

Appendix C

Little Calumet River Watershed Curve Number Calculation

Introduction

SCS hydrology uses the empirical curve number (CN) parameter as a part of calculating runoff volumes based on landscape characteristics such as soil type, land cover, imperviousness, and land-use development. Areas characterized by saturated or poorly infiltrating soils, or impervious development, have higher CN values, converting a greater portion of rainfall volume into runoff. The principle data sources used to develop CN values for the Little Calumet River (LCR) watershed are the Natural Resource Conversation Service (NRCS) soil data for Cook County and the 2001 Northeast Illinois Planning Commission (NIPC) land-use mapping for Cook County. The below subsections discusses the procedure used to develop a CN grid for use in hydrologic modeling for the LCR watershed and the assumptions inherent in this procedure.

Approach

CN values are dependent on a number of factors, including the soil infiltration characteristics and condition, as well as land cover characteristics such as directly connected impervious area and cover type. Therefore both soil data and land-use data are required to estimate CN. The best available soil and land-use data for Cook County are the NRCS soil data and NIPC land-use data. **Table C1** lists curve numbers based on combinations of land-use data and soil data for small urban watersheds.

Table C1: Curve Number Generation for Small Urban Watersheds

Cover description Cover type and hydrologic condition	Average percent impervious area ^{2/}	Curve numbers for hydrologic soil group			
		A	B	C	D
<i>Fully developed urban areas (vegetation established)</i>					
Open space (lawns, parks, golf courses, cemeteries, etc.) ^{2/} :					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)					
		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)					
		98	98	98	98
Paved; open ditches (including right-of-way)					
		83	89	92	93
Gravel (including right-of-way)					
		76	85	89	91
Dirt (including right-of-way)					
		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) ^{2/}					
		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)					
		96	96	96	96
Urban districts:					
Commercial and business					
	85	89	92	94	95
Industrial					
	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)					
	65	77	85	90	92
1/4 acre					
	38	61	75	83	87
1/3 acre					
	30	57	72	81	86
1/2 acre					
	25	54	70	80	85
1 acre					
	20	51	68	79	84
2 acres					
	12	46	65	77	82
<i>Developing urban areas</i>					
Newly graded areas (pervious areas only, no vegetation) ^{2/}					
		77	86	91	94

Table excerpted from Technical Release 55, Urban Hydrology for Small Watersheds, June 1986

A slightly modified version of this table will be used for curve number generation in the LCR DWP, shown in **Table C2**. Both the NRCS soil data and the land use data require preprocessing before generating curve numbers using the lookup table.

Table C2: Modified Curve Number Generation for LCR DWP

Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
		A	B	C	D	
Residential (High Density)	65	77	85	90	92	Multi-family, Apartments, Condos, Trailer Parks
Residential (Med. Density)	30	57	72	81	86	Single-Family, Lot Size ¼ to 1 acre
Residential (Low Density)	15	48	66	78	83	Single-Family, Lot Size 1 acre and Greater
Commercial	85	89	92	94	95	Strip Commercial, Shopping Centers, Convenience Stores
Industrial	72	81	88	91	93	Light Industrial, Schools, Prisons, Treatment Plants

Table C2: Modified Curve Number Generation for LCR DWP

Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
		A	B	C	D	
Disturbed / Transitional	5	76	85	89	91	Gravel Parking, Quarries, Land Under Development
Agricultural	5	67	77	83	87	Cultivated Land, Row crops, Broadcast Legumes
Open Land – Good	5	39	61	74	80	Parks, Golf Courses, Greenways, Grazed Pasture
Meadow	5	30	58	71	78	Hay Fields, Tall Grass, Ungrazed Pasture
Woods (Thick Cover)	5	30	55	70	77	Forest Litter and Brush adequately cover soil
Woods (Thin Cover)	5	43	65	76	82	Light Woods, Woods-Grass combination, Tree Farms
Impervious	95	98	98	98	98	Paved Parking, Shopping Malls, Major Roadways
Water	100	100	100	100	100	Water Bodies, Lakes, Ponds, Wetlands

Data from <http://gis2.esri.com/library/userconf/proc00/professional/papers/PAP657/p657.htm>

Data is for average antecedent moisture condition II- dormant season (5-day) rainfall averaging from 0.5 to 1.1 inches and growing season rainfall from 1.4 to 2.1 inches

NRCS Soil data

NRCS soil data representative of 2005 conditions was obtained for Cook and Will Counties in Illinois and Lake, Porter, and La Porte Counties in Indiana. There are several unmapped areas which include the City of Chicago and some portions of nearby communities that consist primarily of urban land forms. These urban land forms were assumed to be Hydrologic Soil Group C.

The NRCS soil data includes hydrologic soil group, representing the minimum infiltration rate of the soil after wetting. **Table C3** summarizes the hydrologic soil groups.

Table C3: Hydrologic Soil Groups

Hydrologic Soil Group	Description	Texture	Infiltration Rates (in/hr)
A	Low runoff potential and high infiltration rates even when wetted	Sand, loamy sand, or sandy loam	> 0.30
B	Moderate infiltration rates when wetted	Silt loam or loam	0.15 – 0.30
C	Low infiltration rates when wetted	Sandy clay loam	0.05 – 0.15
D	High runoff potential and very low infiltration when wetted	Clay loam, silty clay loam, sandy clay, silty clay, or clay clay, or clay	0 – 0.05

All data from Technical Release 55, Urban Hydrology for Small Watersheds, June 1986

Soil groups with drainage characteristics impacted by a high water table are indicated with a '/D' designation, where the letter preceding the slash indicates the hydrologic group of the soil under drained conditions. Thus an 'A/D' indicates that the soil has characteristics of the A soil group if drained but the D soil group if not. 'A/D', 'B/D', or 'C/D', occur throughout the LCR watershed and represent approximately 7 percent of the total drainage area. Because of the difficulty of establishing the extent of drainage of these soils for each mapped soil polygon, it was assumed that 50 percent (by area) of the soil types are drained.

NIPC Land Use Data

A 2001 land use inventory for the Chicago metropolitan area was received from CMAP in GIS format. The data was used to characterize existing conditions land use within the Little Calumet River Watershed. The data include 49 land use classifications, grouped into seven general categories for summarizing land use within the DWP.

Generation of CN

Table C4 describes the input data used to develop the CN values throughout the watershed.

Table C4: Description of Curve Number Input Data

Variable Used to Determine CN	Approach for Definition of Variable for Little Calumet River Watershed Hydrologic Modeling
Ground cover (Illinois)	Chicago Metropolitan Agency for Planning (CMAP) 2001 land use inventory (v.1.2 2006) was used to define land use. A lookup table was developed to link CMAP categories to CN values and soil types.
Ground cover (Indiana)	USGS 2001 Land Cover was used to define land use. A lookup table was developed to link USGS categories to CN values and soil types.
Soil type	The Natural Resources Conservation Service (NRCS) publishes county soil surveys that include a hydrologic classification of A, B, C, or D. If a soil group's infiltration capacity is affected by a high water table, it is classified as, for instance, "A/D," meaning the drained soil has "A" infiltration characteristics, undrained "D." It was assumed that half of these soil groups (by area) are drained.
Antecedent moisture condition	Antecedent Moisture Conditions (AMC) reflects the initial soil storage capacity available for rainfall. For areas within Northeastern Illinois, it is typical to assume an AMC of II.

The subbasin curve numbers were determined based on existing land use and soil types. The NRCS soil maps were imported into ArcGIS. The NIPC 2001 land use and USGS 2001 land cover data were imported into ArcGIS. The USGS raster data was converted to a polygon file. The soil type polygons and land use polygons were intersected in ArcGIS to end up with polygons with consistent land use and soil type in each polygon. Based on the land use and soil type in these polygons, a curve number was assigned to each polygon. The land use/soil type/curve number assignment was based on *TR-55: Urban Hydrology for Small Watersheds* (U.S. Department of Agriculture [USDA], 1986). These polygons were then converted to raster grid with 25-foot grid cells identical to the locations of the DEM grid cells. The Spatial Analyst extension was then used to calculate the average curve number for each subbasin.

For each subbasin, the Directly Connected Impervious percentage was estimated. This estimate was based on the total impervious area within the subbasin. Directly Connected Impervious areas are impervious areas that drain directly to the waterway via sewers or other lined channels where infiltration will not occur before the runoff from the impervious area reaches the stream. The directly connected impervious percentage for each land use type varied from 20 to 50% of the total impervious percentage. **Table C5** shows the curve number and directly connected impervious by land use type.

Table C5: Curve Number and Directly Connected Impervious by Land Use Type

NIPC 2001 Land Use Code	Land Use Description	A	B	C	D	A/D	B/D	C/D	%DCIA
11	Open Water	100	100	100	100	100	100	100	0
21	Developed, Open Space	37	58	70	76	57	67	73	0
22	Developed, Low Intensity	51	67	76	81	66	74	78	5
23	Developed, Medium Intensity	58	71	79	83	70	77	81	7

Table C5: Curve Number and Directly Connected Impervious by Land Use Type

NIPC 2001 Land Use Code	Land Use Description	A	B	C	D	A/D	B/D	C/D	%DCIA
24	Developed, High Intensity	78	84	87	88	83	86	88	37
31	Barren Land	72	81	85	86	79	84	86	0
41	Deciduous Forest	29	52	67	73	51	63	70	0
42	Evergreen Forest	29	52	67	73	51	63	70	0
43	Mixed Forest	29	52	67	73	51	63	70	0
52	Shrub/Scrub	29	46	62	69	49	57	66	0
71	Grassland	37	58	70	76	57	67	73	0
81	Pasture/Hay	29	55	67	74	51	65	71	0
82	Cultivated Crops	64	74	81	85	74	79	83	0
90	Woody Wetlands	46	64	73	79	62	71	76	0
95	Emergent Wetlands	65	75	82	85	75	80	83	0
1110	1110 RES/SF	54	68	77	82	68	75	80	6
1120	1120 RES/FARM	46	63	74	79	63	71	77	3
1130	1130 RES/MF	54	68	77	82	68	75	80	6
1140	1140 RES/MOBILE HM	73	81	86	87	81	85	86	13
1211	1211 MALL	85	87	89	90	87	89	90	40
1212	1212 RETAIL CNTR	85	87	89	90	87	89	90	40
1221	1221 OFFICE CMPS	85	87	89	90	87	89	90	40
1222	1222 SINGL OFFICE	85	87	89	90	87	89	90	40
1223	1223 BUS. PARK	85	87	89	90	87	89	90	40
1231	1231 URB MX W/PRKNG	85	87	89	90	87	89	90	40
1232	1232 URB MX NO PRKNG	77	84	86	88	83	86	87	35
1240	1240 CULT/ENT	85	87	89	90	87	89	90	40
1250	1250 HOTEL/MOTEL	85	87	89	90	87	89	90	40
1310	1310 MEDICAL	77	84	86	88	83	86	87	35
1320	1320 EDUCATION	77	84	86	88	83	86	87	35
1330	1330 GOVT	85	87	89	90	87	89	90	40
1340	1340 PRISON	77	84	86	88	83	86	87	35
1350	1350 RELIGIOUS	85	87	89	90	87	89	90	40
1360	1360 CEMETERY	37	58	70	76	57	67	73	0
1370	1370 INST/OTHER	46	63	74	79	63	71	77	3
1410	1410 MINERAL EXT	72	81	85	86	80	84	86	0
1420	1420 MANUF/PROC	77	84	86	88	83	86	87	35
1430	1430 WAREH/DIST/WHOL	77	84	86	88	83	86	87	35
1440	1440 INDUST PK	77	84	86	88	83	86	87	35
1511	1511 INTERSTATE/TOLL	79	85	87	89	84	86	88	0
1512	1512 OTHER ROADWY	79	85	87	89	84	86	88	35
1520	1520 OTH LINEAR TRAN	72	81	85	86	80	84	86	0

Table C5: Curve Number and Directly Connected Impervious by Land Use Type

NIPC 2001 Land Use Code	Land Use Description	A	B	C	D	A/D	B/D	C/D	%DCIA
1530	1530 AIR TRANSPORT	66	76	82	85	75	80	84	0
1540	1540 INDEP AUTO PRK	85	87	89	90	87	89	90	40
1550	1550 COMMUNICATION	64	73	79	83	73	78	81	0
1560	1560 UTILITIES/WASTE	72	81	85	86	80	84	86	0
2100	2100 CROP/GRAIN/GRAZ	64	73	79	83	73	78	81	0
2200	2200 NRSRY/GRNHS/ORC	64	73	79	83	73	78	81	0
2300	2300 AG/OTHER	64	73	79	83	73	78	81	0
3100	3100 OPENSF REC	37	58	70	76	57	67	73	0
3200	3200 GOLF COURSE	37	58	70	76	57	67	73	0
3300	3300 OPENSF CONS	37	58	70	76	57	67	73	0
3400	3400 OPENSF PRIVATE	37	58	70	76	57	67	73	0
3500	3500 OPENSF LINEAR	37	58	70	76	57	67	73	0
3600	3600 OPENSF OTHER	37	58	70	76	57	67	73	0
4110	4110 VAC FOR/GRASS	37	58	70	76	57	67	73	0
4120	4120 WETLAND	29	55	67	74	51	65	71	0
4210	4210 CONST RES	72	81	85	86	80	84	86	0
4220	4220 CONST NONRES	72	81	85	86	80	84	86	0
4300	4300 OTHER VACANT	37	58	70	76	57	67	73	0
5100	5100 RIVERS/CANALS	100	100	100	100	100	100	100	0
5200	5200 LAKE/RES/LAGOON	100	100	100	100	100	100	100	0
5300	5300 LAKE MICHIGAN	100	100	100	100	100	100	100	0
9999	9999 OUT OF REGION	100	100	100	100	100	100	100	0