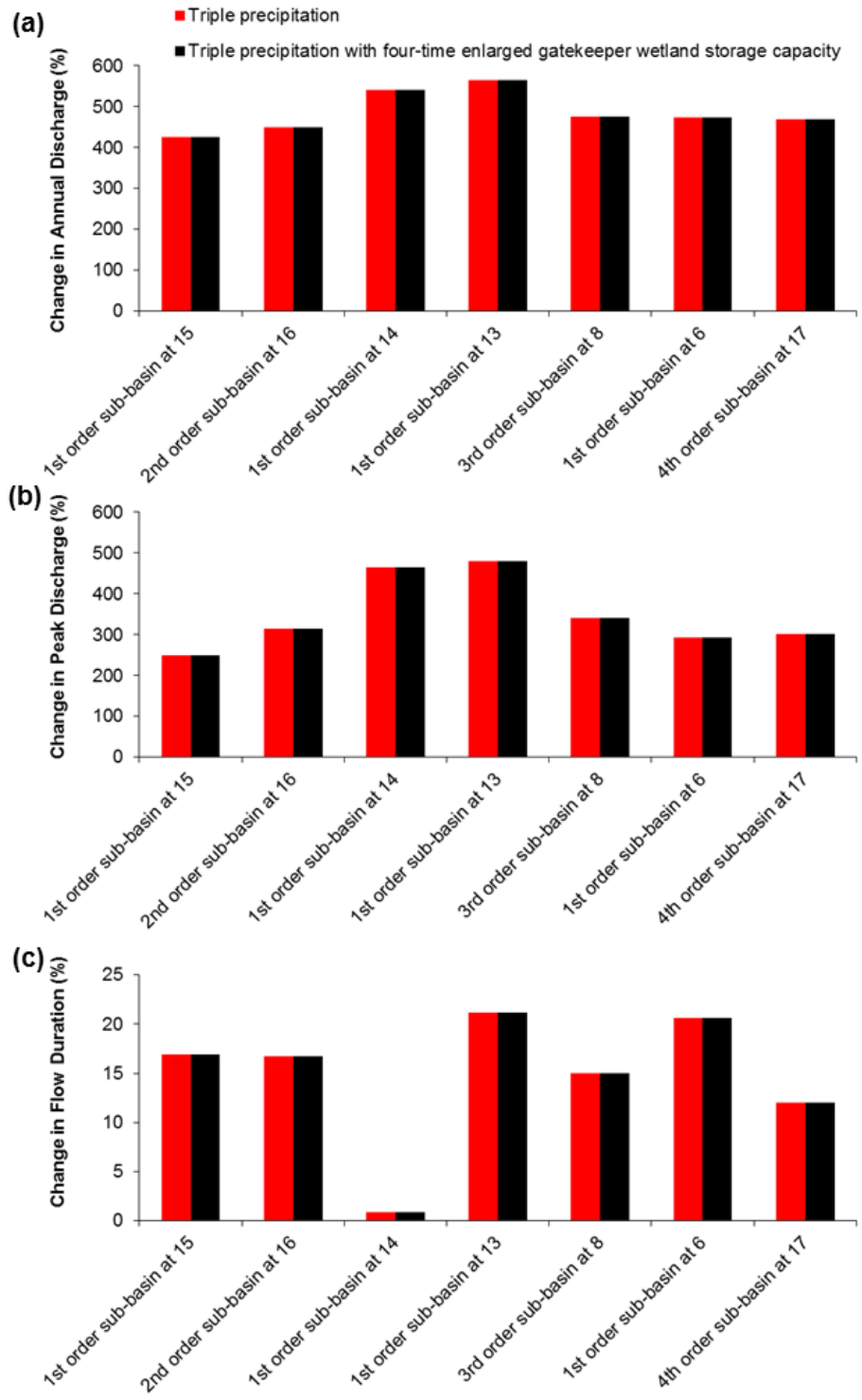

Figure 46. Four-season (1st October 2005 to 30th September 2009) average change (%) in upstream Vermilion River sub-basins for the scenarios of extremely wet condition with and without enlarging gatekeeper wetland: (a) annual discharge, (b) peak discharge, and (c) flow duration.

8 Conclusions and Recommendations

The original CRHM Prairie Hydrological Model with a single wetland simulation predicted soil moisture in the growing season reasonably well and provided a fair prediction of snow accumulation. There was better predictive capability in the upper part of VRB than the lower part. The middle section of Vermilion River has been channelized and operation of the Morecambe structure further complicates streamflow prediction as control structure operation must be taken into account. The structure operation has many hydraulic and engineering guidelines and its simulation is better suited to water management models than to hydrological models such as CRHM. The streamflow response of the Vermilion River Basin at its mouth was found to be dominated by channel hydraulics and control structures. It is influenced by wetlands only to the extent that the management regime of these control structures is affected by tributary hydrological behaviour with respect to volume and timing of streamflow inputs. Thus, changes to wetland storage in the upper basin are unlikely to affect streamflows in the lower basin. Streamflow regime in the upper basin results from basin hydrological processes rather than in-stream water management and channel modifications and thus is more likely to show an impact from manipulation of wetland storage.

The upstream tributaries that are much more sensitive to wetland extent and capacity were therefore the subject of further focused study and model evaluation. Improvement to the initial CRHM prairie hydrological model setup for Vermilion River Basin was made by including a dynamical wetland network in each sub-basin, improving maximum depressional storage parameterisation, estimating annual initial conditions for depressional storage, interpolating precipitation amounts and updating forest canopy and soil infiltration modules. Replacing the single wetland HRU with the dynamical depressional storage network (i.e. fill-and-spill drainage interaction between wetlands) improved predictions of seasonal and peak discharges, which are the primary concerns of watershed managers and land owners.

Various types of sensitivity simulations were conducted for the upstream VRB sub-basins using the improved CHRM model setup. Hydrological processes were examined in detail for sub-basin 6. The results indicate that draining wetlands leads to decreases in cumulative snowmelt, actual evaporation, and seasonal depressional storage fluctuations and causes increases in blowing snow sublimation, infiltration, and seasonal soil moisture fluctuations. The opposite occurs when wetlands are restored. Streamflow was examined for all upstream VRB sub-basins and the results suggest that wetland drainage leads to increases in annual discharge and flow duration. Conversely, wetland restoration causes decreases in annual discharge and flow duration. The large impact of drainage on reducing storage and evapotranspiration means that more water is available for streamflow generation despite reduced snowmelt, increased sublimation, infiltration and soil moisture storage change. Mixed results were found for the impact of wetland manipulation on peak discharge, but, in general, drainage increased it and restoration decreased it at the sub-basin scale. The increases in annual discharge, peak discharge and flow duration with wetland drainage declined as the spatial scale increased from first order (headwater) sub-basins to larger downstream sub-basins, indicating non-emergent behaviour with increasing basin size. These non-emergent drainage impacts are anticipated to be even smaller at the scale of the whole VRB due to streamflow management at the large control

structures in the lower river basin. The impacts of wetland restoration on decreasing annual flow and flow duration were retained or even slightly increased at larger scales suggesting emergent behaviour for restoration impacts at the scale of the whole VRB.

The selective drainage and restoration with respect to wetland size and location was very instructive. Manipulation of larger wetlands in the lower section of each sub-basin was found to cause greater changes (positive and negative) in annual and peak streamflow and streamflow duration compared to manipulation of smaller wetlands in the upper section of sub-basin. This is partly due to larger wetlands occupying a greater area than smaller wetlands, but also due to an apparent gatekeeper function for large wetlands in the lower part of the basin – if they were not filled then they would not pass on inflows received from upstream wetlands. The hydrological function of smaller and upper wetlands was not important itself, but the impact of manipulating the larger, lower wetlands did not equal the impact of manipulating all wetlands in a sub-basin. Clearly, manipulating the gatekeeper wetland function alone is less effective than manipulating wetlands in the whole basin. If upstream flows are not impacted then there is a much smaller multiplier effect from manipulating the action of the downstream gatekeeper wetlands.

Scenario simulations used the same improved model setup of CRHM as the sensitivity simulations and examined i) enlarged gatekeeper wetland in each sub-basin, ii) extreme wet conditions, iii) extreme wet conditions with an enlarged gatekeeper wetland and iv) draining the gatekeeper wetland. The results indicate that decreases in streamflow, peak and duration with gatekeeper enlargement are sometimes found in small basins, but are not evident at larger scales and therefore non-emergent with increasing scale. Draining the gatekeeper wetland led to inconsistent responses in various sub-basins that accumulated to an insignificant impact on streamflow at larger scales. Tripling precipitation created extremely wet conditions, which caused drastic increases in streamflow, mainly because storage was overwhelmed. Enlarging the depressional storage capacity of gatekeeper wetland under the extremely wet condition had no impact on annual discharge, peak discharge and flow duration compared to original wetland extent. This suggests that a single gatekeeper wetland cannot be sufficiently enlarged to influence the hydrology of extremely wet conditions at VRB. However, the enlarged gatekeeper was effective in reducing flows at small scales under moderate and dry conditions.

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10 References

Alberta Environment. 2006. Vermilion River Structures Operating Guidelines – Draft.

Armstrong, R.L., Pomeroy, J.W. and L.W. Martz. 2008. Evaluation of three evaporation estimation methods in a Canadian prairie landscape. *Hydrological Processes*, 22(15). 2801-2815.

Ayers, H.D. 1959. Influence of soil profile and vegetation characteristics on net rainfall supply to runoff. In Proceedings of Hydrology Symposium No.1: Spillway Design Floods, NRCC, Ottawa, 198-205.

Chow, V.T. 1959. *Open Channel Hydraulics*. McGraw-Hill, Inc. New York, USA.

Chow, V.T. 1964. *Handbook of Applied Hydrology*. McGraw-Hill, Inc. New York, USA.

Currie, D.V. and Zacharko, N. 1976. Hydrogeology of the Vermilion area, Alberta. Alberta Research Council, Report 75-5, 18pp.

Dornes, P.F., Pomeroy, J.W., Pietroniro, A., Carey, S.K. and Quinton, W.L. 2008. Influence of landscape aggregation in modelling snow-cover ablation and snowmelt runoff in a sub-arctic mountainous environment. *Hydrological Sciences Journal*, **53**(4), 725-740.

Elliott, J.A. and Efetha, A.A. 1999. Influence of tillage and cropping system on soil organic matter, structure and infiltration in a rolling landscape. *Canadian Journal of Soil Science* **79**: 457–463.

Ellis, C.R., Pomeroy, J.W., Brown, T. and MacDonald, J. 2010. Simulation of snow accumulation and melt in needleleaf forest environments. *Hydrology and Earth System Sciences* **14**: 925-940.

Environment Canada. 2010. Canadian climate normals 1971-2000. Retrieved: September 10, 2010. [Web Page]. Available at: http://climate.weatheroffice.gc.ca/climate_normals/index_e.html.

Fang, X., Pomeroy, J.W., Westbrook, C.J., Guo, X. Minke, A.G. and Brown, T. 2010. Prediction of snowmelt derived streamflow in a wetland dominated prairie basin. *Hydrology and Earth System Sciences* **14**: 991-1006.

Garbrecht, J. and Martz, L.W. 1993. Network and subwatershed parameters extracted from digital elevation models: The Bills Creek experience. *Water Resource Bulletin* **29**: 909-916.

Garbrecht, J. and Martz, L.W. 1997. The assignment of drainage direction over flat surfaces in raster digital elevation models. *Journal of Hydrology* **193**: 204-213.

Garnier, B.J. and Ohmura, A. 1970. The evaluation of surface variations in solar radiation income. *Solar Energy* **13**: 21-34.

Godwin, R.B. and Martin, F.R.J. 1975. Calculation of gross and effective drainage areas for the Prairie Provinces. In: *Canadian Hydrology Symposium - 1975 Proceedings, 11-14 August 1975, Winnipeg, Manitoba.* Associate Committee on Hydrology, National Research Council of Canada, pp. 219-223.

Golder Associates. 2009. Vermilion River Water Supply and Demand Study. Golder Associates, Ltd. Report Number: 08-1326-0031, Calgary, Alberta, 71pp.

Granger, R.J. and Gray, D.M. 1989. Evaporation from natural non-saturated surfaces. *Journal of Hydrology* **111**: 21–29.

Gray, D.M. 1970. *Handbook on the Principles of Hydrology: with special emphasis directed to Canadian conditions in the discussions, applications and presentation of data*. New York: Water Information Center, Inc..

Gray, D.M., Landine, P.G. and Granger, R.J. 1985. Simulating infiltration into frozen Prairie soils in stream flow models. *Canadian Journal of Earth Science* **22**: 464-474.

Gray, D.M. and Landine, P.G. 1987. Albedo model for shallow prairie snow covers. *Canadian Journal of Earth Sciences* **24**: 1760-1768.

Gray, D.M. and Landine, P.G. 1988. An energy-budget snowmelt model for the Canadian Prairies. *Canadian Journal of Earth Sciences* **25**: 1292-1303.

Gray, D.M., Toth, B., Zhao, L., Pomeroy, J.W. and Granger, R.J. 2001. Estimating areal snowmelt infiltration into frozen soils. *Hydrological Processes* **15**: 3095-3111.

Hayashi, M., van der Kamp, G. and Rudolph, D.L. 1998. Water and solute transfer between a prairie wetland and adjacent uplands, 1. Water balance. *Journal of Hydrology* **207**: 42-55.

Hayashi, M., van der Kamp, G. and Schmidt, R. 2003. Focused infiltration of snowmelt water in partially frozen soil under small depressions. *Journal of Hydrology* **270**: 214-229.

LaBaugh, J.W., Winter, T.C. and Rosenberry, D.O. 1998. Hydrologic functions of prairie wetlands, *Great Plains Research* **8**, 17-37.

Lapen, D.R. and Martz, L.W. 1993. The measurement of two simple topographic indices of wind sheltering exposure from raster digital elevation models. *Computer & Geosciences* **19**: 769-779.

Leavesley, G.H., Lichty, R.W., Troutman, B.M. and Saindon, L.G. 1983. Precipitation-runoff modelling system: user's manual. US Geological Survey Water Resources Investigations Report 83-4238. 207 pp.

Male, D.H. and Gray, D.M. 1981. Snowcover ablation and runoff. In Gray, D.M. and Male, D.H. (Eds.), *Handbook of Snow: principles, processes, management & use.* Ontario: Pergamon Press Canada Ltd., pp. 360-436.

North Saskatchewan Watershed Alliance. 2005. State of the North Saskatchewan Watershed Report – A Foundation for Collaborative Watershed Management. North Saskatchewan Watershed Alliance, Edmonton, Alberta, 202pp.

Ogden, F.L. and Saghafian, B. 1997. Green and Ampt infiltration with redistribution. *Journal of Irrigation and Drainage Engineering* **123**: 386-393.

Phillips, R. W., Spence, C., and Pomeroy, J. W. (2011). Connectivity and runoff dynamics in heterogeneous basins. *Hydrological Processes*, *3075*(May), 3061-3075. doi:10.1002/hyp.8123

Pomeroy, J.W., Gray, D.M. and Landine, P.G. 1993. The prairie blowing snow models: characteristics, validation, operation. *Journal of Hydrology* **144**: 165-192.

Pomeroy, J.W., R. Granger, A. Pietroniro, J. Elliott, B. Toth and N. Hedstrom. 1999. Classification of the boreal forest for hydrological processes. In, (ed. Severin Woxholtt) *Proceedings, the Ninth International Boreal Forest Research Association Conference, Oslo, September 21-23, 1998. Aktuelt fra skogforskningen, 4/99, Norsk institutt for skogforskning*. Norwegian Forest Research Institute, Oslo. 49-59.

Pomeroy, J.W. and Li, L. 2000. Prairie and Arctic areal snow cover mass balance using a blowing snow model. *Journal of Geophysical Research* **105**: 26619-26634.

Pomeroy, J.W., Gray, D.M., Brown, T., Hedstrom, N.R., Quinton, W., Granger, R.J. and Carey, S. 2007. The Cold Regions Hydrological Model, a platform for basing process representation and model structure on physical evidence. *Hydrological Processes* **21**: 2650-2667.

Pomeroy, J.W., Fang, X. and Ellis, C. 2012. Sensitivity of snowmelt hydrology in Marmot Creek, Alberta to forest cover disturbance. *Hydrological Processes*, DOI: 10.1002/hyp.9248

Pomeroy, J.W., Fang, X., Westbrook, C., Minke, A., Guo, X. and Brown, T. 2010. Prairie Hydrological Model Study Final Report. Centre for Hydrology Report No. 7, University of Saskatchewan, Saskatoon, 113pp.

Priestley, C.H.B. and Taylor, R.J. 1972. On the assessment of surface heat flux and evaporation using large-scale parameters. *Monthly Weather Review* **100**: 81-92.

Shapiro, M., and Westervelt, J. (1992). *An Algebra for GIS and Image Processing* (pp. 1-22).

Shook, K.R. and Pomeroy, J.W. 2011a. Synthesis of incoming shortwave radiation for hydrological simulation. *Hydrology Research* **42**: 433-446.

Shook, K.R. and Pomeroy, J.W. 2011b. Memory effects of depressional storage in Northern Prairie hydrology. *Hydrological Processes* **25**: 3890-3898.

Sicart, J.E., Pomeroy, J.W., Essery, R.L.H., Hardy, J., Link, T. and Marks, D. 2004. A sensitivity study of daytime net radiation during snowmelt to forest canopy and atmospheric conditions. *Journal of Hydrometeorology* **5**: 774-784.

Statistics Canada. 2006. 2006 Census of Agriculture, Farm Data and Farm Operator Data, catalogue no. 95-629-XWE.

van der Kamp, G. and Hayashi, M. 1998. The groundwater recharge function of small wetlands in the semi-arid Northern Prairies. *Great Plains Research* **8**: 39-56.

van der Kamp, G. and Hayashi, M. 2009. Groundwater-wetland ecosystem interaction in the semiarid glaciated plains of North America. *Hydrogeology Journal* **17**: 203-214.

Walmsley, J.L., Taylor, P.A. and Salmon, J.R. 1989. Simple guidelines for estimating windspeed variations due to small-scale topographic features – an update, *Climatological Bulletin* **23**: 3-14.

11 Appendices

Appendix 1 Basin physiographic parameters for the initial model setup

The tables below are the values of area, elevation, and slope of HRUs at 23-sub-basins used in the initial model setup. They were derived from the landuse generalization and terrain preprocessing procedures.

Table A1. Area (km^2) of HRUs at 23 sub-basins in the initial model setup for the Vermilion River Basin.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	0.98	3.31	3.11	5.93	4.08	1.03	13.28	5.27	9.59	16.65	10.60	4.05	0.07	0.69	0.00	1.49	2.27	1.03	3.07	2.17	1.04	0.16	0.87
Cropland (fallow)	3.20	16.84	7.51	11.23	5.93	5.65	23.53	14.40	14.38	27.68	8.98	8.25	1.20	4.43	1.71	10.10	8.74	9.04	9.57	8.53	4.27	1.81	1.86
Cropland (stubble)	98.41	518.08	231.13	345.42	182.25	173.69	723.59	442.99	442.24	851.34	276.09	253.67	36.93	136.14	52.57	310.79	268.73	278.10	294.39	262.38	131.31	55.77	57.14
Grassland	0.00	26.31	0.00	4.00	0.00	7.00	56.87	26.70	105.67	204.92	41.46	26.96	6.96	12.96	0.09	8.43	26.34	0.00	7.79	0.00	0.00	0.00	1.62
Shrubland	0.49	8.63	1.18	10.04	0.36	0.09	9.27	1.72	2.33	4.89	1.30	1.86	0.04	0.06	0.86	3.46	0.88	0.96	5.60	0.20	0.27	0.00	0.68
Woodland	4.15	45.23	4.14	68.23	4.05	4.90	29.55	9.52	18.68	26.75	7.97	17.41	1.01	0.98	0.71	4.58	4.82	4.51	52.50	10.98	3.88	1.42	11.14
Wetland	1.04	9.11	1.40	2.68	0.09	1.56	12.22	3.69	8.85	25.85	6.08	10.92	0.13	1.45	0.39	4.48	3.53	0.13	7.72	0.22	0.01	1.30	0.68
Open Water	0.49	3.28	0.60	9.95	0.96	0.22	31.12	0.41	0.27	4.41	2.42	4.45	0.01	0.06	0.00	0.79	0.34	0.06	7.81	0.05	0.10	1.71	1.50
Channel	0.10	0.93	0.14	0.41	0.23	0.12	0.78	0.48	0.85	1.99	0.60	0.46	0.05	0.14	0.07	0.36	0.45	0.21	0.25	0.17	0.16	0.05	0.11

Table A2. Averaged elevation (m) of HRUs at 23 sub-basins in the initial model setup for the Vermilion River Basin.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	615.8	657.8	613.9	612.7	626.4	654.2	648.1	675.8	607.6	618.3	610.6	646.5	652.5	679.2	n/a	701.0	642.7	634.0	654.9	657.9	636.9	649.1	618.0
Cropland (fallow)	621.8	652.6	622.2	630.6	624.2	662.2	674.2	680.0	613.1	624.9	631.1	663.5	665.9	676.5	712.4	700.3	654.5	636.6	662.0	656.9	636.0	633.2	633.6
Cropland (stubble)	621.8	652.6	622.2	630.6	624.2	662.2	674.2	680.0	613.1	624.9	631.1	663.5	665.9	676.5	712.4	700.3	654.5	636.6	662.0	656.9	636.0	633.2	633.6
Grassland	0.0	632.7	0.0	662.6	0.0	666.8	656.2	667.6	588.8	612.8	611.9	652.9	665.5	674.3	717.2	689.2	659.9	0.0	671.9	0.0	0.0	0.0	649.6
Shrubland	633.0	674.1	648.7	646.5	617.8	670.2	679.4	699.1	598.1	670.6	676.7	668.6	676.9	684.0	713.8	710.9	670.6	633.6	659.1	632.6	626.2	0.0	675.0
Woodland	621.2	657.7	634.0	649.6	621.8	665.2	664.8	682.4	599.8	624.1	615.1	663.1	663.5	675.4	714.3	704.9	654.7	647.4	669.5	659.0	634.9	631.2	639.9
Wetland	592.3	617.3	618.1	610.1	607.1	663.7	658.7	677.8	582.6	606.1	604.2	635.1	669.7	675.0	710.9	704.6	661.9	645.9	656.3	652.5	613.8	598.7	611.6
Open Water	597.5	636.3	617.1	607.5	624.9	661.6	634.0	670.4	571.0	610.7	579.5	646.5	661.6	677.5	0.0	701.7	643.6	618.0	643.3	661.1	642.5	603.7	603.7
Channel	610.3	633.4	618.1	625.8	618.6	655.5	667.0	677.0	604.2	619.1	619.9	657.8	663.2	674.2	709.9	695.7	648.3	635.3	656.7	653.5	627.8	622.7	631.8

Table A3. Averaged slope (°) of HRUs at 23 sub-basins in the initial model setup for the Vermilion River Basin.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	2.99	2.82	2.55	2.80	2.70	3.08	3.23	2.49	2.59	2.93	3.69	2.78	4.28	1.65	n/a	2.72	3.19	2.82	3.10	2.20	2.36	2.30	3.32
Cropland (fallow)	3.01	2.96	2.68	2.90	2.91	2.80	2.62	2.52	2.60	3.01	3.13	2.96	2.26	2.27	2.88	2.60	2.83	2.44	2.80	2.46	2.80	2.95	3.31
Cropland (stubble)	3.01	2.96	2.68	2.90	2.91	2.80	2.62	2.52	2.60	3.01	3.13	2.96	2.26	2.27	2.88	2.60	2.83	2.44	2.80	2.46	2.80	2.95	3.31
Grassland	0.00	3.20	0.00	3.20	0.00	2.80	3.10	2.30	2.90	3.30	3.60	3.00	2.30	2.30	3.50	2.60	2.90	0.00	2.70	0.00	0.00	0.00	3.50
Shrubland	3.10	2.60	2.60	2.90	2.90	3.10	2.60	3.60	4.00	3.70	2.40	2.90	2.40	2.00	2.70	2.60	2.40	1.80	3.30	2.20	3.20	0.00	3.60
Woodland	3.11	3.38	2.71	3.21	2.80	2.63	3.51	2.54	4.02	4.59	5.60	3.59	2.23	2.35	3.21	2.82	2.84	2.30	3.09	2.30	2.50	3.40	3.31
Wetland	3.30	2.90	2.80	3.20	2.30	2.30	3.20	2.40	3.50	3.50	3.30	3.00	2.40	2.50	3.10	2.80	3.20	2.40	3.20	2.20	1.70	4.20	2.80
Open Water	3.70	3.20	2.60	3.50	5.80	3.00	4.90	3.20	4.10	7.10	4.90	3.90	1.20	1.80	0.00	2.30	5.50	4.10	3.70	1.70	5.00	5.10	2.90
Channel	3.00	3.30	2.30	3.10	2.80	2.60	2.80	2.50	3.10	3.30	3.20	3.10	2.30	2.10	3.10	2.60	2.90	2.10	3.20	2.20	2.60	3.30	3.50

Appendix 2 Canopy and blowing snow parameters for the initial model setup

Table A4. Canopy and blowing snow parameters for the HRUs used in the initial model setup for the Vermilion River Basin.

HRU Name	Canopy Parameter	Blowing Snow Parameter				
	LAI ()	Fetch Distance (m)	Vegetation Height (m)	Stalk Diameter (m)	Stalk Density (#/m^2)	Distribution Factor ()
Builtup and Exposed Land	0.001	300	0.001	0.003	1	0.1
Cropland (fallow)	0.001	1000	0.001	0.003	320	0.1
Cropland (stubble)	0.001	1000	0.12	0.003	320	0.5
Grassland	0.001	1000	0.4	0.003	320	0.5
Shrubland	0.001	300	0.7	0.003	100	1
Woodland	0.4	300	6	0.01	100	2
Wetland	0.001	300	1.5	0.1	100	3
Open Water	0.001	300	0.001	0	1	0.5
Channel	0.001	300	0.5	0	1	1

Appendix 3 Frozen soil parameters for the initial model setup

Table A5. Pre-melt soil saturation (%) for the HRUs during four seasons: 2005-06, 2006-07, 2007-08, and 2008-09 used in the initial model setup for the Vermilion River Basin.

Pre-melt Soil Saturation (2005-06)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cropland (fallow)	49	64	49	49	49	44	64	44	64	64	64	64	44	44	44	44	44	49	49	44	49	49	49
Cropland (stubble)	49	64	49	49	49	44	64	44	64	64	64	64	44	44	44	44	44	49	49	44	49	49	49
Grassland	49	64	49	49	49	44	64	44	64	64	64	64	44	44	44	44	44	49	49	44	49	49	49
Shrubland	49	64	49	49	49	44	64	44	64	64	64	64	44	44	44	44	44	49	49	44	49	49	49
Woodland	49	64	49	49	49	44	64	44	64	64	64	64	44	44	44	44	44	49	49	44	49	49	49
Wetland	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Open Water	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Channel	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Pre-melt Soil Saturation (2006-07)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cropland (fallow)	43	41	43	43	43	42	41	42	41	41	41	41	42	42	42	42	42	43	43	42	43	43	43
Cropland (stubble)	43	41	43	43	43	42	41	42	41	41	41	41	42	42	42	42	42	43	43	42	43	43	43
Grassland	43	41	43	43	43	42	41	42	41	41	41	41	42	42	42	42	42	43	43	42	43	43	43
Shrubland	43	41	43	43	43	42	41	42	41	41	41	41	42	42	42	42	42	43	43	42	43	43	43
Woodland	43	41	43	43	43	42	41	42	41	41	41	41	42	42	42	42	42	43	43	42	43	43	43
Wetland	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Open Water	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Channel	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Pre-melt Soil Saturation (2007-08)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cropland (fallow)	41	39	41	41	41	43	39	43	39	39	39	39	43	43	43	43	43	41	41	43	41	41	41
Cropland (stubble)	41	39	41	41	41	43	39	43	39	39	39	39	43	43	43	43	43	41	41	43	41	41	41
Grassland	41	39	41	41	41	43	39	43	39	39	39	39	43	43	43	43	43	41	41	43	41	41	41
Shrubland	41	39	41	41	41	43	39	43	39	39	39	39	43	43	43	43	43	41	41	43	41	41	41
Woodland	41	39	41	41	41	43	39	43	39	39	39	39	43	43	43	43	43	41	41	43	41	41	41
Wetland	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Open Water	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Channel	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Pre-melt Soil Saturation (2008-09)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cropland (fallow)	38	37	38	38	38	41	37	41	37	37	37	37	41	41	41	41	41	38	38	41	38	38	38
Cropland (stubble)	38	37	38	38	38	41	37	41	37	37	37	37	41	41	41	41	41	38	38	41	38	38	38
Grassland	38	37	38	38	38	41	37	41	37	37	37	37	41	41	41	41	41	38	38	41	38	38	38
Shrubland	38	37	38	38	38	41	37	41	37	37	37	37	41	41	41	41	41	38	38	41	38	38	38
Woodland	38	37	38	38	38	41	37	41	37	37	37	37	41	41	41	41	41	38	38	41	38	38	38
Wetland	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Open Water	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Channel	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table A6. Pre-melt soil temperature (K) for the HRUs during four seasons: 2005-06, 2006-07, 2007-08, and 2008-09 used in the initial model setup for the Vermilion River Basin.

Pre-melt Soil Temperature (2005-06)																							
HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Cropland (fallow)	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Cropland (stubble)	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Grassland	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Shrubland	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Woodland	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Wetland	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Open Water	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Channel	269.8	270.8	269.8	269.8	269.8	270.7	270.8	270.7	270.8	270.8	270.8	270.8	270.7	270.7	270.7	270.7	270.7	269.8	269.8	270.7	269.8	269.8	269.8
Pre-melt Soil Temperature (2006-07)																							
HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Cropland (fallow)	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Cropland (stubble)	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Grassland	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Shrubland	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Woodland	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Wetland	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Open Water	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Channel	271.5	271.9	271.5	271.5	271.5	272.1	271.9	272.1	271.9	271.9	271.9	271.9	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Pre-melt Soil Temperature (2007-08)																							
HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Cropland (fallow)	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Cropland (stubble)	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Grassland	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Shrubland	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Woodland	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Wetland	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Open Water	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Channel	271.5	272.1	271.5	271.5	271.5	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	272.1	271.5	271.5	272.1	271.5	271.5	271.5
Pre-melt Soil Temperature (2008-09)																							
HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Cropland (fallow)	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Cropland (stubble)	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Grassland	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Shrubland	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Woodland	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Wetland	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Open Water	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8
Channel	269.8	270.7	269.8	269.8	269.8	270.1	270.7	270.1	270.7	270.7	270.7	270.7	270.1	270.1	270.1	270.1	270.1	269.8	269.8	270.1	269.8	269.8	269.8

Appendix 4 Soil moisture balance and wetland module parameters for the initial model setup

Table A7. Parameters of soil recharge layer, soil column, and subsurface and groundwater drainage for the soil moisture balance and wetland module in the initial model setup for the Vermilion River Basin.

HRU Name	Maximum Water Holding Capacity (mm)		Subsurface and Groundwater Drainage Factor (mm/day)
	Soil Recharge Layer	Soil Column	
Builtup and Exposed Land	60	600	0.001
Cropland (fallow)	60	600	0.001
Cropland (stubble)	60	600	0.001
Grassland	60	600	0.001
Shrubland	60	600	0.001
Woodland	60	600	0.001
Wetland	0	0	0.001
Open Water	0	0	0.001
Channel	0	0	0.001

Table A8. Initial values of available water in the soil recharge layer (mm) for the HRUs during four seasons: 2005-06, 2006-07, 2007-08, and 2008-09 used in the initial model setup for the Vermilion River Basin.

Initial Value of Available Water (2005-06)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	
Cropland (fallow)	29	38	29	29	29	26	38	26	38	38	38	38	26	26	26	26	26	29	29	26	29	29	29	
Cropland (stubble)	29	38	29	29	29	26	38	26	38	38	38	38	26	26	26	26	26	29	29	26	29	29	29	
Grassland	29	38	29	29	29	26	38	26	38	38	38	38	26	26	26	26	26	29	29	26	29	29	29	
Shrubland	29	38	29	29	29	26	38	26	38	38	38	38	26	26	26	26	26	29	29	26	29	29	29	
Woodland	29	38	29	29	29	26	38	26	38	38	38	38	26	26	26	26	26	29	29	26	29	29	29	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Initial Value of Available Water (2006-07)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	
Cropland (fallow)	26	24	26	26	26	25	24	25	24	24	24	24	25	25	25	25	25	26	26	25	26	26	26	
Cropland (stubble)	26	24	26	26	26	25	24	25	24	24	24	24	25	25	25	25	25	26	26	25	26	26	26	
Grassland	26	24	26	26	26	25	24	25	24	24	24	24	25	25	25	25	25	26	26	25	26	26	26	
Shrubland	26	24	26	26	26	25	24	25	24	24	24	24	25	25	25	25	25	26	26	25	26	26	26	
Woodland	26	24	26	26	26	25	24	25	24	24	24	24	25	25	25	25	25	26	26	25	26	26	26	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Initial Value of Available Water (2007-08)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	
Cropland (fallow)	25	24	25	25	25	26	24	26	24	24	24	24	26	26	26	26	26	25	25	26	25	25	25	
Cropland (stubble)	25	24	25	25	25	26	24	26	24	24	24	24	26	26	26	26	26	25	25	26	25	25	25	
Grassland	25	24	25	25	25	26	24	26	24	24	24	24	26	26	26	26	26	25	25	26	25	25	25	
Shrubland	25	24	25	25	25	26	24	26	24	24	24	24	26	26	26	26	26	25	25	26	25	25	25	
Woodland	25	24	25	25	25	26	24	26	24	24	24	24	26	26	26	26	26	25	25	26	25	25	25	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Initial Value of Available Water (2008-09)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	
Cropland (fallow)	23	22	23	23	23	24	22	24	22	22	22	22	24	24	24	24	24	23	23	24	23	23	23	
Cropland (stubble)	23	22	23	23	23	24	22	24	22	22	22	22	24	24	24	24	24	23	23	24	23	23	23	
Grassland	23	22	23	23	23	24	22	24	22	22	22	22	24	24	24	24	24	23	23	24	23	23	23	
Shrubland	23	22	23	23	23	24	22	24	22	22	22	22	24	24	24	24	24	23	23	24	23	23	23	
Woodland	23	22	23	23	23	24	22	24	22	22	22	22	24	24	24	24	24	23	23	24	23	23	23	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table A9. Initial values of available water in the soil column (mm) for the HRUs during four seasons: 2005-06, 2006-07, 2007-08, and 2008-09 used in the initial model setup for the Vermilion River Basin.

Initial Value of Available Water (2005-06)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	
Cropland (fallow)	294	383	294	294	294	264	383	264	383	383	383	383	264	264	264	264	264	294	294	264	294	294	294	
Cropland (stubble)	294	383	294	294	294	264	383	264	383	383	383	383	264	264	264	264	264	294	294	264	294	294	294	
Grassland	294	383	294	294	294	264	383	264	383	383	383	383	264	264	264	264	264	294	294	264	294	294	294	
Shrubland	294	383	294	294	294	264	383	264	383	383	383	383	264	264	264	264	264	294	294	264	294	294	294	
Woodland	294	383	294	294	294	264	383	264	383	383	383	383	264	264	264	264	264	294	294	264	294	294	294	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Initial Value of Available Water (2006-07)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	
Cropland (fallow)	259	245	259	259	259	254	245	254	245	245	245	245	254	254	254	254	254	259	259	254	259	259	259	
Cropland (stubble)	259	245	259	259	259	254	245	254	245	245	245	245	254	254	254	254	254	259	259	254	259	259	259	
Grassland	259	245	259	259	259	254	245	254	245	245	245	245	254	254	254	254	254	259	259	254	259	259	259	
Shrubland	259	245	259	259	259	254	245	254	245	245	245	245	254	254	254	254	254	259	259	254	259	259	259	
Woodland	259	245	259	259	259	254	245	254	245	245	245	245	254	254	254	254	254	259	259	254	259	259	259	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Initial Value of Available Water (2007-08)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	
Cropland (fallow)	247	236	247	247	247	257	236	257	236	236	236	236	257	257	257	257	257	247	247	257	247	247	247	
Cropland (stubble)	247	236	247	247	247	257	236	257	236	236	236	236	257	257	257	257	257	247	247	257	247	247	247	
Grassland	247	236	247	247	247	257	236	257	236	236	236	236	257	257	257	257	257	247	247	257	247	247	247	
Shrubland	247	236	247	247	247	257	236	257	236	236	236	236	257	257	257	257	257	247	247	257	247	247	247	
Woodland	247	236	247	247	247	257	236	257	236	236	236	236	257	257	257	257	257	247	247	257	247	247	247	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Initial Value of Available Water (2008-09)																								
HRU Name	Sub-basin																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Builtup and Exposed Land	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	
Cropland (fallow)	231	224	231	231	231	244	224	244	224	224	224	224	244	244	244	244	244	231	231	244	231	231	231	
Cropland (stubble)	231	224	231	231	231	244	224	244	224	224	224	224	244	244	244	244	244	231	231	244	231	231	231	
Grassland	231	224	231	231	231	244	224	244	224	224	224	224	244	244	244	244	244	231	231	244	231	231	231	
Shrubland	231	224	231	231	231	244	224	244	224	224	224	224	244	244	244	244	244	231	231	244	231	231	231	
Woodland	231	224	231	231	231	244	224	244	224	224	224	224	244	244	244	244	244	231	231	244	231	231	231	
Wetland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Open Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table A10. Averaged values of surface depression storage capacity (mm) for the HRUs used in the initial model setup for the Vermilion River Basin.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cropland (fallow)	192	222	220	205	204	251	210	181	227	236	245	245	191	207	222	191	253	221	209	207	207	212	207
Cropland (stubble)	192	222	220	205	204	251	210	181	227	236	245	245	191	207	222	191	253	221	209	207	207	212	207
Grassland	0	249	0	237	0	293	217	180	217	263	292	253	190	200	146	223	248	0	203	0	0	0	208
Shrubland	48	242	449	227	324	94	208	108	298	319	212	316	718	1051	79	224	362	110	196	332	209	0	215
Woodland	283	223	361	213	221	228	229	231	209	258	304	313	193	167	248	153	307	222	211	210	128	185	309
Wetland	276	241	254	176	67	253	167	179	155	245	236	334	203	158	0	186	297	118	173	324	21	447	120
Open Water	589	176	25	163	215	322	184	113	111	199	262	428	339	828	23	355	97	33	231	62	182	272	180
Channel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 5 Routing module parameters for the initial model setup

Table A11. Muskingum routing parameters: Manning's roughness (), hydraulic radius (m), and dimensionless weighting factor () for runoff routing between HRUs within the sub-basins.

HRU Name	Manning's Roughness	Hydraulic Radius (m)	Dimensionless Weighting Factor
Builtup and Exposed Land	0.04	0.01	0.25
Cropland (fallow)	0.04	0.01	0.25
Cropland (stubble)	0.05	0.01	0.25
Grassland	0.11	0.01	0.25
Shrubland	0.2	0.01	0.25
Woodland	0.2	0.01	0.25
Wetland	0.2	0.01	0.25
Open Water	0.11	0.01	0.25
Channel	0.035	0.01	0.25

Table A12. Muskingum routing parameter: longitudinal friction Slope (%) for runoff routing between HRUs within the sub-basins.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Cropland (fallow)	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Cropland (stubble)	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Grassland	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Shrubland	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Woodland	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Wetland	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Open Water	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056
Channel	0.040	0.049	0.024	0.046	0.018	0.018	0.036	0.017	0.038	0.057	0.049	0.047	0.012	0.011	0.016	0.016	0.015	0.015	0.043	0.016	0.032	0.047	0.056

Table A13. Muskingum routing parameter: routing length (m) for runoff routing between HRUs within the sub-basins.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	1266	2493	2410	3448	2799	1304	5396	3227	4503	6119	4761	2789	281	1041	0	1601	2019	1306	2393	1969	1311	457	1188
Cropland (fallow)	2446	6159	3932	4916	3446	3355	7416	5645	5640	8117	4341	4141	1419	2930	1726	4636	4276	4358	4498	4219	2872	1784	1808
Cropland (stubble)	16007	39193	25365	31500	22316	21744	46928	36021	35988	51227	27916	26670	9437	19068	11416	29756	27512	28025	28899	27160	18701	11786	11941
Grassland	0	7733	0	2765	0	3751	11779	7795	16521	23721	9912	7836	3740	5253	351	4154	7737	0	3976	0	0	0	1685
Shrubland	855	4118	1381	4476	723	344	4284	1698	2005	3014	1454	1773	207	279	1160	2490	1174	1230	3247	522	611	0	1015
Woodland	2911	10466	2908	13044	2876	3183	8332	4541	6517	7900	4129	6277	1368	1345	1134	3071	3156	3045	11335	4903	2809	1640	4942
Wetland	1288	4244	1516	2165	331	1608	4986	2582	4177	7531	3398	4687	413	1543	748	2874	2520	404	3875	547	109	1456	1017
Open Water	880	2466	985	4498	1267	569	8345	802	638	2894	2092	2909	130	280	0	1143	726	273	3944	269	380	1729	1613
Channel	69663	681455	98366	276965	74745	58027	535534	254972	462353	1336469	386004	300699	20515	82939	36916	221734	240692	91652	137579	64513	63358	31136	61958

Table A14. Muskingum routing parameter: routing distribution parameter for runoff routing between HRUs within the sub-basins.

Sub-basin1									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.16	0.07	0.05	0.72
Cropland (fallow)	0	0	0	0	0	0.16	0.07	0.05	0.72
Cropland (stubble)	0	0	0	0	0	0.16	0.07	0.05	0.72
Grassland	0	0	0	0	0	0.16	0.07	0.05	0.72
Shrubland	0	0	0	0	0	0.16	0.07	0.05	0.72
Woodland	0	0	0	0	0	0	0.08	0.06	0.86
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin2									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.34	0.14	0.08	0.44
Cropland (fallow)	0	0	0	0	0	0.34	0.14	0.08	0.44
Cropland (stubble)	0	0	0	0	0	0.34	0.14	0.08	0.44
Grassland	0	0	0	0	0	0.34	0.14	0.08	0.44
Shrubland	0	0	0	0	0	0.34	0.14	0.08	0.44
Woodland	0	0	0	0	0	0	0.21	0.12	0.66
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin3									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.16	0.08	0.05	0.71
Cropland (fallow)	0	0	0	0	0	0.16	0.08	0.05	0.71
Cropland (stubble)	0	0	0	0	0	0.16	0.08	0.05	0.71
Grassland	0	0	0	0	0	0.16	0.08	0.05	0.71
Shrubland	0	0	0	0	0	0.16	0.08	0.05	0.71
Woodland	0	0	0	0	0	0	0.10	0.06	0.84
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin4									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.40	0.07	0.14	0.40
Cropland (fallow)	0	0	0	0	0	0.40	0.07	0.14	0.40
Cropland (stubble)	0	0	0	0	0	0.40	0.07	0.14	0.40
Grassland	0	0	0	0	0	0.40	0.07	0.14	0.40
Shrubland	0	0	0	0	0	0.40	0.07	0.14	0.40
Woodland	0	0	0	0	0	0	0.11	0.23	0.67
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0

Table A14. *Continued*.

Sub-basin5									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.16	0.02	0.07	0.75
Cropland (fallow)	0	0	0	0	0	0.16	0.02	0.07	0.75
Cropland (stubble)	0	0	0	0	0	0.16	0.02	0.07	0.75
Grassland	0	0	0	0	0	0.16	0.02	0.07	0.75
Shrubland	0	0	0	0	0	0.16	0.02	0.07	0.75
Woodland	0	0	0	0	0	0	0.02	0.09	0.89
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin6									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.17	0.09	0.03	0.71
Cropland (fallow)	0	0	0	0	0	0.17	0.09	0.03	0.71
Cropland (stubble)	0	0	0	0	0	0.17	0.09	0.03	0.71
Grassland	0	0	0	0	0	0.17	0.09	0.03	0.71
Shrubland	0	0	0	0	0	0.17	0.09	0.03	0.71
Woodland	0	0	0	0	0	0	0.10	0.04	0.86
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin7									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.24	0.14	0.24	0.38
Cropland (fallow)	0	0	0	0	0	0.24	0.14	0.24	0.38
Cropland (stubble)	0	0	0	0	0	0.24	0.14	0.24	0.38
Grassland	0	0	0	0	0	0.24	0.14	0.24	0.38
Shrubland	0	0	0	0	0	0.24	0.14	0.24	0.38
Woodland	0	0	0	0	0	0	0.19	0.31	0.50
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin8									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.21	0.12	0.04	0.63
Cropland (fallow)	0	0	0	0	0	0.21	0.12	0.04	0.63
Cropland (stubble)	0	0	0	0	0	0.21	0.12	0.04	0.63
Grassland	0	0	0	0	0	0.21	0.12	0.04	0.63
Shrubland	0	0	0	0	0	0.21	0.12	0.04	0.63
Woodland	0	0	0	0	0	0	0.16	0.05	0.80
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0

Table A14. *Continued*.

Sub-basin9									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.27	0.17	0.03	0.54
Cropland (fallow)	0	0	0	0	0	0.27	0.17	0.03	0.54
Cropland (stubble)	0	0	0	0	0	0.27	0.17	0.03	0.54
Grassland	0	0	0	0	0	0.27	0.17	0.03	0.54
Shrubland	0	0	0	0	0	0.27	0.17	0.03	0.54
Woodland	0	0	0	0	0	0	0.23	0.04	0.73
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin10									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.25	0.24	0.09	0.42
Cropland (fallow)	0	0	0	0	0	0.25	0.24	0.09	0.42
Cropland (stubble)	0	0	0	0	0	0.25	0.24	0.09	0.42
Grassland	0	0	0	0	0	0.25	0.24	0.09	0.42
Shrubland	0	0	0	0	0	0.25	0.24	0.09	0.42
Woodland	0	0	0	0	0	0	0.32	0.12	0.56
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin11									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.18	0.15	0.09	0.58
Cropland (fallow)	0	0	0	0	0	0.18	0.15	0.09	0.58
Cropland (stubble)	0	0	0	0	0	0.18	0.15	0.09	0.58
Grassland	0	0	0	0	0	0.18	0.15	0.09	0.58
Shrubland	0	0	0	0	0	0.18	0.15	0.09	0.58
Woodland	0	0	0	0	0	0	0.18	0.11	0.71
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin12									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.23	0.17	0.11	0.49
Cropland (fallow)	0	0	0	0	0	0.23	0.17	0.11	0.49
Cropland (stubble)	0	0	0	0	0	0.23	0.17	0.11	0.49
Grassland	0	0	0	0	0	0.23	0.17	0.11	0.49
Shrubland	0	0	0	0	0	0.23	0.17	0.11	0.49
Woodland	0	0	0	0	0	0	0.22	0.14	0.64
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0

Table A14. *Continued*.

Sub-basin13									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.09	0.03	0.01	0.87
Cropland (fallow)	0	0	0	0	0	0.09	0.03	0.01	0.87
Cropland (stubble)	0	0	0	0	0	0.09	0.03	0.01	0.87
Grassland	0	0	0	0	0	0.09	0.03	0.01	0.87
Shrubland	0	0	0	0	0	0.09	0.03	0.01	0.87
Woodland	0	0	0	0	0	0	0.03	0.01	0.96
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin14									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.08	0.09	0.02	0.81
Cropland (fallow)	0	0	0	0	0	0.08	0.09	0.02	0.81
Cropland (stubble)	0	0	0	0	0	0.08	0.09	0.02	0.81
Grassland	0	0	0	0	0	0.08	0.09	0.02	0.81
Shrubland	0	0	0	0	0	0.08	0.09	0.02	0.81
Woodland	0	0	0	0	0	0	0.10	0.02	0.88
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin15									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.08	0.05	0.00	0.88
Cropland (fallow)	0	0	0	0	0	0.08	0.05	0.00	0.88
Cropland (stubble)	0	0	0	0	0	0.08	0.05	0.00	0.88
Grassland	0	0	0	0	0	0.08	0.05	0.00	0.88
Shrubland	0	0	0	0	0	0.08	0.05	0.00	0.88
Woodland	0	0	0	0	0	0	0.05	0.00	0.95
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin16									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.15	0.14	0.06	0.65
Cropland (fallow)	0	0	0	0	0	0.15	0.14	0.06	0.65
Cropland (stubble)	0	0	0	0	0	0.15	0.14	0.06	0.65
Grassland	0	0	0	0	0	0.15	0.14	0.06	0.65
Shrubland	0	0	0	0	0	0.15	0.14	0.06	0.65
Woodland	0	0	0	0	0	0	0.17	0.07	0.77
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0

Table A14. *Continued*.

Sub-basin17									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.16	0.13	0.04	0.67
Cropland (fallow)	0	0	0	0	0	0.16	0.13	0.04	0.67
Cropland (stubble)	0	0	0	0	0	0.16	0.13	0.04	0.67
Grassland	0	0	0	0	0	0.16	0.13	0.04	0.67
Shrubland	0	0	0	0	0	0.16	0.13	0.04	0.67
Woodland	0	0	0	0	0	0	0.15	0.04	0.80
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin18									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.18	0.02	0.02	0.78
Cropland (fallow)	0	0	0	0	0	0.18	0.02	0.02	0.78
Cropland (stubble)	0	0	0	0	0	0.18	0.02	0.02	0.78
Grassland	0	0	0	0	0	0.18	0.02	0.02	0.78
Shrubland	0	0	0	0	0	0.18	0.02	0.02	0.78
Woodland	0	0	0	0	0	0	0.03	0.02	0.95
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin19									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.35	0.12	0.12	0.41
Cropland (fallow)	0	0	0	0	0	0.35	0.12	0.12	0.41
Cropland (stubble)	0	0	0	0	0	0.35	0.12	0.12	0.41
Grassland	0	0	0	0	0	0.35	0.12	0.12	0.41
Shrubland	0	0	0	0	0	0.35	0.12	0.12	0.41
Woodland	0	0	0	0	0	0	0.18	0.19	0.63
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin20									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.26	0.03	0.01	0.70
Cropland (fallow)	0	0	0	0	0	0.26	0.03	0.01	0.70
Cropland (stubble)	0	0	0	0	0	0.26	0.03	0.01	0.70
Grassland	0	0	0	0	0	0.26	0.03	0.01	0.70
Shrubland	0	0	0	0	0	0.26	0.03	0.01	0.70
Woodland	0	0	0	0	0	0	0.04	0.02	0.94
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0

Table A14. *Concluded*.

Sub-basin21									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.17	0.01	0.02	0.80
Cropland (fallow)	0	0	0	0	0	0.17	0.01	0.02	0.80
Cropland (stubble)	0	0	0	0	0	0.17	0.01	0.02	0.80
Grassland	0	0	0	0	0	0.17	0.01	0.02	0.80
Shrubland	0	0	0	0	0	0.17	0.01	0.02	0.80
Woodland	0	0	0	0	0	0	0.01	0.03	0.96
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin22									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.09	0.08	0.10	0.73
Cropland (fallow)	0	0	0	0	0	0.09	0.08	0.10	0.73
Cropland (stubble)	0	0	0	0	0	0.09	0.08	0.10	0.73
Grassland	0	0	0	0	0	0.09	0.08	0.10	0.73
Shrubland	0	0	0	0	0	0.09	0.08	0.10	0.73
Woodland	0	0	0	0	0	0	0.09	0.11	0.81
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0
Sub-basin23									
HRU Name	Builtup and Exposed Land	Cropland (fallow)	Cropland (stubble)	Grassland	Shrubland	Woodland	Wetland	Open Water	Channel
Builtup and Exposed Land	0	0	0	0	0	0.24	0.05	0.08	0.64
Cropland (fallow)	0	0	0	0	0	0.24	0.05	0.08	0.64
Cropland (stubble)	0	0	0	0	0	0.24	0.05	0.08	0.64
Grassland	0	0	0	0	0	0.24	0.05	0.08	0.64
Shrubland	0	0	0	0	0	0.24	0.05	0.08	0.64
Woodland	0	0	0	0	0	0	0.06	0.10	0.83
Wetland	0	0	0	0	0	0	0	1	0
Open Water	0	0	0	0	0	0	0	0	1
Channel	0	0	0	0	0	0	0	0	0

Table A15. Muskingum routing parameters for channel routing between the sub-basins.

Sub-basin	Area (km^2)	Routing Length (m)	Manning's Roughness	Hydraulic Radius (m)	Dimensionless Weighting Factor	Longitudinal friction Slope (%)
1	108.9	16850	0.035	2	0.25	0.05
2	631.7	81552	0.035	2	0.25	0.06
3	249.2	16892	0.035	2	0.25	0.04
4	457.9	67482	0.035	2	0.25	0.05
5	198.0	126310	0.035	2	0.25	0.05
6	194.3	42714	0.035	2	0.25	0.05
7	900.2	91392	0.035	2	0.25	0.05
8	505.2	142328	0.035	2	0.25	0.04
9	602.9	215928	0.035	2	0.25	0.05
10	1164.5	264718	0.035	2	0.25	0.06
11	355.5	103200	0.035	2	0.25	0.06
12	328.0	83330	0.035	2	0.25	0.05
13	46.4	22390	0.035	2	0.25	0.04
14	156.9	35102	0.035	2	0.25	0.04
15	56.4	21284	0.035	2	0.25	0.05
16	344.5	76796	0.035	2	0.25	0.05
17	316.1	141016	0.035	2	0.25	0.05
18	294.0	80598	0.035	2	0.25	0.04
19	388.7	68930	0.035	2	0.25	0.06
20	284.7	74982	0.035	2	0.25	0.04
21	141.0	67666	0.035	2	0.25	0.05
22	62.2	13582	0.035	2	0.25	0.06
23	75.6	31972	0.035	2	0.25	0.06

Appendix 6 Revised HRU area

The following table lists the revised values for the HRUs at 23 sub-basins of Vermilion River to the initial values shown in Table A1. The current (2004) DUC wetland inventory of impact class was used for the revision.

Table A16. Revised area (km^2) of HRUs at 23 sub-basins in the initial model setup for the Vermilion River Basin.

HRU Name	Sub-basin																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Builtup and Exposed Land	0.98	3.31	3.11	5.93	4.08	1.03	13.28	5.27	9.59	16.65	10.60	4.05	0.07	0.69	0.00	1.49	2.27	1.03	3.07	2.17	1.04	0.16	0.87
Cropland (fallow)	3.20	16.84	7.51	11.23	5.93	5.65	23.53	14.40	14.38	27.68	8.98	8.25	1.20	4.43	1.71	10.10	8.74	9.04	9.57	8.53	4.27	1.81	1.86
Cropland (stubble)	93.92	491.58	222.71	321.31	178.21	165.90	684.91	420.39	430.09	799.82	265.52	245.66	34.53	126.11	49.88	290.30	268.53	263.91	273.90	250.76	127.02	54.09	55.19
Grassland	0.00	25.14	0.00	3.88	0.00	6.38	51.85	25.50	102.79	186.45	39.69	26.05	6.57	12.15	0.09	7.92	25.30	0.00	7.14	0.00	0.00	0.00	1.58
Shrubland	0.48	8.19	1.17	9.52	0.33	0.09	8.51	1.47	2.21	4.25	1.21	1.71	0.04	0.05	0.69	3.00	0.87	0.89	4.74	0.19	0.25	0.00	0.67
Woodland	3.10	42.68	4.06	63.46	3.86	4.44	27.01	7.88	18.41	25.67	7.75	15.64	0.89	0.61	0.58	3.51	3.88	4.37	47.84	10.11	3.63	1.32	10.21
Wetland	6.39	39.22	9.55	31.19	4.20	10.38	58.27	29.25	23.44	95.15	18.12	21.59	3.03	12.64	3.39	26.94	5.58	14.06	33.50	12.28	4.29	2.94	3.55
Open Water	0.69	3.84	0.97	10.96	1.12	0.26	32.07	0.56	1.09	6.83	3.04	4.63	0.04	0.09	0.00	0.87	0.49	0.52	8.69	0.49	0.39	1.84	1.55
Channel	0.10	0.93	0.14	0.41	0.23	0.12	0.78	0.48	0.85	1.99	0.60	0.46	0.05	0.14	0.07	0.36	0.45	0.21	0.25	0.17	0.16	0.05	0.11

Appendix 7 HRU area and routing length parameters in the dynamical depressional storage model setup

Table A17. HRU area (km^2) in the dynamical depressional storage model setup for the upstream Vermilion River sub-basins. These values are for the HRUs of the simulated sub-region in the dynamical depressional storage model setup.

	Sub-basin						
HRU Name	15	16	14	13	8	6	17
Builtup	0.000001	0.0289	0.0284	0.0113	0.0938	0.0518	0.2116
Fallow	0.2627	0.1954	0.1824	0.2065	0.2565	0.2834	0.8158
Stubble	7.6654	5.6136	5.1982	5.9385	7.4876	8.3269	25.0729
Grassland	0.0133	0.1532	0.5009	1.1292	0.4541	0.3205	2.3626
Shrubland	0.1055	0.0581	0.0022	0.0063	0.0262	0.0047	0.0814
Woodland	0.0887	0.0679	0.0251	0.1522	0.1403	0.2229	0.3621
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
OpenWater	0.0033	0.8666	0.0866	0.0383	0.5589	0.2650	0.4851
Channel	0.0707	0.3597	0.1434	0.0485	0.4819	0.1190	0.4517

Table A18. Muskingum routing parameter: routing length (m) between HRUs within the sub-basins in the dynamical depressional storage model setup for the upstream Vermilion River sub-basins.

	Sub-basin						
HRU Name	15	16	14	13	8	6	17
Builtup	1	179	177	106	344	247	540
Fallow	609	517	498	533	602	636	1144
Stubble	4043	3418	3279	3523	3992	4228	7659
Grassland	123	465	889	1385	842	696	2073
Shrubland	365	263	43	78	170	66	317
Woodland	371	322	189	496	475	608	789
Wetland1	23	23	23	23	23	23	23
Wetland2	129	129	129	129	129	129	129
Wetland3	12	12	12	12	12	12	12
Wetland4	50	50	50	50	50	50	50
Wetland5	34	34	34	34	34	34	34
Wetland6	30	30	30	30	30	30	30
Wetland7	67	67	67	67	67	67	67
Wetland8	17	17	17	17	17	17	17
Wetland9	45	45	45	45	45	45	45
Wetland10	96	96	96	96	96	96	96
Wetland11	8	8	8	8	8	8	8
Wetland12	15	15	15	15	15	15	15
Wetland13	27	27	27	27	27	27	27
Wetland14	111	111	111	111	111	111	111
Wetland15	30	30	30	30	30	30	30
Wetland16	19	19	19	19	19	19	19
Wetland17	12	12	12	12	12	12	12
Wetland18	28	28	28	28	28	28	28
Wetland19	71	71	71	71	71	71	71
Wetland20	12	12	12	12	12	12	12
Wetland21	12	12	12	12	12	12	12
Wetland22	25	25	25	25	25	25	25
Wetland23	38	38	38	38	38	38	38
Wetland24	78	78	78	78	78	78	78
Wetland25	27	27	27	27	27	27	27
Wetland26	473	473	473	473	473	473	473
Wetland27	47	47	47	47	47	47	47
Wetland28	257	257	257	257	257	257	257
Wetland29	12	12	12	12	12	12	12
Wetland30	19	19	19	19	19	19	19
Wetland31	122	122	122	122	122	122	122
Wetland32	31	31	31	31	31	31	31
Wetland33	8	8	8	8	8	8	8
Wetland34	60	60	60	60	60	60	60
Wetland35	206	206	206	206	206	206	206
Wetland36	15	15	15	15	15	15	15
Wetland37	27	27	27	27	27	27	27
Wetland38	58	58	58	58	58	58	58
Wetland39	43	43	43	43	43	43	43
Wetland40	8	8	8	8	8	8	8
Wetland41	217	217	217	217	217	217	217
Wetland42	107	107	107	107	107	107	107
Wetland43	346	346	346	346	346	346	346
Wetland44	45	45	45	45	45	45	45
Wetland45	73	73	73	73	73	73	73
Wetland46	53	53	53	53	53	53	53
OpenWater	58	1198	344	221	945	630	875
Channel	36916	221734	82939	20515	254972	58027	240692

Appendix 8 Depressional Storage parameters in the dynamical depressional storage model setup

Table A19. Depressional storage capacity (mm) in the dynamical depressional storage model setup for the upstream Vermilion River sub-basins.

	Sub-basin						
HRU Name	15	16	14	13	8	6	17
Builtup	0	0	0	0	0	0	0
Fallow	59	61	66	75	69	81	82
Stubble	59	61	66	75	69	81	82
Grassland	70	66	61	95	71	61	73
Shrubland	58	60	24	38	49	94	92
Woodland	52	52	75	71	72	64	80
Wetland1	199	199	199	199	199	199	199
Wetland2	721	721	721	721	721	721	721
Wetland3	188	188	188	188	188	188	188
Wetland4	203	203	203	203	203	203	203
Wetland5	308	308	308	308	308	308	308
Wetland6	240	240	240	240	240	240	240
Wetland7	299	299	299	299	299	299	299
Wetland8	196	196	196	196	196	196	196
Wetland9	345	345	345	345	345	345	345
Wetland10	255	255	255	255	255	255	255
Wetland11	182	182	182	182	182	182	182
Wetland12	203	203	203	203	203	203	203
Wetland13	202	202	202	202	202	202	202
Wetland14	581	581	581	581	581	581	581
Wetland15	238	238	238	238	238	238	238
Wetland16	262	262	262	262	262	262	262
Wetland17	230	230	230	230	230	230	230
Wetland18	287	287	287	287	287	287	287
Wetland19	326	326	326	326	326	326	326
Wetland20	197	197	197	197	197	197	197
Wetland21	187	187	187	187	187	187	187
Wetland22	238	238	238	238	238	238	238
Wetland23	217	217	217	217	217	217	217
Wetland24	208	208	208	208	208	208	208
Wetland25	224	224	224	224	224	224	224
Wetland26	1019	1019	1019	1019	1019	1019	1019
Wetland27	257	257	257	257	257	257	257
Wetland28	772	772	772	772	772	772	772
Wetland29	199	199	199	199	199	199	199
Wetland30	213	213	213	213	213	213	213
Wetland31	850	850	850	850	850	850	850
Wetland32	238	238	238	238	238	238	238
Wetland33	193	193	193	193	193	193	193
Wetland34	199	199	199	199	199	199	199
Wetland35	821	821	821	821	821	821	821
Wetland36	192	192	192	192	192	192	192
Wetland37	275	275	275	275	275	275	275
Wetland38	256	256	256	256	256	256	256
Wetland39	241	241	241	241	241	241	241
Wetland40	189	189	189	189	189	189	189
Wetland41	571	571	571	571	571	571	571
Wetland42	676	676	676	676	676	676	676
Wetland43	682	682	682	682	682	682	682
Wetland44	247	247	247	247	247	247	247
Wetland45	323	323	323	323	323	323	323
Wetland46	307	307	307	307	307	307	307
OpenWater	0	225	684	339	92	192	93
Channel	0	0	0	0	0	0	0

Table A20. Initial depressional storage (mm) in the dynamical depressional storage model setup for the upstream Vermilion River sub-basins.

	Sub-basin						
HRU Name	15	16	14	13	8	6	17
Builtup	0	0	0	0	0	0	0
Fallow	30	31	33	38	35	40	41
Stubble	30	31	33	38	35	40	41
Grassland	35	33	30	48	36	30	37
Shrubland	29	30	12	19	25	47	46
Woodland	26	26	38	36	36	32	40
Wetland1	100	100	100	100	100	100	100
Wetland2	361	361	361	361	361	361	361
Wetland3	94	94	94	94	94	94	94
Wetland4	102	102	102	102	102	102	102
Wetland5	154	154	154	154	154	154	154
Wetland6	120	120	120	120	120	120	120
Wetland7	150	150	150	150	150	150	150
Wetland8	98	98	98	98	98	98	98
Wetland9	173	173	173	173	173	173	173
Wetland10	128	128	128	128	128	128	128
Wetland11	91	91	91	91	91	91	91
Wetland12	102	102	102	102	102	102	102
Wetland13	101	101	101	101	101	101	101
Wetland14	291	291	291	291	291	291	291
Wetland15	119	119	119	119	119	119	119
Wetland16	131	131	131	131	131	131	131
Wetland17	115	115	115	115	115	115	115
Wetland18	144	144	144	144	144	144	144
Wetland19	163	163	163	163	163	163	163
Wetland20	99	99	99	99	99	99	99
Wetland21	94	94	94	94	94	94	94
Wetland22	119	119	119	119	119	119	119
Wetland23	109	109	109	109	109	109	109
Wetland24	104	104	104	104	104	104	104
Wetland25	112	112	112	112	112	112	112
Wetland26	510	510	510	510	510	510	510
Wetland27	129	129	129	129	129	129	129
Wetland28	386	386	386	386	386	386	386
Wetland29	100	100	100	100	100	100	100
Wetland30	107	107	107	107	107	107	107
Wetland31	425	425	425	425	425	425	425
Wetland32	119	119	119	119	119	119	119
Wetland33	97	97	97	97	97	97	97
Wetland34	100	100	100	100	100	100	100
Wetland35	411	411	411	411	411	411	411
Wetland36	96	96	96	96	96	96	96
Wetland37	138	138	138	138	138	138	138
Wetland38	128	128	128	128	128	128	128
Wetland39	121	121	121	121	121	121	121
Wetland40	95	95	95	95	95	95	95
Wetland41	286	286	286	286	286	286	286
Wetland42	338	338	338	338	338	338	338
Wetland43	341	341	341	341	341	341	341
Wetland44	124	124	124	124	124	124	124
Wetland45	162	162	162	162	162	162	162
Wetland46	154	154	154	154	154	154	154
OpenWater	0	112	342	170	46	96	47
Channel	0	0	0	0	0	0	0

Appendix 9 HRU area, routing length, and scaling ratio in the sensitivity simulations

Table A21. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring all 46 wetlands by 25% from the current to the historical level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.257346	0.191858	0.178908	0.203966	0.252763	0.277833	0.799621	603	512	492	530	597	629	1132
Stubble	7.605298	5.603887	5.192816	5.963901	7.472357	8.252016	24.58024	4026	3415	3278	3532	3988	4207	7578
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000788	0.00072	0.000714	0.000672	0.000729	0.000801	0.001392	25	24	23	23	24	25	34
Wetland2	0.018015	0.016459	0.016316	0.01536	0.016664	0.018312	0.031814	138	132	131	127	132	139	189
Wetland3	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland4	0.003153	0.00288	0.002855	0.002688	0.002916	0.003205	0.005567	53	50	50	49	51	53	72
Wetland5	0.001576	0.00144	0.001428	0.001344	0.001458	0.001602	0.002784	36	34	34	33	35	37	49
Wetland6	0.001239	0.001132	0.001122	0.001056	0.001146	0.001259	0.002187	32	30	30	29	30	32	43
Wetland7	0.005405	0.004938	0.004895	0.004608	0.004999	0.005494	0.009544	71	68	68	65	68	72	97
Wetland8	0.00045	0.000411	0.000408	0.000384	0.000417	0.000458	0.000795	18	17	17	17	17	18	25
Wetland9	0.00259	0.002366	0.002345	0.002208	0.002395	0.002632	0.004573	48	45	45	44	46	48	65
Wetland10	0.010359	0.009464	0.009382	0.008832	0.009582	0.010529	0.018293	102	97	97	93	98	103	139
Wetland11	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland12	0.000338	0.000309	0.000306	0.000288	0.000312	0.000343	0.000597	16	15	15	14	15	16	21
Wetland13	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland14	0.013511	0.012344	0.012237	0.01152	0.012498	0.013734	0.02386	118	112	112	108	113	119	161
Wetland15	0.001239	0.001132	0.001122	0.001056	0.001146	0.001259	0.002187	32	30	30	29	30	32	43
Wetland16	0.000563	0.000514	0.00051	0.00048	0.000521	0.000572	0.000994	21	20	19	19	20	21	28
Wetland17	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland18	0.001126	0.001029	0.00102	0.00096	0.001041	0.001145	0.001988	30	29	28	28	29	30	41
Wetland19	0.005968	0.005452	0.005405	0.005088	0.00552	0.006066	0.010538	75	72	71	69	72	76	103
Wetland20	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland21	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland22	0.000901	0.000823	0.000816	0.000768	0.000833	0.000916	0.001591	27	25	25	24	25	27	36
Wetland23	0.001914	0.001749	0.001734	0.001632	0.001771	0.001946	0.00338	40	38	38	37	39	41	55
Wetland24	0.007093	0.006481	0.006424	0.006048	0.006561	0.00721	0.012527	83	79	78	76	79	84	113
Wetland25	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland26	0.19006	0.173642	0.172135	0.162047	0.175803	0.193192	0.335634	505	481	478	463	484	510	691
Wetland27	0.002815	0.002572	0.002549	0.0024	0.002604	0.002861	0.004971	50	47	47	46	48	50	68
Wetland28	0.062828	0.057401	0.056902	0.053568	0.058115	0.063863	0.11095	275	261	260	252	263	277	376
Wetland29	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland30	0.000563	0.000514	0.00051	0.00048	0.000521	0.000572	0.000994	21	20	19	19	20	21	28
Wetland31	0.016101	0.01471	0.014583	0.013728	0.014893	0.016366	0.028433	130	124	123	119	124	131	178
Wetland32	0.001351	0.001234	0.001224	0.001152	0.00125	0.001373	0.002386	33	32	31	30	32	34	45
Wetland33	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland34	0.004504	0.004115	0.004079	0.00384	0.004166	0.004578	0.007953	64	61	61	59	62	65	88
Wetland35	0.041885	0.038267	0.037935	0.035712	0.038743	0.042576	0.073967	220	209	208	201	211	222	301
Wetland36	0.000338	0.000309	0.000306	0.000288	0.000312	0.000343	0.000597	16	15	15	14	15	16	21
Wetland37	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland38	0.004166	0.003806	0.003773	0.003552	0.003854	0.004235	0.007357	62	59	58	57	59	62	84
Wetland39	0.002477	0.002263	0.002243	0.002112	0.002291	0.002518	0.004374	46	44	44	43	44	47	63
Wetland40	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland41	0.045939	0.04197	0.041606	0.039168	0.042493	0.046696	0.081125	231	220	219	212	222	233	316
Wetland42	0.012723	0.011624	0.011523	0.010848	0.011769	0.012933	0.022468	114	109	108	105	109	115	156
Wetland43	0.107641	0.098342	0.097489	0.091776	0.099566	0.109415	0.190087	369	352	350	338	354	373	505
Wetland44	0.00259	0.002366	0.002345	0.002208	0.002395	0.002632	0.004573	48	45	45	44	46	48	65
Wetland45	0.006305	0.005761	0.005711	0.005376	0.005832	0.006409	0.011135	78	74	73	71	74	78	106
Wetland46	0.00349	0.003189	0.003161	0.002976	0.003229	0.003548	0.006164	56	53	53	51	54	57	77
OpenWater	0.008537	0.818441	0.072767	0.028719	0.44509	0.36476	0.447855	98	1161	313	189	835	750	838
Channel	0.06386	0.321464	0.123239	0.046231	0.44757	0.123434	0.424414	33298	199033	69117	19674	241769	67026	231062

Table A22. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring all 46 wetlands by 50% from the current to the historical level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.252034	0.188321	0.175375	0.201438	0.248997	0.272219	0.783454	596	507	487	526	592	622	1119
Stubble	7.545243	5.594154	5.18746	5.989305	7.457151	8.177128	24.0876	4009	3412	3276	3540	3984	4187	7496
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000876	0.00074	0.000728	0.000644	0.000758	0.000902	0.002084	26	24	24	22	24	27	42
Wetland2	0.02003	0.016918	0.016632	0.01472	0.017328	0.020624	0.047627	147	134	132	124	135	149	236
Wetland3	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland4	0.003505	0.002961	0.002911	0.002576	0.003032	0.003609	0.008335	56	51	51	47	52	57	90
Wetland5	0.001753	0.00148	0.001455	0.001288	0.001516	0.001805	0.004167	38	35	35	32	35	39	62
Wetland6	0.001377	0.001163	0.001143	0.001012	0.001191	0.001418	0.003274	34	31	30	28	31	34	54
Wetland7	0.006009	0.005075	0.00499	0.004416	0.005198	0.006187	0.014288	76	69	68	64	70	77	122
Wetland8	0.000501	0.000423	0.000416	0.000368	0.000433	0.000516	0.001191	19	18	17	16	18	20	31
Wetland9	0.002879	0.002432	0.002391	0.002116	0.002491	0.002965	0.006846	50	46	46	43	47	51	81
Wetland10	0.011517	0.009728	0.009564	0.008464	0.009963	0.011859	0.027386	108	98	98	91	100	110	174
Wetland11	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland12	0.000376	0.000317	0.000312	0.000276	0.000325	0.000387	0.000893	16	15	15	14	15	17	26
Wetland13	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland14	0.015023	0.012688	0.012474	0.01104	0.012996	0.015468	0.03572	125	114	113	106	115	127	201
Wetland15	0.001377	0.001163	0.001143	0.001012	0.001191	0.001418	0.003274	34	31	30	28	31	34	54
Wetland16	0.000626	0.000529	0.00052	0.00046	0.000541	0.000645	0.001488	22	20	20	18	20	22	35
Wetland17	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland18	0.001252	0.001057	0.00104	0.00092	0.001083	0.001289	0.002977	32	29	29	27	29	32	51
Wetland19	0.006635	0.005604	0.005509	0.004876	0.00574	0.006832	0.015777	80	73	72	67	74	81	128
Wetland20	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland21	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland22	0.001002	0.000846	0.000832	0.000736	0.000866	0.001031	0.002381	28	26	25	24	26	29	45
Wetland23	0.002128	0.001798	0.001767	0.001564	0.001841	0.002191	0.00506	43	39	39	36	39	43	69
Wetland24	0.007887	0.006661	0.006549	0.005796	0.006823	0.008121	0.018753	88	80	79	74	81	89	141
Wetland25	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland26	0.21132	0.178483	0.17547	0.155295	0.182806	0.217585	0.502468	535	488	483	452	494	544	862
Wetland27	0.00313	0.002643	0.002599	0.0023	0.002707	0.003223	0.007442	53	48	48	45	49	54	85
Wetland28	0.069856	0.059001	0.058005	0.051336	0.06043	0.071927	0.1661	291	265	263	246	269	296	469
Wetland29	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland30	0.000626	0.000529	0.00052	0.00046	0.000541	0.000645	0.001488	22	20	20	18	20	22	35
Wetland31	0.017902	0.01512	0.014865	0.013156	0.015487	0.018433	0.042567	138	126	124	116	127	140	222
Wetland32	0.001502	0.001269	0.001247	0.001104	0.0013	0.001547	0.003572	35	32	32	30	33	36	57
Wetland33	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland34	0.005008	0.004229	0.004158	0.00368	0.004332	0.005156	0.011907	68	62	62	58	63	69	110
Wetland35	0.046571	0.039334	0.03867	0.034224	0.040287	0.047951	0.110733	233	212	210	197	215	237	375
Wetland36	0.000376	0.000317	0.000312	0.000276	0.000325	0.000387	0.000893	16	15	15	14	15	17	26
Wetland37	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland38	0.004632	0.003912	0.003846	0.003404	0.004007	0.004769	0.011014	65	60	59	55	60	67	105
Wetland39	0.002754	0.002326	0.002287	0.002024	0.002383	0.002836	0.006549	49	45	44	42	45	50	79
Wetland40	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland41	0.051077	0.043141	0.042412	0.037536	0.044185	0.052592	0.12145	245	223	221	207	226	249	395
Wetland42	0.014146	0.011948	0.011747	0.010396	0.012238	0.014566	0.033637	121	110	109	102	112	123	195
Wetland43	0.119681	0.101084	0.099378	0.087951	0.103533	0.123229	0.284573	392	357	354	331	362	398	631
Wetland44	0.002879	0.002432	0.002391	0.002116	0.002491	0.002965	0.006846	50	46	46	43	47	51	81
Wetland45	0.007011	0.005921	0.005821	0.005152	0.006065	0.007218	0.01667	82	75	74	69	76	84	132
Wetland46	0.003881	0.003278	0.003222	0.002852	0.003357	0.003996	0.009228	59	54	54	50	55	60	96
OpenWater	0.013779	0.770288	0.05891	0.019146	0.331283	0.464524	0.410625	127	1124	279	152	711	854	799
Channel	0.057058	0.283212	0.103054	0.043952	0.413228	0.127872	0.397134	29681	176332	55296	18832	228566	76025	221433

Table A23. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring all 46 wetlands by 75% from the current to the historical level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.246723	0.184785	0.171843	0.198909	0.24523	0.266605	0.767287	589	501	481	522	587	615	1106
Stubble	7.485188	5.58442	5.182104	6.01471	7.441945	8.10224	23.59496	3992	3409	3274	3548	3979	4166	7413
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000964	0.00076	0.000741	0.000616	0.000787	0.001003	0.002776	28	24	24	22	25	28	49
Wetland2	0.022045	0.017377	0.016948	0.01408	0.017991	0.022936	0.063441	154	136	134	121	138	158	276
Wetland3	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland4	0.003858	0.003041	0.002966	0.002464	0.003149	0.004014	0.011102	59	52	51	46	53	61	106
Wetland5	0.001929	0.00152	0.001483	0.001232	0.001574	0.002007	0.005551	40	35	35	32	36	41	72
Wetland6	0.001516	0.001195	0.001165	0.000968	0.001237	0.001577	0.004362	35	31	31	28	32	36	63
Wetland7	0.006614	0.005213	0.005085	0.004224	0.005397	0.006881	0.019032	80	70	69	62	71	81	142
Wetland8	0.000551	0.000434	0.000424	0.000352	0.00045	0.000573	0.001586	20	18	18	16	18	21	36
Wetland9	0.003169	0.002498	0.002436	0.002024	0.002586	0.003297	0.00912	53	47	46	42	48	54	95
Wetland10	0.012676	0.009992	0.009745	0.008096	0.010345	0.013188	0.036479	114	100	99	89	102	116	204
Wetland11	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland12	0.000413	0.000326	0.000318	0.000264	0.000337	0.00043	0.00119	17	15	15	14	16	18	31
Wetland13	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland14	0.016534	0.013033	0.012711	0.01056	0.013494	0.017202	0.047581	132	116	114	103	118	135	236
Wetland15	0.001516	0.001195	0.001165	0.000968	0.001237	0.001577	0.004362	35	31	31	28	32	36	63
Wetland16	0.000689	0.000543	0.00053	0.00044	0.000562	0.000717	0.001983	23	20	20	18	21	23	41
Wetland17	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland18	0.001378	0.001086	0.001059	0.00088	0.001124	0.001434	0.003965	34	29	29	26	30	34	60
Wetland19	0.007303	0.005756	0.005614	0.004664	0.00596	0.007598	0.021015	84	74	73	66	75	86	150
Wetland20	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland21	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland22	0.001102	0.000869	0.000847	0.000704	0.0009	0.001147	0.003172	30	26	26	23	27	30	53
Wetland23	0.002342	0.001846	0.001801	0.001496	0.001912	0.002437	0.006741	45	39	39	35	40	46	80
Wetland24	0.00868	0.006842	0.006673	0.005544	0.007084	0.009031	0.02498	93	81	80	72	83	95	165
Wetland25	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland26	0.23258	0.183325	0.178805	0.148542	0.18981	0.241977	0.669302	564	495	488	441	505	577	1009
Wetland27	0.003445	0.002715	0.002648	0.0022	0.002811	0.003584	0.009913	56	49	48	43	50	57	100
Wetland28	0.076884	0.060602	0.059107	0.049103	0.062745	0.07999	0.22125	307	269	266	240	275	314	549
Wetland29	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland30	0.000689	0.000543	0.00053	0.00044	0.000562	0.000717	0.001983	23	20	20	18	21	23	41
Wetland31	0.019703	0.01553	0.015148	0.012584	0.01608	0.020499	0.0567	145	127	126	113	130	148	260
Wetland32	0.001653	0.001303	0.001271	0.001056	0.001349	0.00172	0.004758	37	33	32	29	33	38	66
Wetland33	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland34	0.005511	0.004344	0.004237	0.00352	0.004498	0.005734	0.01586	72	63	62	56	64	74	129
Wetland35	0.051256	0.040401	0.039405	0.032736	0.04183	0.053327	0.1475	246	216	213	192	220	251	439
Wetland36	0.000413	0.000326	0.000318	0.000264	0.000337	0.00043	0.00119	17	15	15	14	16	18	31
Wetland37	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland38	0.005098	0.004018	0.003919	0.003256	0.004161	0.005304	0.014671	69	61	60	54	62	71	123
Wetland39	0.003031	0.002389	0.00233	0.001936	0.002474	0.003154	0.008723	52	45	45	41	46	53	93
Wetland40	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland41	0.056216	0.044311	0.043218	0.035904	0.045878	0.058487	0.161774	258	227	224	202	231	264	462
Wetland42	0.01557	0.012272	0.01197	0.009944	0.012706	0.016199	0.044805	128	112	110	100	114	130	228
Wetland43	0.131722	0.103826	0.101267	0.084127	0.107499	0.137044	0.37906	413	362	357	323	369	422	738
Wetland44	0.003169	0.002498	0.002436	0.002024	0.002586	0.003297	0.00912	53	47	46	42	48	54	95
Wetland45	0.007716	0.006082	0.005932	0.004928	0.006297	0.008028	0.022204	87	76	75	68	78	89	155
Wetland46	0.004271	0.003367	0.003284	0.002728	0.003486	0.004444	0.012292	63	55	54	49	56	64	112
OpenWater	0.019021	0.722135	0.045052	0.009574	0.217477	0.564288	0.373394	151	1085	241	104	566	949	759
Channel	0.050256	0.244961	0.082868	0.041672	0.378885	0.132309	0.369854	26063	153630	41474	17991	215362	85024	211803

Table A24. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring all 46 wetlands by 100% from the current to the historical level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.241411	0.181248	0.16831	0.196381	0.241463	0.260991	0.751119	582	496	476	519	582	607	1093
Stubble	7.425133	5.574686	5.176748	6.040114	7.426739	8.027351	23.10231	3974	3405	3272	3556	3975	4145	7329
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.001053	0.00078	0.000755	0.000588	0.000816	0.001105	0.003467	29	25	24	21	25	30	56
Wetland2	0.024061	0.017836	0.017264	0.01344	0.018655	0.025248	0.079255	162	137	135	118	141	166	312
Wetland3	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland4	0.004211	0.003121	0.003021	0.002352	0.003265	0.004418	0.01387	62	53	52	45	54	64	120
Wetland5	0.002105	0.001561	0.001511	0.001176	0.001632	0.002209	0.006935	42	36	35	31	37	44	82
Wetland6	0.001654	0.001226	0.001187	0.000924	0.001283	0.001736	0.005449	37	32	31	27	32	38	72
Wetland7	0.007218	0.005351	0.005179	0.004032	0.005597	0.007574	0.023776	84	71	70	61	73	86	161
Wetland8	0.000602	0.000446	0.000432	0.000336	0.000466	0.000631	0.001981	21	18	18	15	19	22	41
Wetland9	0.003459	0.002564	0.002482	0.001932	0.002682	0.003629	0.011393	56	47	46	40	48	57	107
Wetland10	0.013835	0.010256	0.009927	0.007728	0.010727	0.014518	0.045571	120	101	100	87	104	123	230
Wetland11	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland12	0.000451	0.000334	0.000324	0.000252	0.00035	0.000473	0.001486	18	15	15	13	16	19	35
Wetland13	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland14	0.018045	0.013377	0.012948	0.01008	0.013991	0.018936	0.059441	138	117	115	100	120	142	267
Wetland15	0.001654	0.001226	0.001187	0.000924	0.001283	0.001736	0.005449	37	32	31	27	32	38	72
Wetland16	0.000752	0.000557	0.00054	0.00042	0.000583	0.000789	0.002477	24	20	20	17	21	25	46
Wetland17	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland18	0.001504	0.001115	0.001079	0.00084	0.001166	0.001578	0.004953	35	30	29	26	31	36	68
Wetland19	0.00797	0.005908	0.005719	0.004452	0.00618	0.008363	0.026253	88	75	74	64	77	91	170
Wetland20	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland21	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland22	0.001203	0.000892	0.000863	0.000672	0.000933	0.001262	0.003963	31	26	26	23	27	32	60
Wetland23	0.002556	0.001895	0.001834	0.001428	0.001982	0.002683	0.008421	47	40	39	34	41	48	91
Wetland24	0.009474	0.007023	0.006798	0.005292	0.007346	0.009942	0.031207	97	82	81	70	84	100	187
Wetland25	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland26	0.25384	0.188167	0.18214	0.14179	0.196813	0.266369	0.836136	592	502	493	430	515	608	1141
Wetland27	0.003759	0.002787	0.002698	0.0021	0.002915	0.003945	0.012384	58	50	49	42	51	60	112
Wetland28	0.083912	0.062202	0.06021	0.046871	0.06506	0.088053	0.2764	322	273	268	234	280	331	621
Wetland29	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland30	0.000752	0.000557	0.00054	0.00042	0.000583	0.000789	0.002477	24	20	20	17	21	25	46
Wetland31	0.021504	0.015941	0.01543	0.012012	0.016673	0.022566	0.070834	152	129	127	111	132	156	293
Wetland32	0.001805	0.001338	0.001295	0.001008	0.001399	0.001894	0.005944	39	33	32	28	34	40	75
Wetland33	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland34	0.006015	0.004459	0.004316	0.00336	0.004664	0.006312	0.019814	76	64	63	55	66	78	146
Wetland35	0.055941	0.041468	0.04014	0.031248	0.043373	0.058702	0.184267	258	219	215	187	224	265	497
Wetland36	0.000451	0.000334	0.000324	0.000252	0.00035	0.000473	0.001486	18	15	15	13	16	19	35
Wetland37	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland38	0.005564	0.004125	0.003992	0.003108	0.004314	0.005839	0.018328	72	61	60	53	63	74	140
Wetland39	0.003308	0.002452	0.002374	0.001848	0.002565	0.003472	0.010898	54	46	45	40	47	56	105
Wetland40	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland41	0.061355	0.045481	0.044024	0.034272	0.047571	0.064383	0.202099	271	230	226	197	236	278	522
Wetland42	0.016993	0.012596	0.012193	0.009492	0.013175	0.017832	0.055974	134	114	112	97	116	137	258
Wetland43	0.143762	0.106568	0.103155	0.080303	0.111465	0.150858	0.473546	433	367	361	314	377	445	834
Wetland44	0.003459	0.002564	0.002482	0.001932	0.002682	0.003629	0.011393	56	47	46	40	48	57	107
Wetland45	0.008421	0.006242	0.006043	0.004704	0.006529	0.008837	0.027739	91	77	76	66	79	93	175
Wetland46	0.004662	0.003456	0.003345	0.002604	0.003614	0.004892	0.015356	66	56	55	48	57	67	127
OpenWater	0.024263	0.673982	0.031195	0.000001	0.10367	0.664052	0.336164	173	1045	198	1	379	1037	717
Channel	0.043454	0.206709	0.062683	0.039393	0.344543	0.136747	0.342574	22445	130929	27652	17149	202159	94023	202173

Table A25. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining all 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.266131	0.199546	0.186399	0.209941	0.260634	0.287446	0.819862	614	523	504	538	607	641	1148
Stubble	7.772218	5.741365	5.319964	6.044525	7.613853	8.44992	25.1982	4074	3460	3321	3557	4029	4261	7680
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000552	0.000528	0.000532	0.000555	0.000528	0.000534	0.000541	20	20	20	20	20	20	20
Wetland2	0.012615	0.012077	0.012165	0.012688	0.012071	0.012201	0.012373	114	111	111	114	111	112	112
Wetland3	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland4	0.002208	0.002114	0.002129	0.00222	0.002112	0.002135	0.002165	44	43	43	44	43	43	43
Wetland5	0.001104	0.001057	0.001064	0.00111	0.001056	0.001068	0.001083	30	29	29	30	29	29	29
Wetland6	0.000867	0.00083	0.000836	0.000872	0.00083	0.000839	0.000851	26	25	26	26	25	26	26
Wetland7	0.003784	0.003623	0.003649	0.003806	0.003621	0.00366	0.003712	59	57	57	59	57	58	58
Wetland8	0.000315	0.000302	0.000304	0.000317	0.000302	0.000305	0.000309	15	15	15	15	15	15	15
Wetland9	0.001813	0.001736	0.001749	0.001824	0.001735	0.001754	0.001779	39	38	38	39	38	38	39
Wetland10	0.007253	0.006944	0.006995	0.007296	0.006941	0.007015	0.007115	84	82	82	84	82	82	83
Wetland11	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland12	0.000237	0.000226	0.000228	0.000238	0.000226	0.000229	0.000232	13	12	13	13	12	13	13
Wetland13	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland14	0.009461	0.009058	0.009124	0.009516	0.009053	0.009151	0.00928	97	95	95	97	95	95	96
Wetland15	0.000867	0.00083	0.000836	0.000872	0.00083	0.000839	0.000851	26	25	26	26	25	26	26
Wetland16	0.000394	0.000377	0.00038	0.000396	0.000377	0.000381	0.000387	17	16	17	17	16	17	17
Wetland17	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland18	0.000788	0.000755	0.00076	0.000793	0.000754	0.000763	0.000773	25	24	24	25	24	24	24
Wetland19	0.004179	0.004001	0.00403	0.004203	0.003999	0.004042	0.004099	62	60	61	62	60	61	61
Wetland20	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland21	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland22	0.000631	0.000604	0.000608	0.000634	0.000604	0.00061	0.000619	22	21	21	22	21	21	22
Wetland23	0.00134	0.001283	0.001293	0.001348	0.001283	0.001296	0.001315	33	32	32	33	32	33	33
Wetland24	0.004967	0.004755	0.00479	0.004996	0.004753	0.004804	0.004872	68	66	67	68	66	67	67
Wetland25	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland26	0.133086	0.127416	0.128339	0.133858	0.127352	0.128718	0.13054	415	405	407	416	405	408	411
Wetland27	0.001971	0.001887	0.001901	0.001982	0.001886	0.001906	0.001933	41	40	40	41	40	40	40
Wetland28	0.043994	0.04212	0.042425	0.044249	0.042098	0.04255	0.043153	226	221	221	227	220	222	223
Wetland29	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland30	0.000394	0.000377	0.00038	0.000396	0.000377	0.000381	0.000387	17	16	17	17	16	17	17
Wetland31	0.011274	0.010794	0.010872	0.01134	0.010789	0.010904	0.011059	107	104	105	107	104	105	106
Wetland32	0.000946	0.000906	0.000912	0.000952	0.000905	0.000915	0.000928	27	27	27	27	27	27	27
Wetland33	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland34	0.003154	0.003019	0.003041	0.003172	0.003018	0.00305	0.003093	53	52	52	53	52	52	52
Wetland35	0.029329	0.02808	0.028283	0.029499	0.028066	0.028367	0.028768	181	176	177	181	176	177	179
Wetland36	0.000237	0.000226	0.000228	0.000238	0.000226	0.000229	0.000232	13	12	13	13	12	13	13
Wetland37	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland38	0.002917	0.002793	0.002813	0.002934	0.002791	0.002821	0.002861	51	50	50	51	50	50	50
Wetland39	0.001735	0.001661	0.001673	0.001745	0.00166	0.001678	0.001701	38	37	37	38	37	37	38
Wetland40	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland41	0.032168	0.030797	0.03102	0.032354	0.030782	0.031112	0.031552	190	186	186	191	186	187	188
Wetland42	0.008909	0.00853	0.008591	0.008961	0.008525	0.008617	0.008739	94	92	92	94	92	92	93
Wetland43	0.075373	0.072162	0.072685	0.07581	0.072126	0.0729	0.073932	304	297	298	305	296	298	300
Wetland44	0.001813	0.001736	0.001749	0.001824	0.001735	0.001754	0.001779	39	38	38	39	38	38	39
Wetland45	0.004415	0.004227	0.004258	0.004441	0.004225	0.00427	0.004331	64	62	63	64	62	63	63
Wetland46	0.002444	0.00234	0.002357	0.002458	0.002339	0.002364	0.002397	46	45	45	46	45	45	46
OpenWater	0.002471	0.649946	0.064968	0.028719	0.419172	0.198748	0.363814	50	1025	294	189	808	539	748
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A26. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining all 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.269604	0.203699	0.190358	0.213387	0.264739	0.291444	0.823935	618	529	510	543	612	646	1151
Stubble	7.879082	5.869109	5.441755	6.150554	7.740142	8.572936	25.32351	4104	3501	3361	3591	4065	4295	7701
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000404	0.000357	0.000364	0.00041	0.000356	0.000368	0.000383	17	16	16	17	16	16	17
Wetland2	0.009229	0.008155	0.00833	0.009376	0.008142	0.008402	0.008747	96	89	90	97	89	91	93
Wetland3	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland4	0.001615	0.001427	0.001458	0.001641	0.001425	0.00147	0.001531	37	34	35	37	34	35	36
Wetland5	0.000808	0.000714	0.000729	0.00082	0.000712	0.000735	0.000765	25	23	24	25	23	24	24
Wetland6	0.000635	0.000561	0.000573	0.000645	0.00056	0.000578	0.000601	22	20	21	22	20	21	21
Wetland7	0.002769	0.002446	0.002499	0.002813	0.002443	0.00252	0.002624	49	46	47	50	46	47	48
Wetland8	0.000231	0.000204	0.000208	0.000234	0.000204	0.00021	0.000219	13	12	12	13	12	12	12
Wetland9	0.001327	0.001172	0.001197	0.001348	0.00117	0.001208	0.001257	33	31	31	33	31	31	32
Wetland10	0.005307	0.004689	0.00479	0.005391	0.004682	0.004831	0.00503	71	66	67	71	66	67	69
Wetland11	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland12	0.000173	0.000153	0.000156	0.000176	0.000153	0.000158	0.000164	11	10	10	11	10	10	10
Wetland13	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland14	0.006922	0.006116	0.006247	0.007032	0.006107	0.006301	0.00656	82	76	77	82	76	78	79
Wetland15	0.000635	0.000561	0.000573	0.000645	0.00056	0.000578	0.000601	22	20	21	22	20	21	21
Wetland16	0.000288	0.000255	0.00026	0.000293	0.000254	0.000263	0.000273	14	13	13	14	13	14	14
Wetland17	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland18	0.000577	0.00051	0.000521	0.000586	0.000509	0.000525	0.000547	21	19	20	21	19	20	20
Wetland19	0.003057	0.002701	0.002759	0.003106	0.002697	0.002783	0.002897	52	49	49	53	49	49	51
Wetland20	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland21	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland22	0.000461	0.000408	0.000416	0.000469	0.000407	0.00042	0.000437	18	17	17	19	17	17	18
Wetland23	0.000981	0.000866	0.000885	0.000996	0.000865	0.000893	0.000929	28	26	26	28	26	26	27
Wetland24	0.003634	0.003211	0.00328	0.003692	0.003206	0.003308	0.003444	57	54	54	58	53	54	56
Wetland25	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland26	0.097371	0.086032	0.087879	0.098915	0.085903	0.088636	0.092281	350	327	330	353	326	332	339
Wetland27	0.001442	0.001274	0.001302	0.001465	0.001272	0.001313	0.001367	34	32	33	35	32	33	33
Wetland28	0.032188	0.02844	0.02905	0.032698	0.028397	0.0293	0.030505	190	178	180	192	178	181	185
Wetland29	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland30	0.000288	0.000255	0.00026	0.000293	0.000254	0.000263	0.000273	14	13	13	14	13	14	14
Wetland31	0.008249	0.007288	0.007445	0.00838	0.007277	0.007509	0.007818	90	84	85	91	84	85	87
Wetland32	0.000692	0.000612	0.000625	0.000703	0.000611	0.00063	0.000656	23	22	22	23	21	22	22
Wetland33	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland34	0.002307	0.002039	0.002082	0.002344	0.002036	0.0021	0.002187	45	42	42	45	42	42	43
Wetland35	0.021459	0.01896	0.019367	0.021799	0.018931	0.019534	0.020337	152	142	144	153	142	145	148
Wetland36	0.000173	0.000153	0.000156	0.000176	0.000153	0.000158	0.000164	11	10	10	11	10	10	10
Wetland37	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland38	0.002134	0.001886	0.001926	0.002168	0.001883	0.001943	0.002023	43	40	40	43	40	41	42
Wetland39	0.001269	0.001121	0.001145	0.001289	0.00112	0.001155	0.001203	32	30	30	32	30	31	31
Wetland40	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland41	0.023535	0.020794	0.021241	0.023908	0.020763	0.021424	0.022305	160	150	151	161	149	152	155
Wetland42	0.006518	0.005759	0.005883	0.006622	0.005751	0.005934	0.006178	79	74	75	80	74	75	77
Wetland43	0.055146	0.048724	0.04977	0.056021	0.048651	0.050199	0.052263	256	239	242	258	239	243	248
Wetland44	0.001327	0.001172	0.001197	0.001348	0.00117	0.001208	0.001257	33	31	31	33	31	31	32
Wetland45	0.00323	0.002854	0.002915	0.003282	0.00285	0.002941	0.003061	54	50	51	54	50	51	52
Wetland46	0.001788	0.00158	0.001614	0.001817	0.001578	0.001628	0.001695	39	36	37	39	36	37	38
OpenWater	0.001648	0.433297	0.043313	0.019146	0.279449	0.132499	0.242543	40	823	236	152	649	433	601
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A27. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining all 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.273078	0.207851	0.194316	0.216834	0.268844	0.295443	0.828008	623	535	515	548	617	651	1154
Stubble	7.985947	5.996853	5.563547	6.256583	7.866432	8.695951	25.44883	4134	3542	3402	3624	4100	4328	7721
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000256	0.000185	0.000197	0.000265	0.000184	0.000201	0.000224	13	11	12	14	11	12	12
Wetland2	0.005844	0.004232	0.004495	0.006064	0.004214	0.004602	0.00512	74	62	64	76	62	65	69
Wetland3	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland4	0.001023	0.000741	0.000787	0.001061	0.000737	0.000805	0.000896	29	24	25	29	24	25	27
Wetland5	0.000511	0.00037	0.000393	0.000531	0.000369	0.000403	0.000448	19	16	17	20	16	17	18
Wetland6	0.000402	0.000291	0.000309	0.000417	0.00029	0.000316	0.000352	17	14	15	17	14	15	16
Wetland7	0.001753	0.00127	0.001348	0.001819	0.001264	0.001381	0.001536	38	32	33	39	32	34	36
Wetland8	0.000146	0.000106	0.000112	0.000152	0.000105	0.000115	0.000128	10	8	8	10	8	9	9
Wetland9	0.00084	0.000608	0.000646	0.000872	0.000606	0.000662	0.000736	26	21	22	26	21	22	24
Wetland10	0.00336	0.002433	0.002584	0.003487	0.002423	0.002646	0.002944	55	46	48	56	46	48	51
Wetland11	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland12	0.00011	7.94E-05	8.43E-05	0.000114	7.9E-05	8.63E-05	9.6E-05	8	7	7	9	7	7	8
Wetland13	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland14	0.004383	0.003174	0.003371	0.004548	0.00316	0.003452	0.00384	64	53	55	65	53	56	59
Wetland15	0.000402	0.000291	0.000309	0.000417	0.00029	0.000316	0.000352	17	14	15	17	14	15	16
Wetland16	0.000183	0.000132	0.00014	0.000189	0.000132	0.000144	0.00016	11	9	10	11	9	10	10
Wetland17	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland18	0.000365	0.000265	0.000281	0.000379	0.000263	0.000288	0.00032	16	14	14	17	14	14	15
Wetland19	0.001936	0.001402	0.001489	0.002009	0.001396	0.001525	0.001696	41	34	35	41	34	36	38
Wetland20	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland21	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland22	0.000292	0.000212	0.000225	0.000303	0.000211	0.00023	0.000256	14	12	12	15	12	13	13
Wetland23	0.000621	0.00045	0.000478	0.000644	0.000448	0.000489	0.000544	22	18	19	22	18	19	20
Wetland24	0.002301	0.001666	0.00177	0.002388	0.001659	0.001812	0.002016	45	37	39	45	37	39	41
Wetland25	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland26	0.061657	0.044648	0.047418	0.063973	0.044455	0.048554	0.054021	272	228	235	277	227	238	253
Wetland27	0.000913	0.000661	0.000702	0.000947	0.000658	0.000719	0.0008	27	22	23	27	22	24	25
Wetland28	0.020382	0.014759	0.015675	0.021147	0.014695	0.016051	0.017858	148	124	128	151	124	130	138
Wetland29	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland30	0.000183	0.000132	0.00014	0.000189	0.000132	0.000144	0.00016	11	9	10	11	9	10	10
Wetland31	0.005223	0.003782	0.004017	0.005419	0.003766	0.004113	0.004576	70	59	61	71	58	61	65
Wetland32	0.000438	0.000317	0.000337	0.000455	0.000316	0.000345	0.000384	18	15	15	18	15	16	17
Wetland33	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland34	0.001461	0.001058	0.001124	0.001516	0.001053	0.001151	0.00128	35	29	30	35	29	30	32
Wetland35	0.013588	0.00984	0.01045	0.014098	0.009797	0.0107	0.011905	118	99	102	121	99	104	110
Wetland36	0.00011	7.94E-05	8.43E-05	0.000114	7.9E-05	8.63E-05	9.6E-05	8	7	7	9	7	7	8
Wetland37	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland38	0.001351	0.000979	0.001039	0.001402	0.000974	0.001064	0.001184	33	28	29	34	28	29	31
Wetland39	0.000804	0.000582	0.000618	0.000834	0.000579	0.000633	0.000704	25	21	22	25	21	22	23
Wetland40	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland41	0.014903	0.010792	0.011461	0.015463	0.010745	0.011736	0.013057	125	104	108	127	104	109	116
Wetland42	0.004127	0.002989	0.003174	0.004283	0.002976	0.00325	0.003616	61	51	53	63	51	54	57
Wetland43	0.034919	0.025286	0.026855	0.036231	0.025177	0.027499	0.030595	199	167	172	203	166	174	185
Wetland44	0.00084	0.000608	0.000646	0.000872	0.000606	0.000662	0.000736	26	21	22	26	21	22	24
Wetland45	0.002045	0.001481	0.001573	0.002122	0.001475	0.001611	0.001792	42	35	36	43	35	37	39
Wetland46	0.001132	0.00082	0.000871	0.001175	0.000816	0.000892	0.000992	30	25	26	31	25	26	28
OpenWater	0.000824	0.216649	0.021657	0.009574	0.139725	0.06625	0.121272	28	565	162	104	446	297	413
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A28. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining all 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.276551	0.212003	0.198275	0.22028	0.272949	0.299441	0.832082	627	541	521	553	623	656	1157
Stubble	8.092811	6.124597	5.685338	6.362612	7.992721	8.818967	25.57415	4163	3583	3442	3657	4135	4361	7742
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000108	1.35E-05	2.89E-05	0.00012	1.25E-05	3.51E-05	6.54E-05	8	3	4	9	3	4	6
Wetland2	0.002459	0.000309	0.000659	0.002752	0.000285	0.000803	0.001494	46	15	22	49	14	25	35
Wetland3	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland4	0.00043	5.41E-05	0.000115	0.000482	4.99E-05	0.000141	0.000261	18	6	9	19	5	10	13
Wetland5	0.000215	2.71E-05	5.77E-05	0.000241	2.49E-05	7.03E-05	0.000131	12	4	6	13	4	7	9
Wetland6	0.000169	2.13E-05	4.53E-05	0.000189	1.96E-05	5.52E-05	0.000103	11	3	5	11	3	6	8
Wetland7	0.000738	9.28E-05	0.000198	0.000826	8.55E-05	0.000241	0.000448	24	8	12	25	7	13	18
Wetland8	6.15E-05	7.73E-06	1.65E-05	6.88E-05	7.12E-06	2.01E-05	3.73E-05	6	2	3	6	2	3	5
Wetland9	0.000353	4.45E-05	9.48E-05	0.000396	4.1E-05	0.000115	0.000215	16	5	8	17	5	9	12
Wetland10	0.001414	0.000178	0.000379	0.001582	0.000164	0.000462	0.000859	34	11	17	36	10	18	26
Wetland11	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland12	4.61E-05	5.8E-06	1.24E-05	5.16E-05	5.34E-06	1.51E-05	2.8E-05	5	2	3	6	2	3	4
Wetland13	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland14	0.001844	0.000232	0.000495	0.002064	0.000214	0.000602	0.00112	39	13	19	42	12	21	30
Wetland15	0.000169	2.13E-05	4.53E-05	0.000189	1.96E-05	5.52E-05	0.000103	11	3	5	11	3	6	8
Wetland16	7.68E-05	9.67E-06	2.06E-05	8.6E-05	8.91E-06	2.51E-05	4.67E-05	7	2	3	7	2	4	5
Wetland17	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland18	0.000154	1.93E-05	4.12E-05	0.000172	1.78E-05	5.02E-05	9.34E-05	10	3	5	11	3	5	8
Wetland19	0.000815	0.000102	0.000218	0.000911	9.44E-05	0.000266	0.000495	25	8	12	27	8	14	19
Wetland20	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland21	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland22	0.000123	1.55E-05	3.3E-05	0.000138	1.42E-05	4.02E-05	7.47E-05	9	3	4	9	3	5	7
Wetland23	0.000261	3.29E-05	7.01E-05	0.000292	3.03E-05	8.53E-05	0.000159	13	4	7	14	4	7	10
Wetland24	0.000968	0.000122	0.00026	0.001083	0.000112	0.000316	0.000588	28	9	13	29	8	15	21
Wetland25	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland26	0.025942	0.003264	0.006958	0.02903	0.003006	0.008473	0.015761	169	54	82	180	52	91	128
Wetland27	0.000384	4.83E-05	0.000103	0.00043	4.45E-05	0.000125	0.000233	17	5	8	18	5	9	13
Wetland28	0.008576	0.001079	0.0023	0.009596	0.000994	0.002801	0.00521	92	29	45	98	28	50	70
Wetland29	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland30	7.68E-05	9.67E-06	2.06E-05	8.6E-05	8.91E-06	2.51E-05	4.67E-05	7	2	3	7	2	4	5
Wetland31	0.002198	0.000277	0.000589	0.002459	0.000255	0.000718	0.001335	43	14	21	46	13	23	33
Wetland32	0.000184	2.32E-05	4.95E-05	0.000206	2.14E-05	6.02E-05	0.000112	11	4	5	12	3	6	8
Wetland33	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland34	0.000615	7.73E-05	0.000165	0.000688	7.12E-05	0.000201	0.000373	22	7	10	23	7	12	16
Wetland35	0.005717	0.000719	0.001533	0.006398	0.000663	0.001867	0.003473	74	24	36	78	22	40	56
Wetland36	4.61E-05	5.8E-06	1.24E-05	5.16E-05	5.34E-06	1.51E-05	2.8E-05	5	2	3	6	2	3	4
Wetland37	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland38	0.000569	7.15E-05	0.000153	0.000636	6.59E-05	0.000186	0.000345	21	7	10	22	6	11	16
Wetland39	0.000338	4.25E-05	9.07E-05	0.000378	3.92E-05	0.00011	0.000205	16	5	8	17	5	8	12
Wetland40	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland41	0.00627	0.000789	0.001682	0.007017	0.000727	0.002048	0.00381	77	25	38	82	24	42	59
Wetland42	0.001737	0.000219	0.000466	0.001943	0.000201	0.000567	0.001055	38	12	19	41	12	21	29
Wetland43	0.014692	0.001849	0.00394	0.016441	0.001703	0.004798	0.008926	124	40	60	131	38	67	94
Wetland44	0.000353	4.45E-05	9.48E-05	0.000396	4.1E-05	0.000115	0.000215	16	5	8	17	5	9	12
Wetland45	0.000861	0.000108	0.000231	0.000963	9.97E-05	0.000281	0.000523	26	8	13	28	8	14	20
Wetland46	0.000476	5.99E-05	0.000128	0.000533	5.52E-05	0.000156	0.000289	19	6	9	20	6	10	14
OpenWater	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	1	1	1	1	1	1	1
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A29. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining upper part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.263121	0.195948	0.182969	0.206955	0.257077	0.283981	0.816332	610	518	499	534	602	637	1145
Stubble	7.679611	5.630665	5.214422	5.952643	7.504413	8.343318	25.0896	4047	3424	3285	3528	3997	4232	7662
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000552	0.000528	0.000532	0.000555	0.000528	0.000534	0.000541	20	20	20	20	20	20	20
Wetland2	0.012615	0.012077	0.012165	0.012688	0.012071	0.012201	0.012373	114	111	111	114	111	112	112
Wetland3	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland4	0.002208	0.002114	0.002129	0.00222	0.002112	0.002135	0.002165	44	43	43	44	43	43	43
Wetland5	0.001104	0.001057	0.001064	0.00111	0.001056	0.001068	0.001083	30	29	29	30	29	29	29
Wetland6	0.000867	0.00083	0.000836	0.000872	0.00083	0.000839	0.000851	26	25	26	26	25	26	26
Wetland7	0.003784	0.003623	0.003649	0.003806	0.003621	0.00366	0.003712	59	57	57	59	57	58	58
Wetland8	0.000315	0.000302	0.000304	0.000317	0.000302	0.000305	0.000309	15	15	15	15	15	15	15
Wetland9	0.001813	0.001736	0.001749	0.001824	0.001735	0.001754	0.001779	39	38	38	39	38	38	39
Wetland10	0.007253	0.006944	0.006995	0.007296	0.006941	0.007015	0.007115	84	82	82	84	82	82	83
Wetland11	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland12	0.000237	0.000226	0.000228	0.000238	0.000226	0.000229	0.000232	13	12	13	13	12	13	13
Wetland13	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland14	0.009461	0.009058	0.009124	0.009516	0.009053	0.009151	0.00928	97	95	95	97	95	95	96
Wetland15	0.000867	0.00083	0.000836	0.000872	0.00083	0.000839	0.000851	26	25	26	26	25	26	26
Wetland16	0.000394	0.000377	0.00038	0.000396	0.000377	0.000381	0.000387	17	16	17	17	16	17	17
Wetland17	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland18	0.000788	0.000755	0.00076	0.000793	0.000754	0.000763	0.000773	25	24	24	25	24	24	24
Wetland19	0.004179	0.004001	0.00403	0.004203	0.003999	0.004042	0.004099	62	60	61	62	60	61	61
Wetland20	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland21	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland22	0.000631	0.000604	0.000608	0.000634	0.000604	0.00061	0.000619	22	21	21	22	21	21	22
Wetland23	0.00134	0.001283	0.001293	0.001348	0.001283	0.001296	0.001315	33	32	32	33	32	33	33
Wetland24	0.004967	0.004755	0.00479	0.004996	0.004753	0.004804	0.004872	68	66	67	68	66	67	67
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A30. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining upper part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.263584	0.196502	0.183497	0.207414	0.257625	0.284514	0.816876	611	519	499	535	603	637	1145
Stubble	7.693869	5.647709	5.230672	5.96679	7.521263	8.359731	25.10632	4051	3429	3290	3533	4002	4237	7665
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000404	0.000357	0.000364	0.00041	0.000356	0.000368	0.000383	17	16	16	17	16	16	17
Wetland2	0.009229	0.008155	0.00833	0.009376	0.008142	0.008402	0.008747	96	89	90	97	89	91	93
Wetland3	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland4	0.001615	0.001427	0.001458	0.001641	0.001425	0.00147	0.001531	37	34	35	37	34	35	36
Wetland5	0.000808	0.000714	0.000729	0.00082	0.000712	0.000735	0.000765	25	23	24	25	23	24	24
Wetland6	0.000635	0.000561	0.000573	0.000645	0.00056	0.000578	0.000601	22	20	21	22	20	21	21
Wetland7	0.002769	0.002446	0.002499	0.002813	0.002443	0.00252	0.002624	49	46	47	50	46	47	48
Wetland8	0.000231	0.000204	0.000208	0.000234	0.000204	0.00021	0.000219	13	12	12	13	12	12	12
Wetland9	0.001327	0.001172	0.001197	0.001348	0.00117	0.001208	0.001257	33	31	31	33	31	31	32
Wetland10	0.005307	0.004689	0.00479	0.005391	0.004682	0.004831	0.00503	71	66	67	71	66	67	69
Wetland11	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland12	0.000173	0.000153	0.000156	0.000176	0.000153	0.000158	0.000164	11	10	10	11	10	10	10
Wetland13	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland14	0.006922	0.006116	0.006247	0.007032	0.006107	0.006301	0.00656	82	76	77	82	76	78	79
Wetland15	0.000635	0.000561	0.000573	0.000645	0.00056	0.000578	0.000601	22	20	21	22	20	21	21
Wetland16	0.000288	0.000255	0.00026	0.000293	0.000254	0.000263	0.000273	14	13	13	14	13	14	14
Wetland17	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland18	0.000577	0.00051	0.000521	0.000586	0.000509	0.000525	0.000547	21	19	20	21	19	20	20
Wetland19	0.003057	0.002701	0.002759	0.003106	0.002697	0.002783	0.002897	52	49	49	53	49	49	51
Wetland20	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland21	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland22	0.000461	0.000408	0.000416	0.000469	0.000407	0.00042	0.000437	18	17	17	19	17	17	18
Wetland23	0.000981	0.000866	0.000885	0.000996	0.000865	0.000893	0.000929	28	26	26	28	26	26	27
Wetland24	0.003634	0.003211	0.00328	0.003692	0.003206	0.003308	0.003444	57	54	54	58	53	54	56
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A31. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining upper part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.264048	0.197056	0.184025	0.207874	0.258173	0.285048	0.817419	611	519	500	535	604	638	1146
Stubble	7.708128	5.664753	5.246922	5.980936	7.538113	8.376144	25.12304	4055	3435	3296	3537	4007	4241	7668
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000256	0.000185	0.000197	0.000265	0.000184	0.000201	0.000224	13	11	12	14	11	12	12
Wetland2	0.005844	0.004232	0.004495	0.006064	0.004214	0.004602	0.00512	74	62	64	76	62	65	69
Wetland3	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland4	0.001023	0.000741	0.000787	0.001061	0.000737	0.000805	0.000896	29	24	25	29	24	25	27
Wetland5	0.000511	0.00037	0.000393	0.000531	0.000369	0.000403	0.000448	19	16	17	20	16	17	18
Wetland6	0.000402	0.000291	0.000309	0.000417	0.00029	0.000316	0.000352	17	14	15	17	14	15	16
Wetland7	0.001753	0.00127	0.001348	0.001819	0.001264	0.001381	0.001536	38	32	33	39	32	34	36
Wetland8	0.000146	0.000106	0.000112	0.000152	0.000105	0.000115	0.000128	10	8	8	10	8	9	9
Wetland9	0.00084	0.000608	0.000646	0.000872	0.000606	0.000662	0.000736	26	21	22	26	21	22	24
Wetland10	0.00336	0.002433	0.002584	0.003487	0.002423	0.002646	0.002944	55	46	48	56	46	48	51
Wetland11	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland12	0.00011	7.94E-05	8.43E-05	0.000114	7.9E-05	8.63E-05	9.6E-05	8	7	7	9	7	7	8
Wetland13	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland14	0.004383	0.003174	0.003371	0.004548	0.00316	0.003452	0.00384	64	53	55	65	53	56	59
Wetland15	0.000402	0.000291	0.000309	0.000417	0.00029	0.000316	0.000352	17	14	15	17	14	15	16
Wetland16	0.000183	0.000132	0.00014	0.000189	0.000132	0.000144	0.00016	11	9	10	11	9	10	10
Wetland17	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland18	0.000365	0.000265	0.000281	0.000379	0.000263	0.000288	0.00032	16	14	14	17	14	14	15
Wetland19	0.001936	0.001402	0.001489	0.002009	0.001396	0.001525	0.001696	41	34	35	41	34	36	38
Wetland20	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland21	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland22	0.000292	0.000212	0.000225	0.000303	0.000211	0.00023	0.000256	14	12	12	15	12	13	13
Wetland23	0.000621	0.00045	0.000478	0.000644	0.000448	0.000489	0.000544	22	18	19	22	18	19	20
Wetland24	0.002301	0.001666	0.00177	0.002388	0.001659	0.001812	0.002016	45	37	39	45	37	39	41
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A32. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining upper part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.264511	0.19761	0.184553	0.208334	0.25872	0.285581	0.817963	612	520	501	536	604	638	1146
Stubble	7.722386	5.681797	5.263171	5.995083	7.554963	8.392557	25.13976	4059	3441	3301	3542	4012	4246	7670
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000108	1.35E-05	2.89E-05	0.00012	1.25E-05	3.51E-05	6.54E-05	8	3	4	9	3	4	6
Wetland2	0.002459	0.000309	0.000659	0.002752	0.000285	0.000803	0.001494	46	15	22	49	14	25	35
Wetland3	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland4	0.00043	5.41E-05	0.000115	0.000482	4.99E-05	0.000141	0.000261	18	6	9	19	5	10	13
Wetland5	0.000215	2.71E-05	5.77E-05	0.000241	2.49E-05	7.03E-05	0.000131	12	4	6	13	4	7	9
Wetland6	0.000169	2.13E-05	4.53E-05	0.000189	1.96E-05	5.52E-05	0.000103	11	3	5	11	3	6	8
Wetland7	0.000738	9.28E-05	0.000198	0.000826	8.55E-05	0.000241	0.000448	24	8	12	25	7	13	18
Wetland8	6.15E-05	7.73E-06	1.65E-05	6.88E-05	7.12E-06	2.01E-05	3.73E-05	6	2	3	6	2	3	5
Wetland9	0.000353	4.45E-05	9.48E-05	0.000396	4.1E-05	0.000115	0.000215	16	5	8	17	5	9	12
Wetland10	0.001414	0.000178	0.000379	0.001582	0.000164	0.000462	0.000859	34	11	17	36	10	18	26
Wetland11	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland12	4.61E-05	5.8E-06	1.24E-05	5.16E-05	5.34E-06	1.51E-05	2.8E-05	5	2	3	6	2	3	4
Wetland13	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland14	0.001844	0.000232	0.000495	0.002064	0.000214	0.000602	0.00112	39	13	19	42	12	21	30
Wetland15	0.000169	2.13E-05	4.53E-05	0.000189	1.96E-05	5.52E-05	0.000103	11	3	5	11	3	6	8
Wetland16	7.68E-05	9.67E-06	2.06E-05	8.6E-05	8.91E-06	2.51E-05	4.67E-05	7	2	3	7	2	4	5
Wetland17	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland18	0.000154	1.93E-05	4.12E-05	0.000172	1.78E-05	5.02E-05	9.34E-05	10	3	5	11	3	5	8
Wetland19	0.000815	0.000102	0.000218	0.000911	9.44E-05	0.000266	0.000495	25	8	12	27	8	14	19
Wetland20	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland21	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland22	0.000123	1.55E-05	3.3E-05	0.000138	1.42E-05	4.02E-05	7.47E-05	9	3	4	9	3	5	7
Wetland23	0.000261	3.29E-05	7.01E-05	0.000292	3.03E-05	8.53E-05	0.000159	13	4	7	14	4	7	10
Wetland24	0.000968	0.000122	0.00026	0.001083	0.000112	0.000316	0.000588	28	9	13	29	8	15	21
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A33. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining lower part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.265667	0.198993	0.185871	0.209481	0.260087	0.286912	0.819319	613	522	503	537	606	640	1147
Stubble	7.757959	5.724321	5.303714	6.030379	7.597003	8.433507	25.18148	4070	3454	3315	3553	4024	4257	7677
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland26	0.133086	0.127416	0.128339	0.133858	0.127352	0.128718	0.13054	415	405	407	416	405	408	411
Wetland27	0.001971	0.001887	0.001901	0.001982	0.001886	0.001906	0.001933	41	40	40	41	40	40	40
Wetland28	0.043994	0.04212	0.042425	0.044249	0.042098	0.04255	0.043153	226	221	221	227	220	222	223
Wetland29	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland30	0.000394	0.000377	0.00038	0.000396	0.000377	0.000381	0.000387	17	16	17	17	16	17	17
Wetland31	0.011274	0.010794	0.010872	0.01134	0.010789	0.010904	0.011059	107	104	105	107	104	105	106
Wetland32	0.000946	0.000906	0.000912	0.000952	0.000905	0.000915	0.000928	27	27	27	27	27	27	27
Wetland33	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland34	0.003154	0.003019	0.003041	0.003172	0.003018	0.00305	0.003093	53	52	52	53	52	52	52
Wetland35	0.029329	0.02808	0.028283	0.029499	0.028066	0.028367	0.028768	181	176	177	181	176	177	179
Wetland36	0.000237	0.000226	0.000228	0.000238	0.000226	0.000229	0.000232	13	12	13	13	12	13	13
Wetland37	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland38	0.002917	0.002793	0.002813	0.002934	0.002791	0.002821	0.002861	51	50	50	51	50	50	50
Wetland39	0.001735	0.001661	0.001673	0.001745	0.00166	0.001678	0.001701	38	37	37	38	37	37	38
Wetland40	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland41	0.032168	0.030797	0.03102	0.032354	0.030782	0.031112	0.031552	190	186	186	191	186	187	188
Wetland42	0.008909	0.00853	0.008591	0.008961	0.008525	0.008617	0.008739	94	92	92	94	92	92	93
Wetland43	0.075373	0.072162	0.072685	0.07581	0.072126	0.0729	0.073932	304	297	298	305	296	298	300
Wetland44	0.001813	0.001736	0.001749	0.001824	0.001735	0.001754	0.001779	39	38	38	39	38	38	39
Wetland45	0.004415	0.004227	0.004258	0.004441	0.004225	0.00427	0.004331	64	62	63	64	62	63	63
Wetland46	0.002444	0.00234	0.002357	0.002458	0.002339	0.002364	0.002397	46	45	45	46	45	45	46
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A34. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining lower part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.268677	0.202591	0.189301	0.212468	0.263644	0.290377	0.822848	617	528	508	542	611	644	1150
Stubble	7.850566	5.835021	5.409256	6.122261	7.706442	8.540109	25.29007	4096	3490	3351	3582	4055	4286	7695
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland26	0.097371	0.086032	0.087879	0.098915	0.085903	0.088636	0.092281	350	327	330	353	326	332	339
Wetland27	0.001442	0.001274	0.001302	0.001465	0.001272	0.001313	0.001367	34	32	33	35	32	33	33
Wetland28	0.032188	0.02844	0.02905	0.032698	0.028397	0.0293	0.030505	190	178	180	192	178	181	185
Wetland29	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland30	0.000288	0.000255	0.00026	0.000293	0.000254	0.000263	0.000273	14	13	13	14	13	14	14
Wetland31	0.008249	0.007288	0.007445	0.00838	0.007277	0.007509	0.007818	90	84	85	91	84	85	87
Wetland32	0.000692	0.000612	0.000625	0.000703	0.000611	0.00063	0.000656	23	22	22	23	21	22	22
Wetland33	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland34	0.002307	0.002039	0.002082	0.002344	0.002036	0.0021	0.002187	45	42	42	45	42	42	43
Wetland35	0.021459	0.01896	0.019367	0.021799	0.018931	0.019534	0.020337	152	142	144	153	142	145	148
Wetland36	0.000173	0.000153	0.000156	0.000176	0.000153	0.000158	0.000164	11	10	10	11	10	10	10
Wetland37	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland38	0.002134	0.001886	0.001926	0.002168	0.001883	0.001943	0.002023	43	40	40	43	40	41	42
Wetland39	0.001269	0.001121	0.001145	0.001289	0.00112	0.001155	0.001203	32	30	30	32	30	31	31
Wetland40	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland41	0.023535	0.020794	0.021241	0.023908	0.020763	0.021424	0.022305	160	150	151	161	149	152	155
Wetland42	0.006518	0.005759	0.005883	0.006622	0.005751	0.005934	0.006178	79	74	75	80	74	75	77
Wetland43	0.055146	0.048724	0.04977	0.056021	0.048651	0.050199	0.052263	256	239	242	258	239	243	248
Wetland44	0.001327	0.001172	0.001197	0.001348	0.00117	0.001208	0.001257	33	31	31	33	31	31	32
Wetland45	0.00323	0.002854	0.002915	0.003282	0.00285	0.002941	0.003061	54	50	51	54	50	51	52
Wetland46	0.001788	0.00158	0.001614	0.001817	0.001578	0.001628	0.001695	39	36	37	39	36	37	38
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A35. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining lower part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.271687	0.206189	0.192732	0.215454	0.267201	0.293842	0.826378	621	533	513	546	615	649	1153
Stubble	7.943172	5.945721	5.514797	6.214143	7.815882	8.646712	25.39867	4122	3526	3386	3611	4086	4315	7713
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland26	0.061657	0.044648	0.047418	0.063973	0.044455	0.048554	0.054021	272	228	235	277	227	238	253
Wetland27	0.000913	0.000661	0.000702	0.000947	0.000658	0.000719	0.0008	27	22	23	27	22	24	25
Wetland28	0.020382	0.014759	0.015675	0.021147	0.014695	0.016051	0.017858	148	124	128	151	124	130	138
Wetland29	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland30	0.000183	0.000132	0.00014	0.000189	0.000132	0.000144	0.00016	11	9	10	11	9	10	10
Wetland31	0.005223	0.003782	0.004017	0.005419	0.003766	0.004113	0.004576	70	59	61	71	58	61	65
Wetland32	0.000438	0.000317	0.000337	0.000455	0.000316	0.000345	0.000384	18	15	15	18	15	16	17
Wetland33	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland34	0.001461	0.001058	0.001124	0.001516	0.001053	0.001151	0.00128	35	29	30	35	29	30	32
Wetland35	0.013588	0.00984	0.01045	0.014098	0.009797	0.0107	0.011905	118	99	102	121	99	104	110
Wetland36	0.00011	7.94E-05	8.43E-05	0.000114	7.9E-05	8.63E-05	9.6E-05	8	7	7	9	7	7	8
Wetland37	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland38	0.001351	0.000979	0.001039	0.001402	0.000974	0.001064	0.001184	33	28	29	34	28	29	31
Wetland39	0.000804	0.000582	0.000618	0.000834	0.000579	0.000633	0.000704	25	21	22	25	21	22	23
Wetland40	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland41	0.014903	0.010792	0.011461	0.015463	0.010745	0.011736	0.013057	125	104	108	127	104	109	116
Wetland42	0.004127	0.002989	0.003174	0.004283	0.002976	0.00325	0.003616	61	51	53	63	51	54	57
Wetland43	0.034919	0.025286	0.026855	0.036231	0.025177	0.027499	0.030595	199	167	172	203	166	174	185
Wetland44	0.00084	0.000608	0.000646	0.000872	0.000606	0.000662	0.000736	26	21	22	26	21	22	24
Wetland45	0.002045	0.001481	0.001573	0.002122	0.001475	0.001611	0.001792	42	35	36	43	35	37	39
Wetland46	0.001132	0.00082	0.000871	0.001175	0.000816	0.000892	0.000992	30	25	26	31	25	26	28
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A36. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining lower part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.274697	0.209787	0.196162	0.218441	0.270758	0.297307	0.829908	625	538	518	550	620	653	1155
Stubble	8.035778	6.056421	5.620339	6.306025	7.925321	8.753314	25.50727	4147	3561	3420	3639	4117	4343	7731
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland26	0.025942	0.003264	0.006958	0.02903	0.003006	0.008473	0.015761	169	54	82	180	52	91	128
Wetland27	0.000384	4.83E-05	0.000103	0.00043	4.45E-05	0.000125	0.000233	17	5	8	18	5	9	13
Wetland28	0.008576	0.001079	0.0023	0.009596	0.000994	0.002801	0.00521	92	29	45	98	28	50	70
Wetland29	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland30	7.68E-05	9.67E-06	2.06E-05	8.6E-05	8.91E-06	2.51E-05	4.67E-05	7	2	3	7	2	4	5
Wetland31	0.002198	0.000277	0.000589	0.002459	0.000255	0.000718	0.001335	43	14	21	46	13	23	33
Wetland32	0.000184	2.32E-05	4.95E-05	0.000206	2.14E-05	6.02E-05	0.000112	11	4	5	12	3	6	8
Wetland33	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland34	0.000615	7.73E-05	0.000165	0.000688	7.12E-05	0.000201	0.000373	22	7	10	23	7	12	16
Wetland35	0.005717	0.000719	0.001533	0.006398	0.000663	0.001867	0.003473	74	24	36	78	22	40	56
Wetland36	4.61E-05	5.8E-06	1.24E-05	5.16E-05	5.34E-06	1.51E-05	2.8E-05	5	2	3	6	2	3	4
Wetland37	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland38	0.000569	7.15E-05	0.000153	0.000636	6.59E-05	0.000186	0.000345	21	7	10	22	6	11	16
Wetland39	0.000338	4.25E-05	9.07E-05	0.000378	3.92E-05	0.00011	0.000205	16	5	8	17	5	8	12
Wetland40	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland41	0.00627	0.000789	0.001682	0.007017	0.000727	0.002048	0.00381	77	25	38	82	24	42	59
Wetland42	0.001737	0.000219	0.000466	0.001943	0.000201	0.000567	0.001055	38	12	19	41	12	21	29
Wetland43	0.014692	0.001849	0.00394	0.016441	0.001703	0.004798	0.008926	124	40	60	131	38	67	94
Wetland44	0.000353	4.45E-05	9.48E-05	0.000396	4.1E-05	0.000115	0.000215	16	5	8	17	5	9	12
Wetland45	0.000861	0.000108	0.000231	0.000963	9.97E-05	0.000281	0.000523	26	8	13	28	8	14	20
Wetland46	0.000476	5.99E-05	0.000128	0.000533	5.52E-05	0.000156	0.000289	19	6	9	20	6	10	14
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A37. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining larger part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.26567	0.198996	0.185874	0.209484	0.26009	0.286915	0.819322	613	522	503	537	606	640	1147
Stubble	7.758041	5.724419	5.303808	6.03046	7.5971	8.433601	25.18158	4070	3454	3315	3553	4024	4257	7677
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.012615	0.012077	0.012165	0.012688	0.012071	0.012201	0.012373	114	111	111	114	111	112	112
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.009461	0.009058	0.009124	0.009516	0.009053	0.009151	0.00928	97	95	95	97	95	95	96
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.133086	0.127416	0.128339	0.133858	0.127352	0.128718	0.13054	415	405	407	416	405	408	411
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.043994	0.04212	0.042425	0.044249	0.042098	0.04255	0.043153	226	221	221	227	220	222	223
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.011274	0.010794	0.010872	0.01134	0.010789	0.010904	0.011059	107	104	105	107	104	105	106
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.029329	0.02808	0.028283	0.029499	0.028066	0.028367	0.028768	181	176	177	181	176	177	179
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.032168	0.030797	0.03102	0.032354	0.030782	0.031112	0.031552	190	186	186	191	186	187	188
Wetland42	0.008909	0.00853	0.008591	0.008961	0.008525	0.008617	0.008739	94	92	92	94	92	92	93
Wetland43	0.075373	0.072162	0.072685	0.07581	0.072126	0.0729	0.073932	304	297	298	305	296	298	300
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A38. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining larger part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.268683	0.202597	0.189308	0.212473	0.26365	0.290383	0.822855	617	528	508	542	611	644	1150
Stubble	7.85073	5.835217	5.409443	6.122424	7.706636	8.540298	25.29027	4096	3490	3351	3582	4055	4286	7695
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.009229	0.008155	0.00833	0.009376	0.008142	0.008402	0.008747	96	89	90	97	89	91	93
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.006922	0.006116	0.006247	0.007032	0.006107	0.006301	0.00656	82	76	77	82	76	78	79
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.097371	0.086032	0.087879	0.098915	0.085903	0.088636	0.092281	350	327	330	353	326	332	339
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.032188	0.02844	0.02905	0.032698	0.028397	0.0293	0.030505	190	178	180	192	178	181	185
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.008249	0.007288	0.007445	0.00838	0.007277	0.007509	0.007818	90	84	85	91	84	85	87
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.021459	0.01896	0.019367	0.021799	0.018931	0.019534	0.020337	152	142	144	153	142	145	148
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.023535	0.020794	0.021241	0.023908	0.020763	0.021424	0.022305	160	150	151	161	149	152	155
Wetland42	0.006518	0.005759	0.005883	0.006622	0.005751	0.005934	0.006178	79	74	75	80	74	75	77
Wetland43	0.055146	0.048724	0.04977	0.056021	0.048651	0.050199	0.052263	256	239	242	258	239	243	248
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A39. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining larger part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.271695	0.206198	0.192741	0.215462	0.26721	0.293851	0.826387	621	533	513	546	615	649	1153
Stubble	7.943418	5.946015	5.515078	6.214387	7.816173	8.646995	25.39896	4122	3526	3386	3611	4086	4315	7713
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.005844	0.004232	0.004495	0.006064	0.004214	0.004602	0.00512	74	62	64	76	62	65	69
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.004383	0.003174	0.003371	0.004548	0.00316	0.003452	0.00384	64	53	55	65	53	56	59
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.061657	0.044648	0.047418	0.063973	0.044455	0.048554	0.054021	272	228	235	277	227	238	253
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.020382	0.014759	0.015675	0.021147	0.014695	0.016051	0.017858	148	124	128	151	124	130	138
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.005223	0.003782	0.004017	0.005419	0.003766	0.004113	0.004576	70	59	61	71	58	61	65
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.013588	0.00984	0.01045	0.014098	0.009797	0.0107	0.011905	118	99	102	121	99	104	110
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.014903	0.010792	0.011461	0.015463	0.010745	0.011736	0.013057	125	104	108	127	104	109	116
Wetland42	0.004127	0.002989	0.003174	0.004283	0.002976	0.00325	0.003616	61	51	53	63	51	54	57
Wetland43	0.034919	0.025286	0.026855	0.036231	0.025177	0.027499	0.030595	199	167	172	203	166	174	185
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A40. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining larger part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.274708	0.2098	0.196175	0.218451	0.270771	0.297319	0.82992	625	538	518	550	620	653	1155
Stubble	8.036107	6.056814	5.620713	6.306351	7.925709	8.753692	25.50765	4148	3561	3421	3640	4117	4343	7731
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.002459	0.000309	0.000659	0.002752	0.000285	0.000803	0.001494	46	15	22	49	14	25	35
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.001844	0.000232	0.000495	0.002064	0.000214	0.000602	0.00112	39	13	19	42	12	21	30
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.025942	0.003264	0.006958	0.02903	0.003006	0.008473	0.015761	169	54	82	180	52	91	128
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.008576	0.001079	0.0023	0.009596	0.000994	0.002801	0.00521	92	29	45	98	28	50	70
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.002198	0.000277	0.000589	0.002459	0.000255	0.000718	0.001335	43	14	21	46	13	23	33
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.005717	0.000719	0.001533	0.006398	0.000663	0.001867	0.003473	74	24	36	78	22	40	56
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.00627	0.000789	0.001682	0.007017	0.000727	0.002048	0.00381	77	25	38	82	24	42	59
Wetland42	0.001737	0.000219	0.000466	0.001943	0.000201	0.000567	0.001055	38	12	19	41	12	21	29
Wetland43	0.014692	0.001849	0.00394	0.016441	0.001703	0.004798	0.008926	124	40	60	131	38	67	94
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A41. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining smaller part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262707	0.195454	0.182498	0.206544	0.256589	0.283505	0.815848	610	517	498	533	602	636	1144
Stubble	7.666892	5.61546	5.199926	5.940023	7.489382	8.328676	25.07469	4044	3419	3280	3524	3993	4228	7660
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000552	0.000528	0.000532	0.000555	0.000528	0.000534	0.000541	20	20	20	20	20	20	20
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.000315	0.000302	0.000304	0.000317	0.000302	0.000305	0.000309	15	15	15	15	15	15	15
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland12	0.000237	0.000226	0.000228	0.000238	0.000226	0.000229	0.000232	13	12	13	13	12	13	13
Wetland13	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000394	0.000377	0.00038	0.000396	0.000377	0.000381	0.000387	17	16	17	17	16	17	17
Wetland17	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland21	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland22	0.000631	0.000604	0.000608	0.000634	0.000604	0.00061	0.000619	22	21	21	22	21	21	22
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.000158	0.000151	0.000152	0.000159	0.000151	0.000153	0.000155	10	10	10	10	10	10	10
Wetland30	0.000394	0.000377	0.00038	0.000396	0.000377	0.000381	0.000387	17	16	17	17	16	17	17
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.000237	0.000226	0.000228	0.000238	0.000226	0.000229	0.000232	13	12	13	13	12	13	13
Wetland37	0.00071	0.000679	0.000684	0.000714	0.000679	0.000686	0.000696	23	23	23	23	23	23	23
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	7.88E-05	7.55E-05	7.6E-05	7.93E-05	7.54E-05	7.63E-05	7.73E-05	7	7	7	7	7	7	7
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A42. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining smaller part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262757	0.195514	0.182555	0.206594	0.256648	0.283563	0.815906	610	517	498	533	602	636	1144
Stubble	7.66843	5.617299	5.20168	5.94155	7.4912	8.330447	25.07649	4044	3419	3281	3524	3994	4229	7660
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000404	0.000357	0.000364	0.00041	0.000356	0.000368	0.000383	17	16	16	17	16	16	17
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.000231	0.000204	0.000208	0.000234	0.000204	0.00021	0.000219	13	12	12	13	12	12	12
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland12	0.000173	0.000153	0.000156	0.000176	0.000153	0.000158	0.000164	11	10	10	11	10	10	10
Wetland13	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000288	0.000255	0.00026	0.000293	0.000254	0.000263	0.000273	14	13	13	14	13	14	14
Wetland17	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland21	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland22	0.000461	0.000408	0.000416	0.000469	0.000407	0.00042	0.000437	18	17	17	19	17	17	18
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.000115	0.000102	0.000104	0.000117	0.000102	0.000105	0.000109	9	8	8	9	8	8	8
Wetland30	0.000288	0.000255	0.00026	0.000293	0.000254	0.000263	0.000273	14	13	13	14	13	14	14
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.000173	0.000153	0.000156	0.000176	0.000153	0.000158	0.000164	11	10	10	11	10	10	10
Wetland37	0.000519	0.000459	0.000469	0.000527	0.000458	0.000473	0.000492	20	18	19	20	18	19	19
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	5.77E-05	5.1E-05	5.21E-05	5.86E-05	5.09E-05	5.25E-05	5.47E-05	6	5	6	6	5	6	6
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A43. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining smaller part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262807	0.195574	0.182612	0.206644	0.256707	0.28362	0.815965	610	517	498	533	602	636	1145
Stubble	7.669969	5.619139	5.203433	5.943076	7.493019	8.332218	25.0783	4045	3420	3281	3525	3994	4229	7660
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000256	0.000185	0.000197	0.000265	0.000184	0.000201	0.000224	13	11	12	14	11	12	12
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.000146	0.000106	0.000112	0.000152	0.000105	0.000115	0.000128	10	8	8	10	8	9	9
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland12	0.00011	7.94E-05	8.43E-05	0.000114	7.9E-05	8.63E-05	9.6E-05	8	7	7	9	7	7	8
Wetland13	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000183	0.000132	0.00014	0.000189	0.000132	0.000144	0.00016	11	9	10	11	9	10	10
Wetland17	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland21	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland22	0.000292	0.000212	0.000225	0.000303	0.000211	0.00023	0.000256	14	12	12	15	12	13	13
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	7.31E-05	5.29E-05	5.62E-05	7.58E-05	5.27E-05	5.75E-05	6.4E-05	7	6	6	7	6	6	6
Wetland30	0.000183	0.000132	0.00014	0.000189	0.000132	0.000144	0.00016	11	9	10	11	9	10	10
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.00011	7.94E-05	8.43E-05	0.000114	7.9E-05	8.63E-05	9.6E-05	8	7	7	9	7	7	8
Wetland37	0.000329	0.000238	0.000253	0.000341	0.000237	0.000259	0.000288	15	13	13	16	13	13	14
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	3.65E-05	2.65E-05	2.81E-05	3.79E-05	2.63E-05	2.88E-05	3.2E-05	5	4	4	5	4	4	4
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A44. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for draining smaller part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262857	0.195634	0.182669	0.206693	0.256766	0.283678	0.816024	610	517	498	533	602	636	1145
Stubble	7.671508	5.620978	5.205187	5.944603	7.494837	8.333989	25.0801	4045	3421	3282	3525	3995	4230	7661
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000108	1.35E-05	2.89E-05	0.00012	1.25E-05	3.51E-05	6.54E-05	8	3	4	9	3	4	6
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	6.15E-05	7.73E-06	1.65E-05	6.88E-05	7.12E-06	2.01E-05	3.73E-05	6	2	3	6	2	3	5
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland12	4.61E-05	5.8E-06	1.24E-05	5.16E-05	5.34E-06	1.51E-05	2.8E-05	5	2	3	6	2	3	4
Wetland13	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	7.68E-05	9.67E-06	2.06E-05	8.6E-05	8.91E-06	2.51E-05	4.67E-05	7	2	3	7	2	4	5
Wetland17	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland21	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland22	0.000123	1.55E-05	3.3E-05	0.000138	1.42E-05	4.02E-05	7.47E-05	9	3	4	9	3	5	7
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	3.07E-05	3.87E-06	8.24E-06	3.44E-05	3.56E-06	1E-05	1.87E-05	4	1	2	4	1	2	3
Wetland30	7.68E-05	9.67E-06	2.06E-05	8.6E-05	8.91E-06	2.51E-05	4.67E-05	7	2	3	7	2	4	5
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	4.61E-05	5.8E-06	1.24E-05	5.16E-05	5.34E-06	1.51E-05	2.8E-05	5	2	3	6	2	3	4
Wetland37	0.000138	1.74E-05	3.71E-05	0.000155	1.6E-05	4.52E-05	8.4E-05	9	3	5	10	3	5	7
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	1.54E-05	1.93E-06	4.12E-06	1.72E-05	1.78E-06	5.02E-06	9.34E-06	3	1	1	3	1	2	2
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A45. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring upper part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.261949	0.194923	0.181969	0.206157	0.256027	0.282698	0.813632	609	516	497	533	601	635	1143
Stubble	7.65734	5.612322	5.197458	5.941886	7.485535	8.316913	25.00715	4041	3418	3279	3525	3992	4225	7649
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000788	0.00072	0.000714	0.000672	0.000729	0.000801	0.001392	25	24	23	23	24	25	34
Wetland2	0.018015	0.016459	0.016316	0.01536	0.016664	0.018312	0.031814	138	132	131	127	132	139	189
Wetland3	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland4	0.003153	0.00288	0.002855	0.002688	0.002916	0.003205	0.005567	53	50	50	49	51	53	72
Wetland5	0.001576	0.00144	0.001428	0.001344	0.001458	0.001602	0.002784	36	34	34	33	35	37	49
Wetland6	0.001239	0.001132	0.001122	0.001056	0.001146	0.001259	0.002187	32	30	30	29	30	32	43
Wetland7	0.005405	0.004938	0.004895	0.004608	0.004999	0.005494	0.009544	71	68	68	65	68	72	97
Wetland8	0.00045	0.000411	0.000408	0.000384	0.000417	0.000458	0.000795	18	17	17	17	17	18	25
Wetland9	0.00259	0.002366	0.002345	0.002208	0.002395	0.002632	0.004573	48	45	45	44	46	48	65
Wetland10	0.010359	0.009464	0.009382	0.008832	0.009582	0.010529	0.018293	102	97	97	93	98	103	139
Wetland11	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland12	0.000338	0.000309	0.000306	0.000288	0.000312	0.000343	0.000597	16	15	15	14	15	16	21
Wetland13	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland14	0.013511	0.012344	0.012237	0.01152	0.012498	0.013734	0.02386	118	112	112	108	113	119	161
Wetland15	0.001239	0.001132	0.001122	0.001056	0.001146	0.001259	0.002187	32	30	30	29	30	32	43
Wetland16	0.000563	0.000514	0.00051	0.00048	0.000521	0.000572	0.000994	21	20	19	19	20	21	28
Wetland17	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland18	0.001126	0.001029	0.00102	0.00096	0.001041	0.001145	0.001988	30	29	28	28	29	30	41
Wetland19	0.005968	0.005452	0.005405	0.005088	0.00552	0.006066	0.010538	75	72	71	69	72	76	103
Wetland20	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland21	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland22	0.000901	0.000823	0.000816	0.000768	0.000833	0.000916	0.001591	27	25	25	24	25	27	36
Wetland23	0.001914	0.001749	0.001734	0.001632	0.001771	0.001946	0.00338	40	38	38	37	39	41	55
Wetland24	0.007093	0.006481	0.006424	0.006048	0.006561	0.00721	0.012527	83	79	78	76	79	84	113
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A46. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring upper part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.26124	0.194451	0.181498	0.20582	0.255524	0.281949	0.811475	608	516	496	532	600	634	1141
Stubble	7.649328	5.611023	5.196743	5.945275	7.483506	8.306921	24.94142	4039	3417	3279	3526	3991	4222	7638
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000876	0.00074	0.000728	0.000644	0.000758	0.000902	0.002084	26	24	24	22	24	27	42
Wetland2	0.02003	0.016918	0.016632	0.01472	0.017328	0.020624	0.047627	147	134	132	124	135	149	236
Wetland3	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland4	0.003505	0.002961	0.002911	0.002576	0.003032	0.003609	0.008335	56	51	51	47	52	57	90
Wetland5	0.001753	0.00148	0.001455	0.001288	0.001516	0.001805	0.004167	38	35	35	32	35	39	62
Wetland6	0.001377	0.001163	0.001143	0.001012	0.001191	0.001418	0.003274	34	31	30	28	31	34	54
Wetland7	0.006009	0.005075	0.00499	0.004416	0.005198	0.006187	0.014288	76	69	68	64	70	77	122
Wetland8	0.000501	0.000423	0.000416	0.000368	0.000433	0.000516	0.001191	19	18	17	16	18	20	31
Wetland9	0.002879	0.002432	0.002391	0.002116	0.002491	0.002965	0.006846	50	46	46	43	47	51	81
Wetland10	0.011517	0.009728	0.009564	0.008464	0.009963	0.011859	0.027386	108	98	98	91	100	110	174
Wetland11	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland12	0.000376	0.000317	0.000312	0.000276	0.000325	0.000387	0.000893	16	15	15	14	15	17	26
Wetland13	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland14	0.015023	0.012688	0.012474	0.01104	0.012996	0.015468	0.03572	125	114	113	106	115	127	201
Wetland15	0.001377	0.001163	0.001143	0.001012	0.001191	0.001418	0.003274	34	31	30	28	31	34	54
Wetland16	0.000626	0.000529	0.00052	0.00046	0.000541	0.000645	0.001488	22	20	20	18	20	22	35
Wetland17	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland18	0.001252	0.001057	0.00104	0.00092	0.001083	0.001289	0.002977	32	29	29	27	29	32	51
Wetland19	0.006635	0.005604	0.005509	0.004876	0.00574	0.006832	0.015777	80	73	72	67	74	81	128
Wetland20	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland21	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland22	0.001002	0.000846	0.000832	0.000736	0.000866	0.001031	0.002381	28	26	25	24	26	29	45
Wetland23	0.002128	0.001798	0.001767	0.001564	0.001841	0.002191	0.00506	43	39	39	36	39	43	69
Wetland24	0.007887	0.006661	0.006549	0.005796	0.006823	0.008121	0.018753	88	80	79	74	81	89	141
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A47. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring upper part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.260531	0.193979	0.181027	0.205483	0.255022	0.2812	0.809318	607	515	496	532	600	633	1139
Stubble	7.641315	5.609725	5.196029	5.948665	7.481477	8.296929	24.87569	4036	3417	3279	3527	3991	4220	7627
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000964	0.00076	0.000741	0.000616	0.000787	0.001003	0.002776	28	24	24	22	25	28	49
Wetland2	0.022045	0.017377	0.016948	0.01408	0.017991	0.022936	0.063441	154	136	134	121	138	158	276
Wetland3	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland4	0.003858	0.003041	0.002966	0.002464	0.003149	0.004014	0.011102	59	52	51	46	53	61	106
Wetland5	0.001929	0.00152	0.001483	0.001232	0.001574	0.002007	0.005551	40	35	35	32	36	41	72
Wetland6	0.001516	0.001195	0.001165	0.000968	0.001237	0.001577	0.004362	35	31	31	28	32	36	63
Wetland7	0.006614	0.005213	0.005085	0.004224	0.005397	0.006881	0.019032	80	70	69	62	71	81	142
Wetland8	0.000551	0.000434	0.000424	0.000352	0.00045	0.000573	0.001586	20	18	18	16	18	21	36
Wetland9	0.003169	0.002498	0.002436	0.002024	0.002586	0.003297	0.00912	53	47	46	42	48	54	95
Wetland10	0.012676	0.009992	0.009745	0.008096	0.010345	0.013188	0.036479	114	100	99	89	102	116	204
Wetland11	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland12	0.000413	0.000326	0.000318	0.000264	0.000337	0.00043	0.00119	17	15	15	14	16	18	31
Wetland13	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland14	0.016534	0.013033	0.012711	0.01056	0.013494	0.017202	0.047581	132	116	114	103	118	135	236
Wetland15	0.001516	0.001195	0.001165	0.000968	0.001237	0.001577	0.004362	35	31	31	28	32	36	63
Wetland16	0.000689	0.000543	0.00053	0.00044	0.000562	0.000717	0.001983	23	20	20	18	21	23	41
Wetland17	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland18	0.001378	0.001086	0.001059	0.00088	0.001124	0.001434	0.003965	34	29	29	26	30	34	60
Wetland19	0.007303	0.005756	0.005614	0.004664	0.00596	0.007598	0.021015	84	74	73	66	75	86	150
Wetland20	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland21	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland22	0.001102	0.000869	0.000847	0.000704	0.0009	0.001147	0.003172	30	26	26	23	27	30	53
Wetland23	0.002342	0.001846	0.001801	0.001496	0.001912	0.002437	0.006741	45	39	39	35	40	46	80
Wetland24	0.00868	0.006842	0.006673	0.005544	0.007084	0.009031	0.02498	93	81	80	72	83	95	165
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A48. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring upper part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.259823	0.193507	0.180555	0.205145	0.254519	0.280451	0.807161	606	514	495	531	599	632	1138
Stubble	7.633302	5.608426	5.195314	5.952054	7.479448	8.286937	24.80996	4034	3417	3278	3528	3990	4217	7616
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.001053	0.00078	0.000755	0.000588	0.000816	0.001105	0.003467	29	25	24	21	25	30	56
Wetland2	0.024061	0.017836	0.017264	0.01344	0.018655	0.025248	0.079255	162	137	135	118	141	166	312
Wetland3	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland4	0.004211	0.003121	0.003021	0.002352	0.003265	0.004418	0.01387	62	53	52	45	54	64	120
Wetland5	0.002105	0.001561	0.001511	0.001176	0.001632	0.002209	0.006935	42	36	35	31	37	44	82
Wetland6	0.001654	0.001226	0.001187	0.000924	0.001283	0.001736	0.005449	37	32	31	27	32	38	72
Wetland7	0.007218	0.005351	0.005179	0.004032	0.005597	0.007574	0.023776	84	71	70	61	73	86	161
Wetland8	0.000602	0.000446	0.000432	0.000336	0.000466	0.000631	0.001981	21	18	18	15	19	22	41
Wetland9	0.003459	0.002564	0.002482	0.001932	0.002682	0.003629	0.011393	56	47	46	40	48	57	107
Wetland10	0.013835	0.010256	0.009927	0.007728	0.010727	0.014518	0.045571	120	101	100	87	104	123	230
Wetland11	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland12	0.000451	0.000334	0.000324	0.000252	0.00035	0.000473	0.001486	18	15	15	13	16	19	35
Wetland13	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland14	0.018045	0.013377	0.012948	0.01008	0.013991	0.018936	0.059441	138	117	115	100	120	142	267
Wetland15	0.001654	0.001226	0.001187	0.000924	0.001283	0.001736	0.005449	37	32	31	27	32	38	72
Wetland16	0.000752	0.000557	0.00054	0.00042	0.000583	0.000789	0.002477	24	20	20	17	21	25	46
Wetland17	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland18	0.001504	0.001115	0.001079	0.00084	0.001166	0.001578	0.004953	35	30	29	26	31	36	68
Wetland19	0.00797	0.005908	0.005719	0.004452	0.00618	0.008363	0.026253	88	75	74	64	77	91	170
Wetland20	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland21	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland22	0.001203	0.000892	0.000863	0.000672	0.000933	0.001262	0.003963	31	26	26	23	27	32	60
Wetland23	0.002556	0.001895	0.001834	0.001428	0.001982	0.002683	0.008421	47	40	39	34	41	48	91
Wetland24	0.009474	0.007023	0.006798	0.005292	0.007346	0.009942	0.031207	97	82	81	70	84	100	187
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A49. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring lower part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.258055	0.19233	0.179379	0.204304	0.253266	0.278582	0.801779	604	513	493	530	597	630	1133
Stubble	7.613311	5.605186	5.193531	5.960511	7.474386	8.262008	24.64597	4028	3415	3278	3531	3989	4210	7589
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland26	0.19006	0.173642	0.172135	0.162047	0.175803	0.193192	0.335634	505	481	478	463	484	510	691
Wetland27	0.002815	0.002572	0.002549	0.0024	0.002604	0.002861	0.004971	50	47	47	46	48	50	68
Wetland28	0.062828	0.057401	0.056902	0.053568	0.058115	0.063863	0.11095	275	261	260	252	263	277	376
Wetland29	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland30	0.000563	0.000514	0.00051	0.00048	0.000521	0.000572	0.000994	21	20	19	19	20	21	28
Wetland31	0.016101	0.01471	0.014583	0.013728	0.014893	0.016366	0.028433	130	124	123	119	124	131	178
Wetland32	0.001351	0.001234	0.001224	0.001152	0.00125	0.001373	0.002386	33	32	31	30	32	34	45
Wetland33	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland34	0.004504	0.004115	0.004079	0.00384	0.004166	0.004578	0.007953	64	61	61	59	62	65	88
Wetland35	0.041885	0.038267	0.037935	0.035712	0.038743	0.042576	0.073967	220	209	208	201	211	222	301
Wetland36	0.000338	0.000309	0.000306	0.000288	0.000312	0.000343	0.000597	16	15	15	14	15	16	21
Wetland37	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland38	0.004166	0.003806	0.003773	0.003552	0.003854	0.004235	0.007357	62	59	58	57	59	62	84
Wetland39	0.002477	0.002263	0.002243	0.002112	0.002291	0.002518	0.004374	46	44	44	43	44	47	63
Wetland40	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland41	0.045939	0.04197	0.041606	0.039168	0.042493	0.046696	0.081125	231	220	219	212	222	233	316
Wetland42	0.012723	0.011624	0.011523	0.010848	0.011769	0.012933	0.022468	114	109	108	105	109	115	156
Wetland43	0.107641	0.098342	0.097489	0.091776	0.099566	0.109415	0.190087	369	352	350	338	354	373	505
Wetland44	0.00259	0.002366	0.002345	0.002208	0.002395	0.002632	0.004573	48	45	45	44	46	48	65
Wetland45	0.006305	0.005761	0.005711	0.005376	0.005832	0.006409	0.011135	78	74	73	71	74	78	106
Wetland46	0.00349	0.003189	0.003161	0.002976	0.003229	0.003548	0.006164	56	53	53	51	54	57	77
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A50. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring lower part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.253452	0.189265	0.176318	0.202112	0.250002	0.273717	0.787768	598	508	488	527	593	624	1122
Stubble	7.561269	5.596751	5.18889	5.982526	7.461209	8.197112	24.21906	4014	3413	3276	3538	3985	4192	7518
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland26	0.21132	0.178483	0.17547	0.155295	0.182806	0.217585	0.502468	535	488	483	452	494	544	862
Wetland27	0.00313	0.002643	0.002599	0.0023	0.002707	0.003223	0.007442	53	48	48	45	49	54	85
Wetland28	0.069856	0.059001	0.058005	0.051336	0.06043	0.071927	0.1661	291	265	263	246	269	296	469
Wetland29	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland30	0.000626	0.000529	0.00052	0.00046	0.000541	0.000645	0.001488	22	20	20	18	20	22	35
Wetland31	0.017902	0.01512	0.014865	0.013156	0.015487	0.018433	0.042567	138	126	124	116	127	140	222
Wetland32	0.001502	0.001269	0.001247	0.001104	0.0013	0.001547	0.003572	35	32	32	30	33	36	57
Wetland33	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland34	0.005008	0.004229	0.004158	0.00368	0.004332	0.005156	0.011907	68	62	62	58	63	69	110
Wetland35	0.046571	0.039334	0.03867	0.034224	0.040287	0.047951	0.110733	233	212	210	197	215	237	375
Wetland36	0.000376	0.000317	0.000312	0.000276	0.000325	0.000387	0.000893	16	15	15	14	15	17	26
Wetland37	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland38	0.004632	0.003912	0.003846	0.003404	0.004007	0.004769	0.011014	65	60	59	55	60	67	105
Wetland39	0.002754	0.002326	0.002287	0.002024	0.002383	0.002836	0.006549	49	45	44	42	45	50	79
Wetland40	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland41	0.051077	0.043141	0.042412	0.037536	0.044185	0.052592	0.12145	245	223	221	207	226	249	395
Wetland42	0.014146	0.011948	0.011747	0.010396	0.012238	0.014566	0.033637	121	110	109	102	112	123	195
Wetland43	0.119681	0.101084	0.099378	0.087951	0.103533	0.123229	0.284573	392	357	354	331	362	398	631
Wetland44	0.002879	0.002432	0.002391	0.002116	0.002491	0.002965	0.006846	50	46	46	43	47	51	81
Wetland45	0.007011	0.005921	0.005821	0.005152	0.006065	0.007218	0.01667	82	75	74	69	76	84	132
Wetland46	0.003881	0.003278	0.003222	0.002852	0.003357	0.003996	0.009228	59	54	54	50	55	60	96
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A51. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring lower part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.248849	0.1862	0.173257	0.199921	0.246738	0.268852	0.773758	591	503	484	524	589	617	1111
Stubble	7.509226	5.588316	5.184248	6.004541	7.448032	8.132215	23.79215	3999	3410	3275	3545	3981	4174	7446
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland26	0.23258	0.183325	0.178805	0.148542	0.18981	0.241977	0.669302	564	495	488	441	505	577	1009
Wetland27	0.003445	0.002715	0.002648	0.0022	0.002811	0.003584	0.009913	56	49	48	43	50	57	100
Wetland28	0.076884	0.060602	0.059107	0.049103	0.062745	0.07999	0.22125	307	269	266	240	275	314	549
Wetland29	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland30	0.000689	0.000543	0.00053	0.00044	0.000562	0.000717	0.001983	23	20	20	18	21	23	41
Wetland31	0.019703	0.01553	0.015148	0.012584	0.01608	0.020499	0.0567	145	127	126	113	130	148	260
Wetland32	0.001653	0.001303	0.001271	0.001056	0.001349	0.00172	0.004758	37	33	32	29	33	38	66
Wetland33	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland34	0.005511	0.004344	0.004237	0.00352	0.004498	0.005734	0.01586	72	63	62	56	64	74	129
Wetland35	0.051256	0.040401	0.039405	0.032736	0.04183	0.053327	0.1475	246	216	213	192	220	251	439
Wetland36	0.000413	0.000326	0.000318	0.000264	0.000337	0.00043	0.00119	17	15	15	14	16	18	31
Wetland37	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland38	0.005098	0.004018	0.003919	0.003256	0.004161	0.005304	0.014671	69	61	60	54	62	71	123
Wetland39	0.003031	0.002389	0.00233	0.001936	0.002474	0.003154	0.008723	52	45	45	41	46	53	93
Wetland40	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland41	0.056216	0.044311	0.043218	0.035904	0.045878	0.058487	0.161774	258	227	224	202	231	264	462
Wetland42	0.01557	0.012272	0.01197	0.009944	0.012706	0.016199	0.044805	128	112	110	100	114	130	228
Wetland43	0.131722	0.103826	0.101267	0.084127	0.107499	0.137044	0.37906	413	362	357	323	369	422	738
Wetland44	0.003169	0.002498	0.002436	0.002024	0.002586	0.003297	0.00912	53	47	46	42	48	54	95
Wetland45	0.007716	0.006082	0.005932	0.004928	0.006297	0.008028	0.022204	87	76	75	68	78	89	155
Wetland46	0.004271	0.003367	0.003284	0.002728	0.003486	0.004444	0.012292	63	55	54	49	56	64	112
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A52. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring lower part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.244246	0.183136	0.170195	0.19773	0.243474	0.263987	0.759748	585	499	479	520	584	611	1100
Stubble	7.457184	5.579881	5.179607	6.026556	7.434854	8.067319	23.36523	3984	3407	3273	3552	3977	4156	7374
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland26	0.25384	0.188167	0.18214	0.14179	0.196813	0.266369	0.836136	592	502	493	430	515	608	1141
Wetland27	0.003759	0.002787	0.002698	0.0021	0.002915	0.003945	0.012384	58	50	49	42	51	60	112
Wetland28	0.083912	0.062202	0.06021	0.046871	0.06506	0.088053	0.2764	322	273	268	234	280	331	621
Wetland29	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland30	0.000752	0.000557	0.00054	0.00042	0.000583	0.000789	0.002477	24	20	20	17	21	25	46
Wetland31	0.021504	0.015941	0.01543	0.012012	0.016673	0.022566	0.070834	152	129	127	111	132	156	293
Wetland32	0.001805	0.001338	0.001295	0.001008	0.001399	0.001894	0.005944	39	33	32	28	34	40	75
Wetland33	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland34	0.006015	0.004459	0.004316	0.00336	0.004664	0.006312	0.019814	76	64	63	55	66	78	146
Wetland35	0.055941	0.041468	0.04014	0.031248	0.043373	0.058702	0.184267	258	219	215	187	224	265	497
Wetland36	0.000451	0.000334	0.000324	0.000252	0.00035	0.000473	0.001486	18	15	15	13	16	19	35
Wetland37	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland38	0.005564	0.004125	0.003992	0.003108	0.004314	0.005839	0.018328	72	61	60	53	63	74	140
Wetland39	0.003308	0.002452	0.002374	0.001848	0.002565	0.003472	0.010898	54	46	45	40	47	56	105
Wetland40	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland41	0.061355	0.045481	0.044024	0.034272	0.047571	0.064383	0.202099	271	230	226	197	236	278	522
Wetland42	0.016993	0.012596	0.012193	0.009492	0.013175	0.017832	0.055974	134	114	112	97	116	137	258
Wetland43	0.143762	0.106568	0.103155	0.080303	0.111465	0.150858	0.473546	433	367	361	314	377	445	834
Wetland44	0.003459	0.002564	0.002482	0.001932	0.002682	0.003629	0.011393	56	47	46	40	48	57	107
Wetland45	0.008421	0.006242	0.006043	0.004704	0.006529	0.008837	0.027739	91	77	76	66	79	93	175
Wetland46	0.004662	0.003456	0.003345	0.002604	0.003614	0.004892	0.015356	66	56	55	48	57	67	127
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A53. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring larger part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.258051	0.192327	0.179377	0.204302	0.253263	0.278578	0.801766	604	513	493	530	597	630	1133
Stubble	7.613265	5.605178	5.193527	5.960531	7.474375	8.261951	24.64559	4028	3415	3278	3531	3989	4210	7589
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.018015	0.016459	0.016316	0.01536	0.016664	0.018312	0.031814	138	132	131	127	132	139	189
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.013511	0.012344	0.012237	0.01152	0.012498	0.013734	0.02386	118	112	112	108	113	119	161
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.19006	0.173642	0.172135	0.162047	0.175803	0.193192	0.335634	505	481	478	463	484	510	691
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.062828	0.057401	0.056902	0.053568	0.058115	0.063863	0.11095	275	261	260	252	263	277	376
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.016101	0.01471	0.014583	0.013728	0.014893	0.016366	0.028433	130	124	123	119	124	131	178
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.041885	0.038267	0.037935	0.035712	0.038743	0.042576	0.073967	220	209	208	201	211	222	301
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.045939	0.04197	0.041606	0.039168	0.042493	0.046696	0.081125	231	220	219	212	222	233	316
Wetland42	0.012723	0.011624	0.011523	0.010848	0.011769	0.012933	0.022468	114	109	108	105	109	115	156
Wetland43	0.107641	0.098342	0.097489	0.091776	0.099566	0.109415	0.190087	369	352	350	338	354	373	505
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A54. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring larger part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.253444	0.18926	0.176313	0.202109	0.249996	0.273709	0.787743	597	508	488	527	593	624	1122
Stubble	7.561176	5.596736	5.188881	5.982565	7.461186	8.196997	24.2183	4014	3413	3276	3538	3985	4192	7518
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.02003	0.016918	0.016632	0.01472	0.017328	0.020624	0.047627	147	134	132	124	135	149	236
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.015023	0.012688	0.012474	0.01104	0.012996	0.015468	0.03572	125	114	113	106	115	127	201
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.21132	0.178483	0.17547	0.155295	0.182806	0.217585	0.502468	535	488	483	452	494	544	862
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.069856	0.059001	0.058005	0.051336	0.06043	0.071927	0.1661	291	265	263	246	269	296	469
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.017902	0.01512	0.014865	0.013156	0.015487	0.018433	0.042567	138	126	124	116	127	140	222
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.046571	0.039334	0.03867	0.034224	0.040287	0.047951	0.110733	233	212	210	197	215	237	375
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.051077	0.043141	0.042412	0.037536	0.044185	0.052592	0.12145	245	223	221	207	226	249	395
Wetland42	0.014146	0.011948	0.011747	0.010396	0.012238	0.014566	0.033637	121	110	109	102	112	123	195
Wetland43	0.119681	0.101084	0.099378	0.087951	0.103533	0.123229	0.284573	392	357	354	331	362	398	631
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A55. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring larger part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.248837	0.186192	0.173249	0.199915	0.246729	0.268839	0.773721	591	503	484	524	589	617	1111
Stubble	7.509088	5.588294	5.184236	6.0046	7.447997	8.132043	23.79101	3999	3410	3275	3545	3981	4174	7446
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.022045	0.017377	0.016948	0.01408	0.017991	0.022936	0.063441	154	136	134	121	138	158	276
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.016534	0.013033	0.012711	0.01056	0.013494	0.017202	0.047581	132	116	114	103	118	135	236
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.23258	0.183325	0.178805	0.148542	0.18981	0.241977	0.669302	564	495	488	441	505	577	1009
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.076884	0.060602	0.059107	0.049103	0.062745	0.07999	0.22125	307	269	266	240	275	314	549
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.019703	0.01553	0.015148	0.012584	0.01608	0.020499	0.0567	145	127	126	113	130	148	260
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.051256	0.040401	0.039405	0.032736	0.04183	0.053327	0.1475	246	216	213	192	220	251	439
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.056216	0.044311	0.043218	0.035904	0.045878	0.058487	0.161774	258	227	224	202	231	264	462
Wetland42	0.01557	0.012272	0.01197	0.009944	0.012706	0.016199	0.044805	128	112	110	100	114	130	228
Wetland43	0.131722	0.103826	0.101267	0.084127	0.107499	0.137044	0.37906	413	362	357	323	369	422	738
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A56. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring larger part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.24423	0.183125	0.170185	0.197722	0.243462	0.26397	0.759698	585	499	479	520	584	611	1100
Stubble	7.457	5.579851	5.17959	6.026634	7.434808	8.067089	23.36372	3984	3407	3273	3552	3977	4156	7373
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	23	23	23	23	23	23	23
Wetland2	0.024061	0.017836	0.017264	0.01344	0.018655	0.025248	0.079255	162	137	135	118	141	166	312
Wetland3	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	17	17	17	17	17	17	17
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland12	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland13	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland14	0.018045	0.013377	0.012948	0.01008	0.013991	0.018936	0.059441	138	117	115	100	120	142	267
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland17	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland21	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland22	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	25	25	25	25	25	25	25
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland26	0.25384	0.188167	0.18214	0.14179	0.196813	0.266369	0.836136	592	502	493	430	515	608	1141
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.083912	0.062202	0.06021	0.046871	0.06506	0.088053	0.2764	322	273	268	234	280	331	621
Wetland29	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	12	12	12	12	12	12	12
Wetland30	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	19	19	19	19	19	19	19
Wetland31	0.021504	0.015941	0.01543	0.012012	0.016673	0.022566	0.070834	152	129	127	111	132	156	293
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.055941	0.041468	0.04014	0.031248	0.043373	0.058702	0.184267	258	219	215	187	224	265	497
Wetland36	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	15	15	15	15	15	15	15
Wetland37	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	27	27	27	27	27	27	27
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	8	8	8	8	8	8	8
Wetland41	0.061355	0.045481	0.044024	0.034272	0.047571	0.064383	0.202099	271	230	226	197	236	278	522
Wetland42	0.016993	0.012596	0.012193	0.009492	0.013175	0.017832	0.055974	134	114	112	97	116	137	258
Wetland43	0.143762	0.106568	0.103155	0.080303	0.111465	0.150858	0.473546	433	367	361	314	377	445	834
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A57. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring smaller part of 46 wetlands by 25% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262581	0.195343	0.18239	0.206458	0.256475	0.283367	0.815556	609	517	498	533	601	636	1144
Stubble	7.664488	5.613481	5.198095	5.938862	7.487345	8.325826	25.06579	4043	3418	3279	3524	3992	4228	7658
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000788	0.00072	0.000714	0.000672	0.000729	0.000801	0.001392	25	24	23	23	24	25	34
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.00045	0.000411	0.000408	0.000384	0.000417	0.000458	0.000795	18	17	17	17	17	18	25
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland12	0.000338	0.000309	0.000306	0.000288	0.000312	0.000343	0.000597	16	15	15	14	15	16	21
Wetland13	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000563	0.000514	0.00051	0.00048	0.000521	0.000572	0.000994	21	20	19	19	20	21	28
Wetland17	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland21	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland22	0.000901	0.000823	0.000816	0.000768	0.000833	0.000916	0.001591	27	25	25	24	25	27	36
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.000225	0.000206	0.000204	0.000192	0.000208	0.000229	0.000398	12	12	12	11	12	13	17
Wetland30	0.000563	0.000514	0.00051	0.00048	0.000521	0.000572	0.000994	21	20	19	19	20	21	28
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.000338	0.000309	0.000306	0.000288	0.000312	0.000343	0.000597	16	15	15	14	15	16	21
Wetland37	0.001013	0.000926	0.000918	0.000864	0.000937	0.00103	0.00179	28	27	27	26	27	29	39
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.000113	0.000103	0.000102	9.6E-05	0.000104	0.000114	0.000199	8	8	8	8	8	9	12
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A58. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring smaller part of 46 wetlands by 50% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262504	0.195293	0.182339	0.206422	0.256421	0.283286	0.815323	609	517	498	533	601	636	1144
Stubble	7.663624	5.61334	5.198018	5.939228	7.487126	8.324748	25.0587	4043	3418	3279	3524	3992	4227	7657
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000876	0.00074	0.000728	0.000644	0.000758	0.000902	0.002084	26	24	24	22	24	27	42
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.000501	0.000423	0.000416	0.000368	0.000433	0.000516	0.001191	19	18	17	16	18	20	31
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland12	0.000376	0.000317	0.000312	0.000276	0.000325	0.000387	0.000893	16	15	15	14	15	17	26
Wetland13	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000626	0.000529	0.00052	0.00046	0.000541	0.000645	0.001488	22	20	20	18	20	22	35
Wetland17	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland21	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland22	0.001002	0.000846	0.000832	0.000736	0.000866	0.001031	0.002381	28	26	25	24	26	29	45
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.00025	0.000211	0.000208	0.000184	0.000217	0.000258	0.000595	13	12	12	11	12	13	21
Wetland30	0.000626	0.000529	0.00052	0.00046	0.000541	0.000645	0.001488	22	20	20	18	20	22	35
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.000376	0.000317	0.000312	0.000276	0.000325	0.000387	0.000893	16	15	15	14	15	17	26
Wetland37	0.001127	0.000952	0.000936	0.000828	0.000975	0.00116	0.002679	30	27	27	25	28	31	48
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.000125	0.000106	0.000104	9.2E-05	0.000108	0.000129	0.000298	9	8	8	8	8	9	14
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A59. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring smaller part of 46 wetlands by 75% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262428	0.195242	0.182288	0.206386	0.256367	0.283205	0.815091	609	517	497	533	601	636	1144
Stubble	7.662759	5.6132	5.197941	5.939594	7.486907	8.32367	25.0516	4043	3418	3279	3524	3992	4227	7656
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.000964	0.00076	0.000741	0.000616	0.000787	0.001003	0.002776	28	24	24	22	25	28	49
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.000551	0.000434	0.000424	0.000352	0.00045	0.000573	0.001586	20	18	18	16	18	21	36
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland12	0.000413	0.000326	0.000318	0.000264	0.000337	0.00043	0.00119	17	15	15	14	16	18	31
Wetland13	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000689	0.000543	0.00053	0.00044	0.000562	0.000717	0.001983	23	20	20	18	21	23	41
Wetland17	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland21	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland22	0.001102	0.000869	0.000847	0.000704	0.0009	0.001147	0.003172	30	26	26	23	27	30	53
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.000276	0.000217	0.000212	0.000176	0.000225	0.000287	0.000793	14	12	12	11	12	14	25
Wetland30	0.000689	0.000543	0.00053	0.00044	0.000562	0.000717	0.001983	23	20	20	18	21	23	41
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.000413	0.000326	0.000318	0.000264	0.000337	0.00043	0.00119	17	15	15	14	16	18	31
Wetland37	0.00124	0.000977	0.000953	0.000792	0.001012	0.00129	0.003569	32	28	27	25	28	32	57
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.000138	0.000109	0.000106	8.8E-05	0.000112	0.000143	0.000397	9	8	8	7	8	10	17
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A60. HRU area (km^2) and Muskingum routing length (m) between HRUs within sub-basin for restoring smaller part of 46 wetlands by 100% from the current to the minimal level.

	Area (km^2) for Sub-basin							Routing Length (m) for Sub-basin						
HRU Name	15	16	14	13	8	6	17	15	16	14	13	8	6	17
Builtup	0.000001	0.028857	0.028369	0.011255	0.093812	0.051822	0.211566	1	179	177	106	344	247	540
Fallow	0.262352	0.195191	0.182237	0.206349	0.256313	0.283124	0.814858	609	517	497	533	601	635	1144
Stubble	7.661894	5.61306	5.197864	5.939959	7.486688	8.322592	25.04451	4042	3418	3279	3524	3992	4227	7655
Grassland	0.013322	0.153192	0.500894	1.129235	0.454131	0.320465	2.362647	123	465	889	1385	842	696	2073
Shrubland	0.105509	0.058081	0.002157	0.00631	0.026152	0.004744	0.081444	365	263	43	78	170	66	317
Woodland	0.088719	0.067917	0.025072	0.152241	0.140292	0.222865	0.362075	371	322	189	496	475	608	789
Wetland1	0.001053	0.00078	0.000755	0.000588	0.000816	0.001105	0.003467	29	25	24	21	25	30	56
Wetland2	0.016	0.016	0.016	0.016	0.016	0.016	0.016	129	129	129	129	129	129	129
Wetland3	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland4	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	50	50	50	50	50	50	50
Wetland5	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	34	34	34	34	34	34	34
Wetland6	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland7	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	67	67	67	67	67	67	67
Wetland8	0.000602	0.000446	0.000432	0.000336	0.000466	0.000631	0.001981	21	18	18	15	19	22	41
Wetland9	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland10	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	96	96	96	96	96	96	96
Wetland11	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland12	0.000451	0.000334	0.000324	0.000252	0.00035	0.000473	0.001486	18	15	15	13	16	19	35
Wetland13	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland14	0.012	0.012	0.012	0.012	0.012	0.012	0.012	111	111	111	111	111	111	111
Wetland15	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	30	30	30	30	30	30	30
Wetland16	0.000752	0.000557	0.00054	0.00042	0.000583	0.000789	0.002477	24	20	20	17	21	25	46
Wetland17	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland18	0.001	0.001	0.001	0.001	0.001	0.001	0.001	28	28	28	28	28	28	28
Wetland19	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	71	71	71	71	71	71	71
Wetland20	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland21	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland22	0.001203	0.000892	0.000863	0.000672	0.000933	0.001262	0.003963	31	26	26	23	27	32	60
Wetland23	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	38	38	38	38	38	38	38
Wetland24	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	0.0063	78	78	78	78	78	78	78
Wetland25	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland26	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	0.1688	473	473	473	473	473	473	473
Wetland27	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	47	47	47	47	47	47	47
Wetland28	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	0.0558	257	257	257	257	257	257	257
Wetland29	0.000301	0.000223	0.000216	0.000168	0.000233	0.000316	0.000991	15	12	12	11	13	15	28
Wetland30	0.000752	0.000557	0.00054	0.00042	0.000583	0.000789	0.002477	24	20	20	17	21	25	46
Wetland31	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	122	122	122	122	122	122	122
Wetland32	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	31	31	31	31	31	31	31
Wetland33	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland34	0.004	0.004	0.004	0.004	0.004	0.004	0.004	60	60	60	60	60	60	60
Wetland35	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	206	206	206	206	206	206	206
Wetland36	0.000451	0.000334	0.000324	0.000252	0.00035	0.000473	0.001486	18	15	15	13	16	19	35
Wetland37	0.001353	0.001003	0.000971	0.000756	0.001049	0.00142	0.004458	33	28	28	24	29	34	64
Wetland38	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	58	58	58	58	58	58	58
Wetland39	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	43	43	43	43	43	43	43
Wetland40	0.00015	0.000111	0.000108	8.4E-05	0.000117	0.000158	0.000495	10	8	8	7	9	10	19
Wetland41	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	0.0408	217	217	217	217	217	217	217
Wetland42	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	107	107	107	107	107	107	107
Wetland43	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	0.0956	346	346	346	346	346	346	346
Wetland44	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	45	45	45	45	45	45	45
Wetland45	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	73	73	73	73	73	73	73
Wetland46	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	53	53	53	53	53	53	53
OpenWater	0.003294	0.866594	0.086624	0.038291	0.558896	0.264996	0.485085	58	1198	344	221	945	630	875
Channel	0.070662	0.359716	0.143425	0.04851	0.481913	0.118996	0.451694	36916	221734	82939	20515	254972	58027	240692

Table A61. dynamical depressional storage outflow scaling ratio for the 40 sensitivity simulations.

Sensitivity	Sensitivity	Scaling ratio for Sub-basin						
Simulation #	Description	15	16	14	13	8	6	17
1	Restoring all wetlands by 25%	6.46	44.28	23.58	5.77	51.16	19.02	10.43
2	Restoring all wetlands by 50%	6.46	44.77	23.69	5.78	51.93	18.84	10.45
3	Restoring all wetlands by 75%	6.46	45.27	23.81	5.78	52.71	18.66	10.47
4	Restoring all wetlands by 100%	6.46	45.78	23.93	5.79	53.53	18.48	10.49
5	Draining all wetlands by 25%	6.46	45.02	23.53	5.77	51.12	19.33	10.45
6	Draining all wetlands by 50%	6.46	46.31	23.61	5.77	51.84	19.45	10.49
7	Draining all wetlands by 75%	6.46	47.67	23.68	5.78	52.58	19.57	10.52
8	Draining all wetlands by 100%	6.46	49.11	23.76	5.79	53.34	19.69	10.56
9	Draining upper part of 46 wetland by 25%	6.46	43.80	23.46	5.76	50.42	19.20	10.41
10	Draining upper part of 46 wetland by 50%	6.46	43.80	23.46	5.76	50.41	19.20	10.41
11	Draining upper part of 46 wetland by 75%	6.46	43.80	23.46	5.76	50.41	19.20	10.41
12	Draining upper part of 46 wetland by 100%	6.46	43.79	23.46	5.76	50.41	19.20	10.41
13	Draining lower part of 46 wetland by 25%	6.46	43.79	23.46	5.76	50.41	19.20	10.41
14	Draining lower part of 46 wetland by 50%	6.46	43.77	23.46	5.76	50.40	19.19	10.40
15	Draining lower part of 46 wetland by 75%	6.46	43.75	23.45	5.76	50.38	19.19	10.40
16	Draining lower part of 46 wetland by 100%	6.46	43.72	23.45	5.76	50.37	19.18	10.40
17	Draining larger size of 46 wetland by 25%	6.46	43.79	23.46	5.76	50.41	19.20	10.41
18	Draining larger size of 46 wetland by 50%	6.46	43.77	23.46	5.76	50.40	19.19	10.40
19	Draining larger size of 46 wetland by 75%	6.46	43.75	23.45	5.76	50.38	19.19	10.40
20	Draining larger size of 46 wetland by 100%	6.46	43.72	23.45	5.76	50.37	19.18	10.40
21	Draining smaller size of 46 wetland by 25%	6.46	43.81	23.46	5.76	50.42	19.20	10.41
22	Draining smaller size of 46 wetland by 50%	6.46	43.81	23.46	5.76	50.42	19.20	10.41
23	Draining smaller size of 46 wetland by 75%	6.46	43.80	23.46	5.76	50.42	19.20	10.41
24	Draining smaller size of 46 wetland by 100%	6.46	43.80	23.46	5.76	50.42	19.20	10.41
25	Restoring upper part of 46 wetland by 25%	6.46	43.80	23.46	5.76	50.42	19.21	10.41
26	Restoring upper part of 46 wetland by 50%	6.46	43.80	23.46	5.76	50.41	19.21	10.41
27	Restoring upper part of 46 wetland by 75%	6.46	43.80	23.46	5.76	50.41	19.21	10.41
28	Restoring upper part of 46 wetland by 100%	6.46	43.80	23.46	5.76	50.41	19.21	10.41
29	Restoring lower part of 46 wetland by 25%	6.46	43.80	23.46	5.76	50.41	19.21	10.41
30	Restoring lower part of 46 wetland by 50%	6.46	43.79	23.45	5.76	50.39	19.22	10.41
31	Restoring lower part of 46 wetland by 75%	6.46	43.78	23.45	5.76	50.38	19.23	10.40
32	Restoring lower part of 46 wetland by 100%	6.46	43.77	23.44	5.76	50.37	19.24	10.40
33	Restoring larger size of 46 wetland by 25%	6.46	43.80	23.46	5.76	50.41	19.21	10.41
34	Restoring larger size of 46 wetland by 50%	6.46	43.79	23.45	5.76	50.39	19.22	10.41
35	Restoring larger size of 46 wetland by 75%	6.46	43.78	23.45	5.76	50.38	19.23	10.40
36	Restoring larger size of 46 wetland by 100%	6.46	43.77	23.44	5.76	50.37	19.24	10.40
37	Restoring smaller size of 46 wetland by 25%	6.46	43.81	23.46	5.76	50.42	19.21	10.41
38	Restoring smaller size of 46 wetland by 50%	6.46	43.81	23.46	5.76	50.42	19.21	10.41
39	Restoring smaller size of 46 wetland by 75%	6.46	43.81	23.46	5.76	50.42	19.21	10.41
40	Restoring smaller size of 46 wetland by 100%	6.46	43.81	23.46	5.76	50.42	19.21	10.41