

Attachment 02.04.03-08W  
TVA letter dated February 2, 2010  
RAI Response

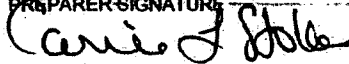



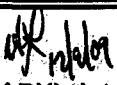
ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.04.03-8W: Processing and Validation of National Weather Service's NEXRAD  
Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins

(57 Pages including Cover Sheet)

## NPG CALCULATION COVERSHEET/CCRIS UPDATE

Page 1

REV 0 EDMS/RIMS NO. L58 081030 008					EDMS TYPE: calculations(nuclear)		EDMS ACCESSION NO (N/A for REV. 0) <b>L 58 091230 054</b>			
Calc Title: Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins										
CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY		
CURRENT	CN	NUC	GEN	CEB	CDQ000020080055	2	3	Entire calc <input checked="" type="checkbox"/> Selected pages <input type="checkbox"/>		
ACTION:		NEW REVISION <input checked="" type="checkbox"/>	DELETE RENAME <input type="checkbox"/>	SUPERSEDE DUPLICATE <input type="checkbox"/>	CCRIS UPDATE ONLY <input type="checkbox"/> (Verifier Approval Signatures Not Required)			No CCRIS Changes <input checked="" type="checkbox"/> (For calc revision, CCRIS been reviewed and no CCRIS changes required)		
UNITS N/A		SYSTEMS N/A			UNIDS N/A					
DCN,EDC,N/A * See Below		APPLICABLE DESIGN DOCUMENT(S) N/A					CLASSIFICATION "E"			
QUALITY RELATED? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	SAFETY RELATED? (If yes, QR = yes) Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	UNVERIFIED ASSUMPTION Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>		DESIGN OUTPUT ATTACHMENT? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	SAR/TS and/or ISFSI SAR/CoC AFFECTED Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>				
PREPARER ID clstokes	PREPARER PHONE NO (615) 252-4343	PREPARING ORG (BRANCH) CEB		VERIFICATION METHOD See Page 5a	NEW METHOD OF ANALYSIS <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
PREPARER SIGNATURE  Carrie L. Stokes		DATE 12/8/09	CHECKER SIGNATURE  Ben Nemec		DATE 12/8/09					
VERIFIER SIGNATURE  Ben Nemec		DATE 12/8/09	APPROVAL SIGNATURE  K.P. Spates		DATE 12/23/09					
STATEMENT OF PROBLEM/ABSTRACT  Develop radar-based mean areal precipitation (MAPX) data series for TVA subbasins from National Weather Service's NEXRAD Stage III hourly precipitation data. The MAPX data series are developed from the 1997-2008 period for which NEXRAD data are available. The resulting MAPX data series are input to other calculations that validate TVA unit hydrographs for recent flood events.										
*EDCN 22404A(SQN), EDCN 54018A(WBN), LATER(BFN)										
This calculation contains electronic attachments and must be stored in EDMS as an Adobe .pdf file to maintain the ability to retrieve the electronic attachments.										
MICROFICHE/EFICHE Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> FICHE NUMBER(S)										
<input type="checkbox"/> LOAD INTO EDMS AND DESTROY <input checked="" type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS: LP4D-C <input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:										

## Page 1 C

PHS  
9/17/09

## TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1b

REV 0 EDMS/RIMS NO. L58 081030 008		EDMS TYPE: calculations(nuclear)		EDMS ACCESSION NO (N/A for REV. 0) <b>L58 090210 004</b>	
Calc Title: Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins					
CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER
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NEW					
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		CCRIS UPDATE ONLY <input type="checkbox"/>		(Verifier Approval Signatures Not Required)	
				No CCRIS Changes <input type="checkbox"/> (For calc revision, CCRIS been reviewed and no CCRIS changes required)	
UNITS N/A		SYSTEMS N/A		UNIDS N/A	
DCN,EDC,N/A N/A		APPLICABLE DESIGN DOCUMENT(S) N/A			CLASSIFICATION "E"
QUALITY RELATED? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	SAFETY RELATED? (If yes, QR = yes) Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	UNVERIFIED ASSUMPTION Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	DESIGN OUTPUT ATTACHMENT? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	SAR/TS and/or ISFSI SAR/CoG AFFECTED Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
PREPARER ID YYAN1	PREPARER PHONE NO (301) 228-6603	PREPARING ORG (BRANCH) Bechtel (CEB)	VERIFICATION METHOD Design Review	NEW METHOD OF ANALYSIS <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
PREPARER SIGNATURE Yongmin Yan	DATE 2/2/2009	CHECKER SIGNATURE Linda K. Springer	DATE 2/2/2009		
VERIFIER SIGNATURE Tracy J. McLane	DATE 2/2/2009	APPROVAL SIGNATURE K.R. Spates	DATE 2/10/09		
STATEMENT OF PROBLEM/ABSTRACT					
<p>Develop radar-based mean areal precipitation (MAPX) data series for TVA subbasins from National Weather Service's NEXRAD Stage III hourly precipitation data. The MAPX data series are developed from the 1997-2008 period for which NEXRAD data are available. The resulting MAPX data series are input to other calculations that validate TVA unit hydrographs for recent flood events.</p>					
<p><b>This calculation contains electronic attachments and must be stored in EDMS as an Adobe .pdf file to maintain the ability to retrieve the electronic attachments.</b></p>					
MICROFICHE/EFICHE Yes <input type="checkbox"/> No <input type="checkbox"/> FICHE NUMBER(S)					
<input type="checkbox"/> LOAD INTO EDMS AND DESTROY <input checked="" type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS: LP4D-C <input type="checkbox"/> LOAD INTO EDMS AND RETURN CALCULATION TO:					



158 081030 008

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

Page 1a

REV 0 EDMS/IRMS NO.		EDMS TYPE: calculations(nuclear)		EDMS ACCESSION NO. (N/A for REV. 0) N/A	
Calc Title: Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins					
CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER
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NEW	CN	NJC	GEN	CEB	CD0000020080055
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				No CCRIS Changes <input type="checkbox"/> (For calc revision, CCRIS been reviewed and no CCRIS changes required)	
UNITS		SYSTEMS		UNIDS	
N/A		N/A		N/A	
DEN EDC N/A		APPLICABLE DESIGN DOCUMENT(S)		CLASSIFICATION	
N/A		N/A		C	
QUALITY RELATED?	SAFETY RELATED? (if yes, CR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS and/or I&E SAR/DC AFFECTED?
Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS	
YYAN1	(301) 228-5603	Bechtel (CEB)	Design Review	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE		
Yongmin Yan	10/24/08	Linda K. Springer	10-24-08		
VERIFIER SIGNATURE	DATE	APPROVAL SIGNATURE	DATE		
Tracy J. McLane	10-24-08	SWT	10-31-08		
STATEMENT OF PROBLEM/ABSTRACT					
Develop radar-based mean areal precipitation (MAPX) data series for TVA subbasins from National Weather Service's NEXRAD Stage III hourly precipitation data. The MAPX data series are developed from the 1997-2008 period for which NEXRAD data are available. The resulting MAPX data series are input to other calculations that validate TVA unit hydrographs for recent flood events.					
This calculation contains electronic attachments and must be stored in EDMS as an Adobe .pdf file to maintain the ability to retrieve the electronic attachments.					
MICROFICHE/FICHE		Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>		FICHE NUMBER(S)	
LOAD INTO EDMS AND DESTROY					
LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY ADDRESS: LP4D-C					
LOAD INTO EDMS AND RETURN CALCULATION TO:					

## Page 2

<u>CALC ID</u>	<u>TYPE</u>	<u>ORG</u>	<u>PLANT</u>	<u>BRANCH</u>	<u>NUMBER</u>	<u>REV</u>
	CN	NUC	GEN	CEB	CDQ000020080055	2

### ALTERNATE CALCULATION IDENTIFICATION

ALTERNATE CALCULATION IDENTIFICATION					
BLDG	ROOM	ELEV	COORD/AZIM	FIRM BWSC	Print Report Yes <input type="checkbox"/>
CATEGORIES NA					

### KEY NOUNS (A-add, D-delete)

<u>ACTION</u>	<u>KEY NOUN</u>	<u>A/D</u>	<u>KEY NOUN</u>
<u>(A/D)</u>			

### CROSS-REFERENCES (A-add, C-change, D-delete)

[illegible]

CCRIS ONLY UPDATES:

Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-2-1 is not included:

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
PREPARER PHONE NO.	EDMS ACCESSION NO.		

NPG CALCULATION RECORD OF REVISION	
CALCULATION IDENTIFIER	CDQ000020080055
Revision: 3	
Title	Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins
Revision No.	DESCRIPTION OF REVISION
0	Initial issue
1	One of the original 46 subbasins "Nickajack Dam" (subbasin 47) was divided into two subbasins (47A and 47B). As a result, new MAPX data series were developed for these two subbasins (The original MAPX data series for 45 other subbasins are still valid and don't require recalculation). A new page 7A was inserted after page 7 to list additional input and output files which were attached to this calculation (Attachments 7-1 to 7-7, 8, 9-1 to 9-12). Page 9 was revised to list a new spreadsheet that compared MAPX for subbasin 47 and the new divided subbasins 47A and 47B (Attachment A-9-15). Page 7, 15, 18, 20, 24, 25, 27, 28, 29 were revised to reflect the changes to the subbasins data layer and their associated statistics. Changes have been incorporated on pages 1, 3 and 13 as a result of the revision. The total number of pages was increased by 1 from 44 to 45.
2	<p>Revised calculation to include the 15 subbasins in the Wheeler Reservoir watershed. Significant changes to text are marked as indicated.</p> <p>Revisions include:</p> <ol style="list-style-type: none"> <li>1. Appendix B added to calculation.</li> <li>2. Page 1b added to calculation.</li> <li>3. Attachment 10 added to calculation.</li> <li>4. Attachment 11 added to calculation.</li> <li>5. Content on page 5 was modified where indicated.</li> <li>6. Content on page 15 was modified where indicated.</li> <li>7. Content on page 17 was modified where indicated.</li> <li>8. Content on page 20 was modified where indicated.</li> <li>9. Content on page 22 was modified where indicated.</li> </ol> <p>Total Hardcopy Pages R2: 49</p>
3	<p>This calculation was revised to address the following:</p> <ul style="list-style-type: none"> <li>• PER 203951-The verification of the original calculation was completed by personnel who had not completed the required NEDP-7 Job Performance Record (JPR). A verification JPR is now in place for all personnel engaged in verification tasks. Checking included only changes made in this revision as the checking of the calculation was not impacted by PER 203951. The verification is inclusive of work completed prior to this revision.</li> <li>• PER 203872- Replaced NEDP-2 forms on pages 3 through 6 with the forms from the NEDP-2 Revision in effect at the time of calculation issuance.</li> </ul> <p>Significant changes in Revision 3 are noted with a right margin revision bar. Administrative changes and typos are excluded.</p> <p>Pages Added: 1c &amp; 5a  Pages Replaced: 1, 3-6, 9 &amp; 22, Appendix B page 1 (Corrected typo in Section 1.0)  Total pages of calculation hard copy for Revision 3= 51</p>

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List of Appendices:		
Appendix A:	Appendix A is written as part of the main calculation text and is included in the table of contents above.	
Appendix B:	Appendix B is a PDF file that is electronically attached to this calculation, Total Pages = 2	
List of Attachments:		
See listing of electronic attachments on page 6-11.		

## NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080055

Revision 3

## Method of verification used:

1. Design Review ☒
2. Alternate Calculation ☐
3. Qualification Test ☐

Verifier Ben Nemec Date



12/8/09

## Comments:

This calculation entitled, Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins was verified by independent design review. The process involved a critical review of the calculation to ensure that it is correct and complete, uses appropriate methodologies, and achieves its intended purpose. The inputs were reviewed and determined to be appropriate inputs for this calculation. The results of the calculation were reviewed and were found to be reasonable and consistent with the inputs provided. Backup files and documents were consulted as necessary to verify data and analysis details found in the calculation.

Detailed comments and editorial suggestions for the changes made in this revision were transmitted to the author and reviewer by email along with a marked up copy of the calculation.

(Note: The design verification of this calculation revision is for the total calculation, not just the changes made in the revision. This complete re-verification is performed to disposition PER 203951 as described in the Calculation Revision Log on Page 3)

**NPG COMPUTER INPUT FILE  
STORAGE INFORMATION SHEET**

Document CDQ000020080055

Rev. 3

Plant: GEN

Subject: Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins

☐ Electronic storage of the input files for this calculation is not required. Comments:☒ Input files for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. (Any retrieved file requires re-verification of its contents before use.)

See listing of electronically attached Input &amp; Output files on the following pages.

## ELECTRONIC FILE ATTACHMENTS

Document: CDQ000020080055

Rev. 2

Plant: Gen

Subject: Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins

The files listed below, which contain both input and output data, are electronically attached to the parent Adobe .pdf calculation file, except for Attachments 1 and A-14. The listed files are therefore stored in an unalterable medium and are retrievable through the EDMS number for this calculation. Click on the "Attachments" Tab within Adobe to view the attachment listing, to access and view the files as needed. Attachments 1 and A-14, due to their size and need to preserve folder structure, are zipped and stored separately in FILEKEEPER and are assigned unique Filekeeper numbers. Both zipped attachments are retrievable through the listed Filekeeper number.

Electronic Attachment	File Name	Comments
<b>Precipitation GIS Utility Input Files</b> <i>Refer to Attachment A-14 for TVA Watershed in ESRI Grid Format</i>		
Attachment 1	NWS_Stage_III_Hourly_Precipitation_Data.zip (FILEKEEPER No. 310990)	NWS NEXRAD Stage III Hourly Precipitation Data in XMRG binary format from January 1997 through April 2008 in the following file naming convention: xmrGMDDYYYYHHZ.
Attachment 2-1	nws_precip_allpoint_conversion.shp	ESRI Shape File for HRAP Grid Centroids
Attachment 2-2	nws_precip_allpoint_conversion.dbf	ESRI Shape File for HRAP Grid Centroids
Attachment 2-3	nws_precip_allpoint_conversion.prj	ESRI Shape File for HRAP Grid Centroids
Attachment 2-4	nws_precip_allpoint_conversion.sbn	ESRI Shape File for HRAP Grid Centroids
Attachment 2-5	nws_precip_allpoint_conversion.sbx	ESRI Shape File for HRAP Grid Centroids
Attachment 2-6	nws_precip_allpoint_conversion.shx	ESRI Shape File for HRAP Grid Centroids
Attachment 3-1	AboveGuntersvilleDrainageAreas_May14_2008.shp	ESRI Shape File for TVA Watershed (original)
Attachment 3-2	AboveGuntersvilleDrainageAreas_May14_2008.dbf	ESRI Shape File for TVA Watershed (original)
Attachment 3-3	AboveGuntersvilleDrainageAreas_May14_2008.prj	ESRI Shape File for TVA Watershed (original)
Attachment 3-4	AboveGuntersvilleDrainageAreas_May14_2008.sbn	ESRI Shape File for TVA Watershed (original)
Attachment 3-5	AboveGuntersvilleDrainageAreas_May14_2008.sbx	ESRI Shape File for TVA Watershed (original)
Attachment 3-6	AboveGuntersvilleDrainageAreas_May14_2008.shx	ESRI Shape File for TVA Watershed (original)
Attachment 4	Watersh.dbf	HRAP Grid to Subbasin Index in DBF format (original)
<b>Precipitation GIS Utility Output Files (Excel Spreadsheets)</b>		
Attachment 5-1	Watershed_Hourly_Precip_01011997_12311997_R000B.xls	MAPX for 1997 (for 46 original subbasins)
Attachment 5-2	Watershed_Hourly_Precip_01011998_12311998_R000B.xls	MAPX for 1998 (for 46 original subbasins)
Attachment 5-3	Watershed_Hourly_Precip_01011999_12311999_R000B.xls	MAPX for 1999 (for 46 original subbasins)
Attachment 5-4	Watershed_Hourly_Precip_01012000_12312000_R000B.xls	MAPX for 2000 (for 46 original subbasins)
Attachment 5-5	Watershed_Hourly_Precip_01012001_12312001_R000B.xls	MAPX for 2001 (for 46 original subbasins)
Attachment 5-6	Watershed_Hourly_Precip_01012002_12312002_R000B.xls	MAPX for 2002 (for 46 original subbasins)
Attachment 5-7	Watershed_Hourly_Precip_01012003_12312003_R000B.xls	MAPX for 2003 (for 46 original subbasins)
Attachment 5-8	Watershed_Hourly_Precip_01012004_12312004_R000B.xls	MAPX for 2004 (for 46 original subbasins)
Attachment 5-9	Watershed_Hourly_Precip_01012005_12312005_R000B.xls	MAPX for 2005 (for 46 original subbasins)
Attachment 5-10	Watershed_Hourly_Precip_01012006_12312006_R000B.xls	MAPX for 2006 (for 46 original subbasins)
Attachment 5-11	Watershed_Hourly_Precip_01012007_12312007_R000B.xls	MAPX for 2007 (for 46 original subbasins)
Attachment 5-12	Watershed_Hourly_Precip_01012008_04302008_R000B.xls	MAPX for January 2008 through April 2008 (original)
<b>Precipitation GIS Utility</b> <i>This application requires Microsoft .Net Framework 2.0 and Microsoft Office Primary Interop Assemblies (downloadable from Microsoft web site) installed on the client computer.</i>		
Attachment 6-1	BecGISHRAP.exe	Application
Attachment 6-2	BecGISHRAP.pdb	Program Debug Database
Attachment 6-3	BecGISHRAP.xml	XML Documentation File
Attachment 6-4	BecGISCommonWindowsControls.dll	Library
Attachment 6-5	BecGISCommonWindowsControls.pdb	Program Debug Database
Attachment 6-6	BecGISCommonWindowsControls.xml	XML Documentation File



## ELECTRONIC FILE ATTACHMENTS

Document: CDQ000020080055

Rev. 2

Plant: Gen

Subject: Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins

Electronic Attachment	File Name	Comments
<b>Precipitation GIS Utility Additional Input Files (for Subbasins 47A and 47B)</b>		
Attachment 7-1	Watersheds_12Dig_Modified_10292008.shp	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 7-2	Watersheds_12Dig_Modified_10292008.dbf	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 7-3	Watersheds_12Dig_Modified_10292008.prj	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 7-4	Watersheds_12Dig_Modified_10292008.sbn	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 7-5	Watersheds_12Dig_Modified_10292008.sbx	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 7-6	Watersheds_12Dig_Modified_10292008.shx	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 7-7	Watersheds_12Dig_Modified_10292008.shp.xml	ESRI Shape File for TVA Watershed (subbasin 47 was subdivided into 47A and 47B)
Attachment 8	Watersh2.dbf	HRAP Grid to Subbasin Index in DBF format for Subbasins 47A and 47B
<b>Precipitation GIS Utility Additional Output Files (for Subbasins 47A and 47B)</b>		
Attachment 9-1	NickajackDam_Hourly_Precip_01011997_12311997_R000A.xls	MAPX for subbasin 47A and 47B for 1997
Attachment 9-2	NickajackDam_Hourly_Precip_01011998_12311998_R000A.xls	MAPX for subbasin 47A and 47B for 1998
Attachment 9-3	NickajackDam_Hourly_Precip_01011999_12311999_R000A.xls	MAPX for subbasin 47A and 47B for 1999
Attachment 9-4	NickajackDam_Hourly_Precip_01012000_12312000_R000A.xls	MAPX for subbasin 47A and 47B for 2000
Attachment 9-5	NickajackDam_Hourly_Precip_01012001_12312001_R000A.xls	MAPX for subbasin 47A and 47B for 2001
Attachment 9-6	NickajackDam_Hourly_Precip_01012002_12312002_R000A.xls	MAPX for subbasin 47A and 47B for 2002
Attachment 9-7	NickajackDam_Hourly_Precip_01012003_12312003_R000A.xls	MAPX for subbasin 47A and 47B for 2003
Attachment 9-8	NickajackDam_Hourly_Precip_01012004_12312004_R000A.xls	MAPX for subbasin 47A and 47B for 2004
Attachment 9-9	NickajackDam_Hourly_Precip_01012005_12312005_R000A.xls	MAPX for subbasin 47A and 47B for 2005
Attachment 9-10	NickajackDam_Hourly_Precip_01012006_12312006_R000A.xls	MAPX for subbasin 47A and 47B for 2006
Attachment 9-11	NickajackDam_Hourly_Precip_01012007_12312007_R000A.xls	MAPX for subbasin 47A and 47B for 2007
Attachment 9-12	NickajackDam_Hourly_Precip_01012008_04302008_R000A.xls	MAPX for subbasin 47A and 47B for January 2008 through April 2008

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**Precipitation GIS Utility Additional Output Files (for Wheeler and Tims Ford Reservoirs)  
Subbasins**

Attachment 10-01	Att 10-11 Watershed_Hourly_Precip_01011997_12311997.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 1997
Attachment 10-02	Att 10-02 Watershed_Hourly_Precip_01011998_12311998.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 1998
Attachment 10-03	Att 10-03 Watershed_Hourly_Precip_01011999_12311999.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 1999
Attachment 10-04	Att 10-04 Watershed_Hourly_Precip_01012000_12312000.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2000
Attachment 10-05	Att 10-05 Watershed_Hourly_Precip_01012001_12312001.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2001
Attachment 10-06	Att 10-06 Watershed_Hourly_Precip_01012002_12312002.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2002
Attachment 10-07	Att 10-07 Watershed_Hourly_Precip_01012003_12312003.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2003
Attachment 10-08	Att 10-08 Watershed_Hourly_Precip_01012004_12312004.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2004
Attachment 10-09	Att 10-09 Watershed_Hourly_Precip_01012005_12312005.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2005
Attachment 10-10	Att 10-10 Watershed_Hourly_Precip_01012006_12312006.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2006
Attachment 10-11	Att 10-11 Watershed_Hourly_Precip_01012007_12312007.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2007
Attachment 10-12	Att 10-12 Watershed_Hourly_Precip_01012008_12312008.xls	MAPX for subbasins 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64 and 65 for 2008

**Additional Electronic Attachments**

Attachment 11	Att 11_Wheeler_Watershed_Maps.pdf	Watershed Map and Subbasin Catchments Key Map for Wheeler Reservoir Watershed. (GIS files used to develop watershed maps are part of a technical Memo that is found under EDMS# L58 090911 800)
Attachment 12	Calc_CDQ000020080055_MAPX_Data_Series_-_Rev_3.doc	Native Word Calculation File

## ELECTRONIC FILE ATTACHMENTS

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Electronic Attachment	File Name	Comments
<b>Validation Input Files</b>		
Attachment A-1	xmrg0506199516z	Sample Hourly Precipitation Data for 5/6/1995 16:00z
Attachment A-2-1	xmrgtoasc.exe	NWS Supplied XMRG Conversion Program
Attachment A-2-2	xmrgtoasc.c	C Source Code for NWS Supplied XMRG Conversion Program
Attachment A-3-1	blue.bdr	ASCII basin boundary for Blue River at Blue Basin in Oklahoma
Attachment A-3-2	blue.shp	ESRI Shape File for Blue River at Blue Basin
Attachment A-3-3	blue.dbf	ESRI Shape File for Blue River at Blue Basin
Attachment A-3-4	blue.prj	ESRI Shape File for Blue River at Blue Basin
Attachment A-3-5	blue.sbn	ESRI Shape File for Blue River at Blue Basin
Attachment A-3-6	blue.sbx	ESRI Shape File for Blue River at Blue Basin
Attachment A-3-7	blue.shx	ESRI Shape File for Blue River at Blue Basin
<b>LMRFC Data Control</b>		
Attachment A-4-1	modeled_tva_basins.dbf	ESRI Shape File for LMRFC Modeled Basins
Attachment A-4-2	modeled_tva_basins.sbn	ESRI Shape File for LMRFC Modeled Basins
Attachment A-4-3	modeled_tva_basins.sbx	ESRI Shape File for LMRFC Modeled Basins
Attachment A-4-4	modeled_tva_basins.shx	ESRI Shape File for LMRFC Modeled Basins
Attachment A-4-5	modeled_tva_basins.shp	ESRI Shape File for LMRFC Modeled Basins
Attachment A-5-1	NOLT1.hrap	HRAP to LMRFC Modeled Basin Index for basin NOLT1
Attachment A-5-2	EMBT1.hrap	HRAP to LMRFC Modeled Basin Index for basin EMBT1
Attachment A-6-1	NOLT1.mapx01	MAPX for LMRFC Modeled Basin NOLT1
Attachment A-6-2	EMBT1.mapx01	MAPX for LMRFC Modeled Basin EMBT1
Attachment A-6-3	BRDG1.mapx01	MAPX for LMRFC Modeled Basin BRDG1
Attachment A-6-4	HURG1.mapx01	MAPX for LMRFC Modeled Basin HURG1
<b>Validation Output Files (Reading of Raw Hourly Precipitation Data)</b>		
<i>Refer to Attachment A-14 for ESRI Grid File for 5/6/1995 16:00</i>		
Attachment A-7-1	xmrg0505200312z.asc	ESRI ASCII Raster File for 5/5/2003 12:00 Processed by the Utility
Attachment A-7-2	xmrg0505200312z.out.asc	ESRI ASCII Raster File for 5/5/2003 12:00 Processed by the NWS Program
Attachment A-7-3	xmrg0916200418z.asc	ESRI ASCII Raster File for 9/16/2004 18:00 Processed by the Utility
Attachment A-7-4	xmrg0916200418z.out.asc	ESRI ASCII Raster File for 9/16/2004 18:00 Processed by the NWS Program
Attachment A-7-5	xmrg0506199516z.asc	ESRI ASCII Raster File for 5/6/1995 16:00 Processed by the Utility
<b>Validation Output Files (HRAP Grid to Subbasin Index)</b>		
Attachment A-8	WatershedComparison_TVA_ModeledLMRFC_Detail.jpg	Figure A-3: "Nolichucky Dam" and "Nolichucky at Embreeville" Subbasins (TVA versus LMRFC)

## ELECTRONIC FILE ATTACHMENTS

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Electronic Attachment	File Name	Comments
<b>Validation Output Files (Aggregation of Hourly Precipitation Data)</b> <i>Refer to Attachment A-14 for ESRI Grid Files for 5/5/2003 12:00 and 9/16/2004 18:00</i>		
Attachment A-9-1	p0505200312_watershed.shp	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00
Attachment A-9-2	p0505200312_watershed.dbf	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00
Attachment A-9-3	p0505200312_watershed.prj	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00
Attachment A-9-4	p0505200312_watershed.sbn	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00
Attachment A-9-5	p0505200312_watershed.sbx	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00
Attachment A-9-6	p0505200312_watershed.shx	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00
Attachment A-9-7	p0505200312_watershed.xls	Detailed Precipitation Data Grid-by-Grid Exported from the Point Data and the Average Precipitation by Subbasin Calculated in Excel for 5/5/2003 12:00
Attachment A-9-8	p0916200418_watershed.shp	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00
Attachment A-9-9	p0916200418_watershed.dbf	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00
Attachment A-9-10	p0916200418_watershed.prj	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00
Attachment A-9-11	p0916200418_watershed.sbn	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00
Attachment A-9-12	p0916200418_watershed.sbx	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00
Attachment A-9-13	p0916200418_watershed.shx	ESRI Shape File for Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00
Attachment A-9-14	p0916200418_watershed.xls	Detailed Precipitation Data Grid-by-Grid Exported from the Point Data and the Average Precipitation by Subbasin Calculated in Excel for 9/16/2004 18:00
Attachment A-9-15	MAPX_Compare_Rev0_Rev1_NickajackDam.xls	Comparison of MAPX for Subbasin 47 Nickajack Dam or its subdivided Subbasins 47A and 47B (Revision 0 versus Revision 1)

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Electronic Attachment	File Name	Comments
<b>Validation Output Files (MAPX Comparison, Utility vs. LMRFC)</b>		
Attachment A-10-1	Watershed_Hourly_Precip_05022003_05082003_R000A.xls	Utility MAPX Results from 5/2/2003 to 5/8/2003 for TVA Watershed
Attachment A-10-2	Watershed_Hourly_Precip_09152004_09212004_R000A.xls	Utility MAPX Results from 9/15/2004 to 9/21/2004 for TVA Watershed
Attachment A-11-1	MAPX_Compare_Utility_RFC_Nolichucky_Dam_May2003_Sept2004.xls	Comparison of MAPXs for "Nolichucky Dam" (NOLT1) subbasin
Attachment A-11-2	MAPX_Compare_Utility_RFC_Nolichucky_at_Embreeville_May2003_Sept2004.xls	Comparison of MAPXs for "Nolichucky at Embreeville" (EMBT1) subbasin
Attachment A-11-3	MAPX_Compare_Utility_RFC_BlueRidge_May2003_Sept2004.xls	Comparison of MAPXs for "Blue Ridge" (BRDG1 and HURG1) subbasin
Attachment A-12-1	Basin_Hourly_Precip_05022003_05082003_R000A.xls	Utility MAPX Results from 5/2/2003 to 5/8/2003 for LMRFC Modeled Basins
Attachment A-12-2	Basin_Hourly_Precip_09152004_09212004_R000A.xls	Utility MAPX Results from 9/15/2004 to 9/21/2004 for LMRFC Modeled Basins
Attachment A-13-1	MAPX_Compare_Utility_RFC_NOLT1_May2003_Sept2004.xls	Comparison of MAPX for LMRFC Modeled Basin NOLT1
Attachment A-13-2	MAPX_Compare_Utility_RFC_EMBT1_May2003_Sept2004.xls	Comparison of MAPX for LMRFC Modeled Basin EMBT1
Attachment A-13-3	MAPX_Compare_Utility_RFC_BRDG1_May2003_Sept2004.xls	Comparison of MAPX for LMRFC Modeled Basin BRDG1
Attachment A-13-4	MAPX_Compare_Utility_RFC_HURG1_May2003_Sept2004.xls	Comparison of MAPX for LMRFC Modeled Basin HURG1
<b>ESRI Grid Files</b>		
Attachment A-14	ESRI_Grid_Files.zip (FILEKEEPER No. 310989)	ESRI Grid Files (contain four ESRI Grids: TVA Watershed, Precipitation Grids for 5/6/1995 16:00, 5/5/2003 12:00, and 9/16/2004 18:00)
	watershed_grd\dblbnd.adf	ESRI Grid File for TVA Watershed
	watershed_grd\hdr.adf	ESRI Grid File for TVA Watershed
	watershed_grd\prj.adf	ESRI Grid File for TVA Watershed
	watershed_grd\sta.adf	ESRI Grid File for TVA Watershed
	watershed_grd\vat.adf	ESRI Grid File for TVA Watershed
	watershed_grd\w001001x.adf	ESRI Grid File for TVA Watershed
	watershed_grd\w001001x.adf	ESRI Grid File for TVA Watershed
	Watershed_grd.aux	ESRI Grid File for TVA Watershed
	p_0506199516\dblbnd.adf	ESRI Grid File for 5/6/1995 16:00
	p_0506199516\hdr.adf	ESRI Grid File for 5/6/1995 16:00
	p_0506199516\prj.adf	ESRI Grid File for 5/6/1995 16:00
	p_0506199516\sta.adf	ESRI Grid File for 5/6/1995 16:00
	p_0506199516\w001001.adf	ESRI Grid File for 5/6/1995 16:00
	p_0506199516\w001001x.adf	ESRI Grid File for 5/6/1995 16:00
	p_0506199516.aux	ESRI Grid File for 5/6/1995 16:00
	p_0505200312\dblbnd.adf	ESRI Grid File for 5/5/2003 12:00
	p_0505200312\hdr.adf	ESRI Grid File for 5/5/2003 12:00
	p_0505200312\prj.adf	ESRI Grid File for 5/5/2003 12:00
	p_0505200312\sta.adf	ESRI Grid File for 5/5/2003 12:00
	p_0505200312\w001001.adf	ESRI Grid File for 5/5/2003 12:00
	p_0505200312\w001001x.adf	ESRI Grid File for 5/5/2003 12:00
	p_0505200312.aux	ESRI Grid File for 5/5/2003 12:00
	p_0916200418\dblbnd.adf	ESRI Grid File for 9/16/2004 18:00
	p_0916200418\hdr.adf	ESRI Grid File for 9/16/2004 18:00
	p_0916200418\prj.adf	ESRI Grid File for 9/16/2004 18:00

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Electronic Attachment	File Name	Comments
<b>ESRI Grid Files (Continued)</b>		
	p_0916200418\sta.adf	ESRI Grid File for 9/16/2004 18:00
	p_0916200418\w001001.adf	ESRI Grid File for 9/16/2004 18:00
	p_0916200418\w001001x.adf	ESRI Grid File for 9/16/2004 18:00
	p_0916200418.aux	ESRI Grid File for 9/16/2004 18:00
	info\arc.dir	ESRI Grid Info Folder File
	info\arc0000.dat	ESRI Grid Info Folder File
	info\arc0000.nit	ESRI Grid Info Folder File
	info\arc0001.dat	ESRI Grid Info Folder File
	info\arc0001.nit	ESRI Grid Info Folder File
	info\arc0002.dat	ESRI Grid Info Folder File
	info\arc0002.nit	ESRI Grid Info Folder File
	info\arc0003.dat	ESRI Grid Info Folder File
	info\arc0003.nit	ESRI Grid Info Folder File
	info\arc0004.dat	ESRI Grid Info Folder File
	info\arc0004.nit	ESRI Grid Info Folder File
	info\arc0005.dat	ESRI Grid Info Folder File
	info\arc0005.nit	ESRI Grid Info Folder File
	info\arc0006.dat	ESRI Grid Info Folder File
	info\arc0006.nit	ESRI Grid Info Folder File
	info\arc0007.dat	ESRI Grid Info Folder File
	info\arc0007.nit	ESRI Grid Info Folder File
	info\arc0008.dat	ESRI Grid Info Folder File
	info\arc0008.nit	ESRI Grid Info Folder File
	info\arc0008r.001	ESRI Grid Info Folder File

## TVA

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	<b>Checked</b>		L.S

## 1 Purpose

Observed rainfall data, or more specifically, Mean Areal Precipitation (MAP), is one of the basic input data sets required for determining the runoff or excess rainfall from any given watershed. The excess rainfall, when convoluted with the watershed's unit hydrograph, can then be used to estimate the discharge hydrograph from the watershed resulting from a particular storm event.

Observed rainfall data in the past were typically derived from gage-based daily and hourly precipitation data. Recently, radar-based Mean Areal Precipitation (MAPX) data series derived from NEXRAD Stage III hourly precipitation data have become a useful alternative due to its great spatial and temporal detail and improved quality over-time.

Radar-based NEXRAD Stage III hourly precipitation data are available from the National Weather Service (NWS). The raw data are stored in XMRG binary format. A XMRG file is essentially a FORTRAN binary file that starts with one or more header records followed by the actual data. The header records for the precipitation data evolves as time goes by, but it defines the origin and the size of the gridded precipitation data at the minimum (Reference 1).

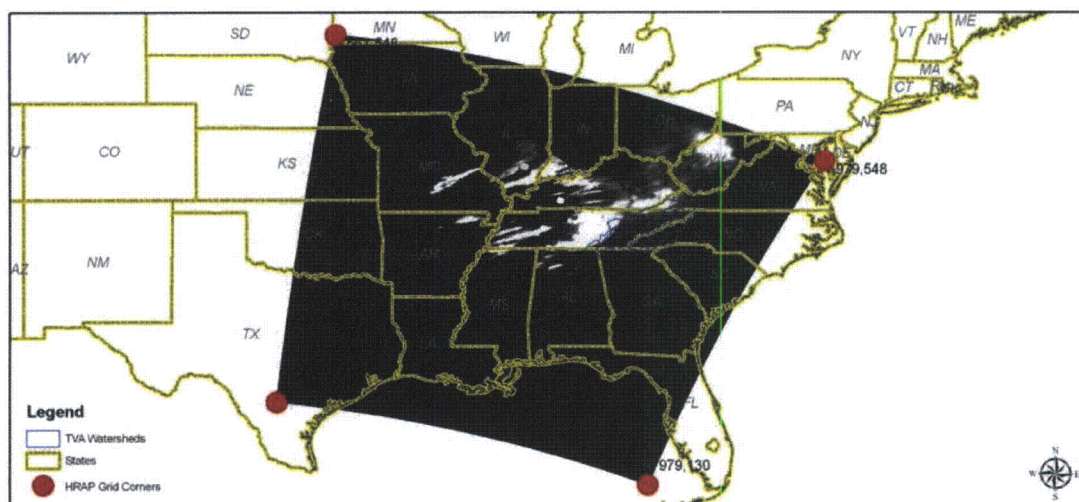
There are 88,200 individual XMRG binary files for a total uncompressed size of 29.9 GB obtained from NWS's Lower Mississippi River Forecast Center (LMRFC) covering the TVA region for the period from January 1997 to April 2008. Each file corresponds to gridded hourly precipitation data ending at a particular hour of a day in Greenwich Mean Time (GMT). GMT is 5 hours ahead of Central Daylight Time (CDT) and 6 hours ahead of Central Standard Time (CST). The naming convention for these files is xmrghhmmddYYYYHHz. MM stands for two digits numeric month from 01 to 12, DD stands for two digits day from 01 to 31, YYYY stands for four digits year from 1997 to 2008, and HH stands for two digits hour from 00 to 23. For example, file xmrgh0502200314z stores precipitation data for the hour between 05/02/2003 13:00 GMT (start) and 05/02/2003 14:00 GMT (end).

The gridded precipitation data use a custom map projection called the Hydrologic Rainfall Analysis Project (HRAP) Grid System. HRAP is based on a Polar Stereographic Map Projection with standard longitude at -105 West and standard latitude at 60 North and assumes a spherical earth of radius 6371.2 km. HRAP grids have a mesh length of 4762.5 meters at 60 North and the grids are shifted so that coordinate (401, 1601) is at the north pole (Reference 2).

Figure 1 shows a sample precipitation grid (in black and white) in relation to TVA watershed (in blue), and state boundaries (in yellow).

## TVA

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		Checked	EEK



**Figure 1: Sample Precipitation Grid (5/5/2003 10:00) with Matching HRAP Grid Centroids at the Four Corners**

To develop the MAPX data series for each of the subbasins comprising the Tennessee River watershed above Wheeler Dam, binary hourly precipitation data were read from the raw XMRG files and then spatially averaged by subbasin, i.e., MAPX for a particular subbasin at a particular hour is the spatial average of hourly precipitation data over all HRAP grids that make up that subbasin.

Because of the vast amount of data, it was not feasible to process the data manually. Therefore, *the BecGIS NWS Hourly Precipitation Data GIS Utility*, a Microsoft.Net Program, was developed to read, process, and aggregate the raw hourly precipitation data. Initially, this *utility* was used to develop the MAPX data series for each of the 46 subbasins comprising the watershed above Guntersville Dam. Subsequently, it was utilized in the same manner to develop the MAPX data series for 15 additional subbasins that are between Wheeler Dam and Guntersville Dam. Henceforth, this tool will be referred to as the *Precipitation GIS Utility* or the *Utility*.

The purpose of this calculation is to document the development of the hourly MAPX data series for the subbasins comprising the Tennessee River watershed above Wheeler Dam. The hourly MAPX data are used in separate calculations to assess the validity of the TVA unit hydrographs for each of the subbasins.

## 2 References

1. NWS, XMRG File Format (pdf file xmr.pdf downloaded from NWS web site <http://www.nws.noaa.gov/oh/hrl/misc/xmr.pdf>).
2. NWS, HRAPGRID Hydrologic Rainfall Analysis Project (HRAP) Grid System (pdf file 21hrapgrid.pdf downloaded from NWS web site [http://www.nws.noaa.gov/oh/hrl/nwsrfs/users\\_manual/part2/\\_pdf/21hrapgrid.pdf](http://www.nws.noaa.gov/oh/hrl/nwsrfs/users_manual/part2/_pdf/21hrapgrid.pdf)).



## **TVA**

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	<b>Checked</b>		L.S.

### **3 Assumptions**

No assumptions or unverified assumptions are contained in this calculation.

### **4 Glossary of Terminology and Acronyms/Abbreviations**

GIS: Geographic Information Systems.

GMT: Greenwich Mean Time.

HRAP: Hydrologic Rainfall Analysis Project.

Identity Tool: an ArcGIS “overlay analysis” tool that assigns attributes/data to a feature/geometry using data from an intersected different feature.

LMRFC: Lower Mississippi River Forecast Center

NEXRAD: Next-Generation Radar

NWS: National Weather Service

MAP: Mean Areal Precipitation

MAPX: Radar-based Mean Areal Precipitation

Raster Math Minus Tool: an ArcGIS spatial analysis tool that calculates difference of two grids on a cell-by-cell basis.

Raster to Point Tool: an ArcGIS conversion tool that converts grids to points (centroids).

XMRG: a binary file format used within the National Weather Service to store gridded data.

### **5 Design Input Data**

The input data necessary for developing MAPX is summarized below.

- Raw Hourly Precipitation Data in XMRG format from the period January 1997 through April 2008
- HRAP Grid Centroids
- TVA Watershed Subbasin Boundaries

Each of these inputs is described in more detail in the following subsections.

#### **5.1 Raw Hourly Precipitation Data in XMRG Format from January 1997 through April 2008**

Raw Hourly Precipitation Data in XMRG format from January 1997 through April 2008 were obtained from LMRFC (Attachment 1).

## TVA

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	Checked		EEK

### 5.2 HRAP Grid Centroids

HRAP Grid Centroids (nws\_precip\_allpoint\_conversion.\*, Attachment 2-1 to 2-5) were downloaded from the NWS web site ([http://water.weather.gov/p\\_download\\_new/nws\\_precip\\_allpoint\\_conversion.tar.gz](http://water.weather.gov/p_download_new/nws_precip_allpoint_conversion.tar.gz)). HRAP Grid Centroids indicate the geometric center of HRAP Grids. These data, along with the TVA watershed subbasin boundaries, were used to develop the HRAP Grid to Subbasin Index.

### 5.3 TVA Watershed Subbasin Boundaries

The original TVA watershed subbasin boundary GIS layer (AboveGuntersvilleDrainageAreas\_May14\_2008.\*, Attachment 3-1 to 3-6) was obtained from TVA, and had a total of 46 subbasins. As a result of the unit hydrograph validation process, however, there was a need to further subdivide subbasin 47 into two subbasins 47A and 47B, resulting in a total of 47 subbasins (TVA provided the GIS layer Watersheds\_12Dig\_Modified\_10292008.\*, Attachment 7-1 to 7-7). Additional analysis during the development of the PMF model revealed the need to develop and include the 15 subbasins of the Wheeler reservoir watershed (see appendix B for additional details). These data, along with HRAP Grid Centroids, were used to develop HRAP Grid to Subbasin Index.

## 6 Computations and Analyses

### 6.1 Methodology

To aggregate hourly precipitation data by subbasin, it is necessary to have a HRAP Grid to Subbasin Index, which maps HRAP Grids to Subbasins. MAPX for a subbasin can then be calculated by simply averaging precipitation data of HRAP Grids that make up the subbasin. In other words, MAPX is the sum of hourly precipitation data of the contributing HRAP Grids divided by the total number of contributing HRAP Grids, i.e.,

$$MAPX_s = \frac{\sum_{g \in s} P_g}{N_s} \quad (1)$$

where:

$MAPX_s$  is MAPX for subbasin  $s$

$P_g$  is Hourly Precipitation for HRAP Grid  $g$ , the centroid of  $g$  is within subbasin  $s$ .

$N_s$  is the total number of HRAP Grids whose centroids are within subbasin  $s$ .

## TVA

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	Checked		L.S.

### 6.2 Development of HRAP Grid to Subbasin Index

The HRAP Grid to Subbasin Index (watersh.dbf Attachment 4 for the original 46 subbasins and watersh2.dbf Attachment 8 for subbasins 47A and 47B) indicates which HRAP Grid belongs to which subbasin. The HRAP Grid to Subbasin Index was derived using an overlay "Identity" analysis tool in ArcGIS, which assigns a subbasin to each HRAP Grid based on their spatial relationship. The index was then visually inspected and validated by manually going through each subbasin and HRAP Grid in GIS.

There are 3880 HRAP Grids within the 47 subbasins. For example the "Clinch at Mouth" subbasin contains 6 HRAP grids. From north to south and east to west, they are (848,408), (849,407), (848,407), (848,406), (847,406), and (846,406) in HRAP coordinates. The "Clinch at Mile 16" subbasin contains 6 HRAP grids as well. They are (851,408), (850,408), (851,407), (850,407), (850,406), and (849,406). So the HRAP Grid to Subbasin Index for "Clinch at Mouth" and "Clinch at Mile 16" subbasins are:

HRAP X	HRAP Y	Subbasin
848	408	Clinch at Mouth
849	407	Clinch at Mouth
848	407	Clinch at Mouth
848	406	Clinch at Mouth
847	406	Clinch at Mouth
846	406	Clinch at Mouth
851	408	Clinch at Mile 16
850	408	Clinch at Mile 16
851	407	Clinch at Mile 16
850	407	Clinch at Mile 16
850	406	Clinch at Mile 16
849	406	Clinch at Mile 16

### 6.3 Development of MAPX

MAPX for a particular subbasin ending at a particular hour was calculated by averaging all hourly precipitation data of the HRAP Grids that belong to the subbasin (Equation 1). For example, for "Clinch at Mouth" subbasin, MAPX were calculated by averaging hourly precipitation of 6 contributing HRAP Grids: (848,408), (849,407), (848,407), (848,406), (847,406), and (846,406), as identified in the HRAP Grid to Subbasin Index. The HRAP Grid to Subbasin Index enables the numbers to be aggregated very efficiently. Similarly, MAPX for "Clinch at Mile 16" subbasin can be obtained by averaging HRAP grids (851,408), (850,408), (851,407), (850,407), (850,406), and (849,406).

For example, here is the hourly precipitation of the HRAP Grids for "Clinch at Mouth" subbasin ending at 9/16/2004 18:00.

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<b>HRAP X</b>	<b>HRAP Y</b>	<b>Hourly Precipitation (in millimeter)</b>
848	408	0.31
849	407	0.31
848	407	0.38
848	406	0.38
847	406	0.38
846	406	0.38

Therefore, MAPX for “Clinch at Mouth” subbasin ending at 9/16/2004 18:00 is:  
 $(0.31+0.31+0.38+0.38+0.38+0.38)/6=0.356666667$ .

For “Clinch at Mile 16” subbasin, the hourly precipitation for HRAP Grids are:

<b>HRAP X</b>	<b>HRAP Y</b>	<b>Hourly Precipitation (in millimeter)</b>
851	408	0.31
850	408	0.31
851	407	0.38
850	407	0.38
850	406	0.38
849	406	0.38

$MAPX = (0.31+0.31+0.38+0.38+0.38+0.38)/6=0.356666667$ .

See Figure 2 for the graphic presentation of the above example.

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		Checked	EEK



**Figure 2: Hourly Precipitation Ending at 9/16/2004 18:00 for "Clinch at Mouth" and "Clinch at Mile 16" Subbasins**

### 6.4 Validation of MAPX Development

Appendix A describes the procedures that were used to validate the MAPX data series.

## 7 Results and Conclusions

The result of this calculation is the MAPX data series by hour and by subbasin that is supplied in Microsoft Excel spreadsheet form (one spreadsheet per calendar year; Attachments 5-1 to 5-12 for the original 46 subbasins; Attachments 9-1 to 9-12 for subbasins 47A and 47B; and Attachments 11-1 to 11-12 for the 15 Subbasins in the Wheeler Reservoir Watershed). Having validated the process used to produce the MAPX data series in Appendix A, it is concluded that these data are suitable for use as input to other calculations that validate TVA unit hydrographs for recent flood events

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## Appendix A: Validation of MAPX Data Series

To validate MAPX data series derived from NEXRAD Stage III Hourly Precipitation Data, the following need to be verified:

1. The row hourly precipitation data in XMRG binary format are read correctly.
2. HRAP Grid to Subbasin Index is correct.
3. Aggregation of hourly precipitation data is correct.

This appendix will first validate each of the above three crucial steps in the developing of MAPX. Then the MAPX data series developed by the Precipitation GIS Utility will be validated against a known MAPX data series.

### A.1 Input Data for Validation

The input data necessary for validating MAPX is summarized below.

- Sample Hourly Precipitation Data
- Blue River at Blue Basin Boundary
- HRAP Grid Centroids
- TVA Watershed Subbasin Boundaries
- LMRFC Modeled Basin Boundaries
- HRAP Grid to LMRFC Modeled Basin Index
- MAPX for LMRFC Modeled Basins provided by LMRFC

Each of these inputs is described in more detail in the following subsections.

#### A.1.1 Sample Hourly Precipitation Data

Sample Hourly Precipitation Data for 5/6/1995 16:00 (Attachment A-1) was downloaded from the NWS web site (<http://www.nws.noaa.gov/oh/hrl/dmip/xmrg0506199516z.gz>). These data, along with the image of the gridded data (downloaded from NWS web site [http://www.nws.noaa.gov/oh/hrl/dmip/2/images/BlueRiver\\_XMRG.png](http://www.nws.noaa.gov/oh/hrl/dmip/2/images/BlueRiver_XMRG.png)), were used to verify that the Precipitation GIS Utility reads the XMRG binary data correctly. Hourly precipitation data for 5/5/2003 12:00 (xmrg0505200312z) and 9/16/2004 18:00 (xmrg0916200418z) were obtained from LMRFC. These two files were processed by the NWS supplied program to verify that the Precipitation GIS Utility read the data correctly.

#### A.1.2 Blue River at Blue Basin Boundary

Blue River at Blue Basin boundary (Attachment A-3-1) was downloaded from the NWS web site ([http://www.weather.gov/ohd\\_files/data/dmip/basin\\_bdnry/blue.bdr](http://www.weather.gov/ohd_files/data/dmip/basin_bdnry/blue.bdr)). These data, along with the sample precipitation data for 5/6/1995 16:00, was used to check if the processed gridded precipitation data were in the right geographic location.

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	<b>Checked</b>		BCN

### ***A.1.3 HRAP Grid Centroids***

HRAP Grid Centroids (nws\_precip\_allpoint\_conversion.\*, Attachment 2-1 to 2-5) were downloaded from the NWS web site

([http://water.weather.gov/p\\_download\\_new/nws\\_precip\\_allpoint\\_conversion.tar.gz](http://water.weather.gov/p_download_new/nws_precip_allpoint_conversion.tar.gz)). HRAP Grid Centroids indicate the geometric center of HRAP Grids. These data, along with the TVA watershed subbasin boundaries, were used to develop the HRAP Grid to Subbasin Index.

### ***A.1.4 TVA Watershed Subbasin Boundaries***

The original TVA Watershed subbasin boundary GIS layer (AboveGuntersvilleDrainageAreas\_May14\_2008.\*, Attachment 3-1 to 3-6) was obtained from TVA, and has a total of 46 subbasins. As a result of the unit hydrograph validation process there was a need to further divide subbasin 47 into two subbasins 47A and 47B, resulting in a total of 47 subbasins (TVA provided the GIS layer Watersheds\_12Dig\_Modified\_10292008.\*, Attachment 7-1 to 7-7). Additional analysis during the development of the PMF model revealed the need to develop and include the 15 subbasins of the Wheeler reservoir watershed (see appendix B for additional details). These data, along with HRAP Grid Centroids, were used to develop HRAP Grid to Subbasin Index.

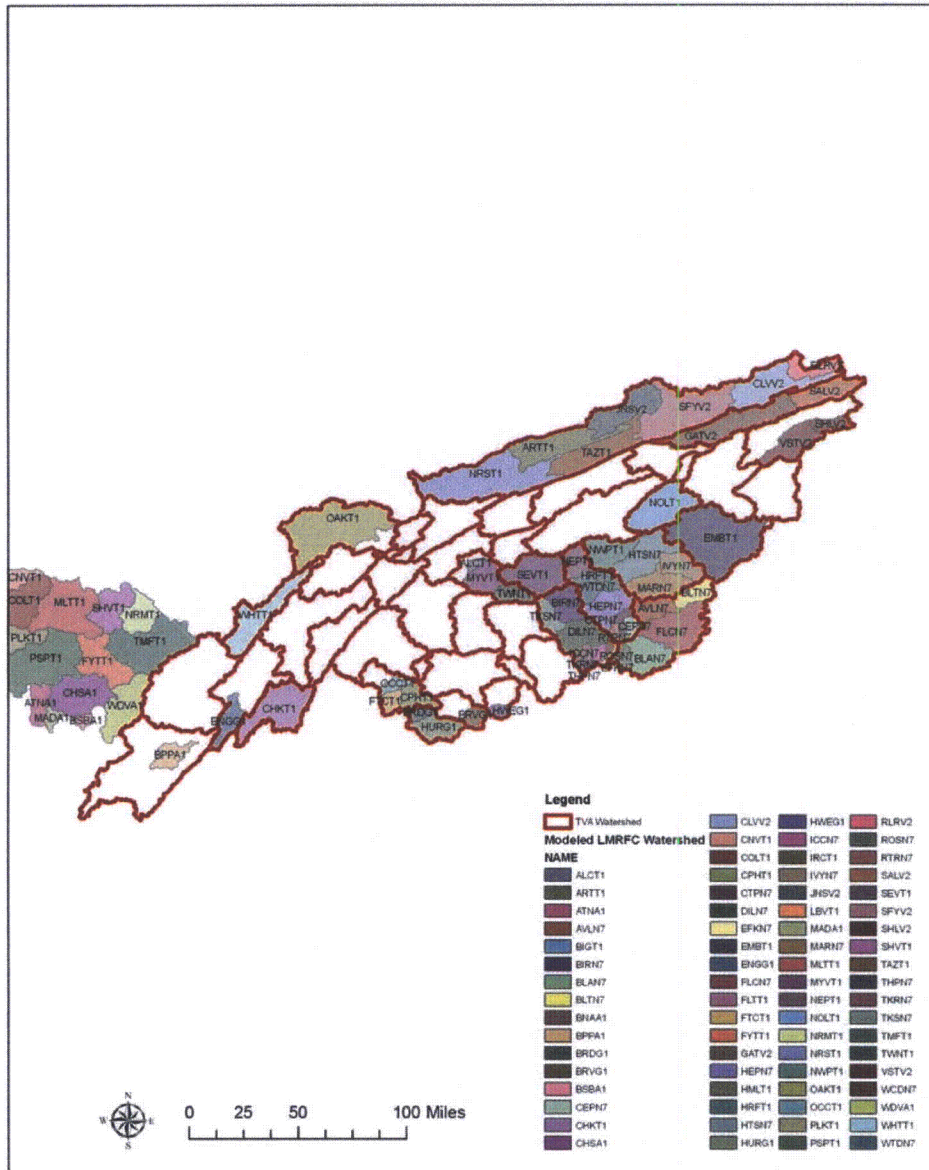
### ***A.1.5 LMRFC Modeled Basin Boundaries***

TVA subbasins are different from the watersheds (basins) used in LMRFC. LMRFC basins generally cover the same area of TVA watershed, but have different subbasin delineation. A few basins within the TVA region were selected to generate MAPX by LMRFC. They are referred to as LMRFC "Modeled Basins" (see Figure A-1 and Attachment A-4-1 to A-4-5).



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**Figure A-1: TVA Subbasins versus LMRFC Modeled Basins**



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### ***A.1.6 HRAP Grid to LMRFC Modeled Basin Index***

The HRAP Grid to LMRFC Modeled Basin Index (Attachment A-5-1 and A-5-2) was obtained from LMRFC as part of MAPX for "LMRFC Modeled Basins" delivery. This index was used to validate the HRAP Grid to TVA Subbasin Index used by the Precipitation GIS Utility.

### ***A.1.7 MAPX for LMRFC Modeled Basins***

MAPX for LMRFC Modeled Basins (Attachment A-6-1 to A-6-4) were obtained from LMRFC. They were used to validate MAPX derived by the Precipitation GIS Utility for TVA subbasins.

## **A.2 Validation**

### ***A.2.1 Validation of Reading of Raw Hourly Precipitation Data***

To facilitate the utilization of precipitation data in GIS, the NWS provides a C program (xmrgtoasc.c) that converts the binary precipitation data to ESRI's ASCII raster file format in either HRAP map projection or HRAP Polar Stereographic map projection that can be directly read and manipulated by ESRI's ArcGIS software.

To validate if the raw hourly precipitation data were read correctly by the Precipitation GIS Utility, data read from the sample hourly precipitation data by the Precipitation GIS Utility were saved as ESRI's ASCII raster files and then they were compared with the results from the NWS supplied conversion program to see if they matched.

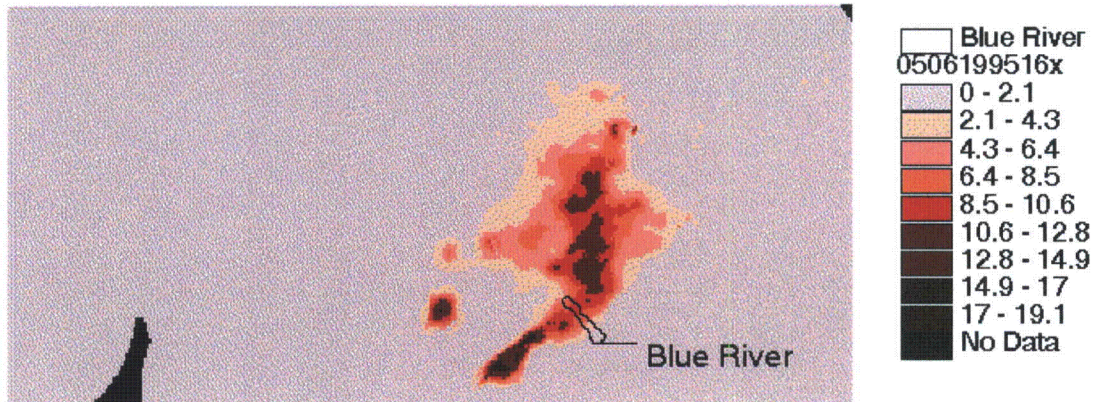
Two precipitation data files (5/5/2003 12:00 and 9/16/2004 18:00) were picked for this exercise. They were processed by both the Precipitation GIS Utility (resulting ESRI ASCII Raster Files: xmrg0505200312z.asc and xmrg0916200418z.asc) and the NWS supplied xmrgtoasc program (resulting ESRI ASCII Raster Files: xmrg0505200312z.out.asc and xmrg0916200418z.out.asc). The resulting ESRI ASCII raster files were identical. In fact, subtracting one raster from the other using "Raster Math" Minus tool in ArcGIS produced all zero cells.

The NWS web site also provided a sample raw precipitation data for 5/6/1995 16:00 and an image of the gridded data along with a background river called "Blue River". The Precipitation GIS Utility was used to process the sample data and then the extracted grid (xmrg0506199516z.asc) was loaded into ArcGIS along with the Blue River data layer (ESRI shape file blue.shp derived from basin boundary file blue.bdr in geographic coordinates). The resulting image looked identical to the image from the NWS web site. The Blue River was also in the right location related to gridded precipitation data, which confirmed that ArcGIS handled the HRAP grids correctly (see Figure A-2).

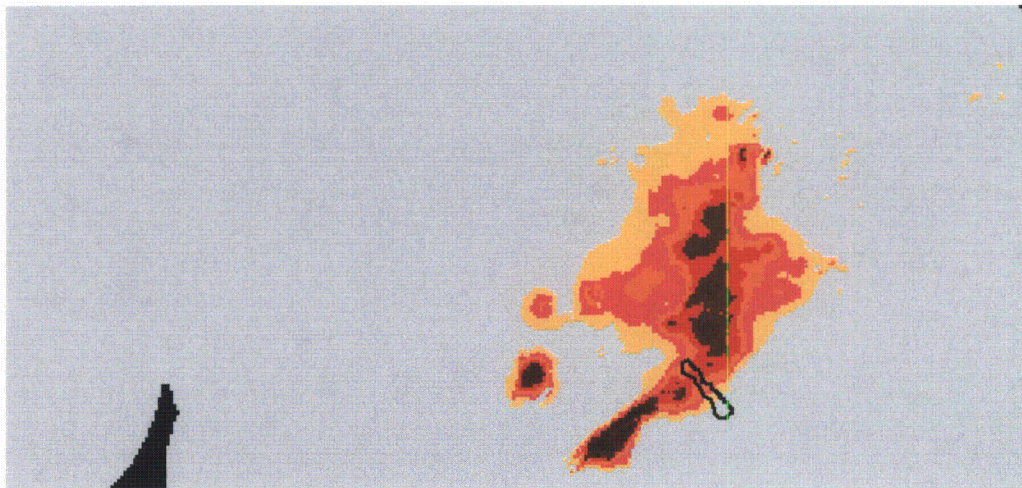
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NWS Provided Sample Data



The same Data Processed by the Utility



**Figure A-2: Comparison of Precipitation Grid Extracted by the Precipitation GIS Utility and the NWS Sample for 5/6/1995 16:00**

Having validated the extracted precipitation data against those developed independently using the NWS program and the sample grid image, it is confirmed that the raw hourly precipitation data are being correctly read by the Precipitation GIS Utility.

### Reference Files for this validation:

- Raw Precipitation Data for 5/5/2003 12:00 (XMRG File *xmrg0505200312z*)
- ESRI ASCII Raster File for 5/5/2003 12:00 Processed by the Utility (ASC File *xmrg0505200312z.asc*)
- ESRI ASCII Raster File for 5/5/2003 12:00 Processed by the NWS Program (ASC File *xmrg0505200312z.out.asc*)
- Raw Precipitation Data for 9/16/2004 18:00 (XMRG File *xmrg0916200418z*)

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- *ESRI ASCII Raster File for 9/16/2004 18:00 Processed by the Utility (ASC File xmrg0916200418z.asc)*
- *ESRI ASCII Raster File for 9/16/2004 18:00 Processed by the NWS Program (ASC File xmrg0916200418z.out.asc)*
- *Raw Precipitation Data for 5/6/1995 16:00 (XMRG File xmrg0506199516z)*
- *ESRI ASCII Raster File for 5/6/1995 16:00 (ASC File xmrg0506199516z.asc)*
- *ESRI Grid for 5/6/1995 16:00 (ESRI Raster File p\_0506199516)*
- *Blue River (ESRI Shape File blue.shp derived from geographic boundary file blue.bdr)*
- *NWS Image for Gridded Precipitation Data for 5/6/1995 16:00 (PNG File BlueRiver\_XMRG.png)*

### A.2.2 Validation of HRAP Grid to Subbasin Index

HRAP Grid to Subbasin Index was obtained by simply running the overlay “Identity” analysis tool in ArcGIS on HRAP Grid Centroids and the TVA Watershed Subbasins, which assigns subbasin names to HRAP Grid Centroids based on their spatial relationship (whether or not the centroids or geometric center points were within subbasins boundaries).

To validate HRAP Grid to Subbasin Index (DBF File Watersh.dbf, Attachment 4 for the original 46 subbasins, and watersh2.dbf, Attachment 8 for subbasins 47A and 47B), HRAP Grid Centroids (ESRI Shape File nws\_precip\_allpoint\_conversion.\*, Attachment 2-1 to 2-5) and TVA Watershed Subbasin Boundaries (ESRI Shape File AboveGuntersvilleDrainageAreas\_May14\_2008.\*, Attachment 3-1 to 3-6, and Watersheds\_12Dig\_Modified\_10292008.\*, Attachment 7-1 to 7-7) were loaded into the GIS for a manual visual review, where it was confirmed that the index correctly captured the relationship between HRAP Grids and TVA Subbasins.

As part of MAPX for “LMRFC Modeled Basins” delivery, LMRFC provided a HRAP Grid to (LMRFC Modeled) Basin Index. As mentioned before, LMRFC Modeled Basins do not match the TVA subbasins exactly, but a couple of subbasins are almost identical (e.g., TVA subbasin “Nolichucky Dam” is very close to LMRFC modeled basin “NOLT1”, and TVA subbasin “Nolichucky at Embreeville” is very similar to LMRFC modeled basin “EMBT1”). Therefore, HRAP Grid to Subbasin Index was compared to HRAP Grid to Modeled Basin Index to see if they matched.

To do so, LMRFC Modeled Basins (ESRI Shape File modeled\_tva\_basins.shp, Attachment A-4-1 to A-4-6) were also loaded into the GIS for a manual visual review, and it was confirmed that the HRAP Grid to Modeled Basin Index was correct. It also revealed that the HRAP Grid to Subbasin Index was very similar to the HRAP Grid to Modeled Basin Index for the same subbasin. The only difference was caused by the slight difference of subbasin delineation (subbasin boundaries). Refer to Figure A-3 and Attachment A-8 for detail.

For “NOLT1” or “Nolichucky Dam”: 59 out of 60 HRAP Grids or 98% HRAP Grids match. HRAP Grid (884, 433) is in the TVA subbasin “Nolichucky Dam”, but not in the LMRFC modeled basin “NOLT1”. HRAP Grid (885, 427) is not in the TVA subbasin “Nolichucky Dam”, but in the LMRFC modeled basin “NOLT1”.

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For “EMBT1” or “Nolichucky at Embreeville”: 125 out of 130 HRAP Grids or 96% HRAP Grids match.

5 HRAP Grids (898, 432), (898, 431), (885, 427), (899, 427), (892, 422) are in the TVA subbasin “Nolichucky at Embreeville”, but not in the LMRFC modeled basin “EMBT1”.

Manual visual inspection of HRAP Grid Centroids, TVA Subbasins, and LMRFC Modeled Basins, and comparison of HRAP Grid to Subbasin Index to HRAP Grid to Modeled Basin Index for the same subbasins confirmed that HRAP Grid to Subbasin Index was correct.

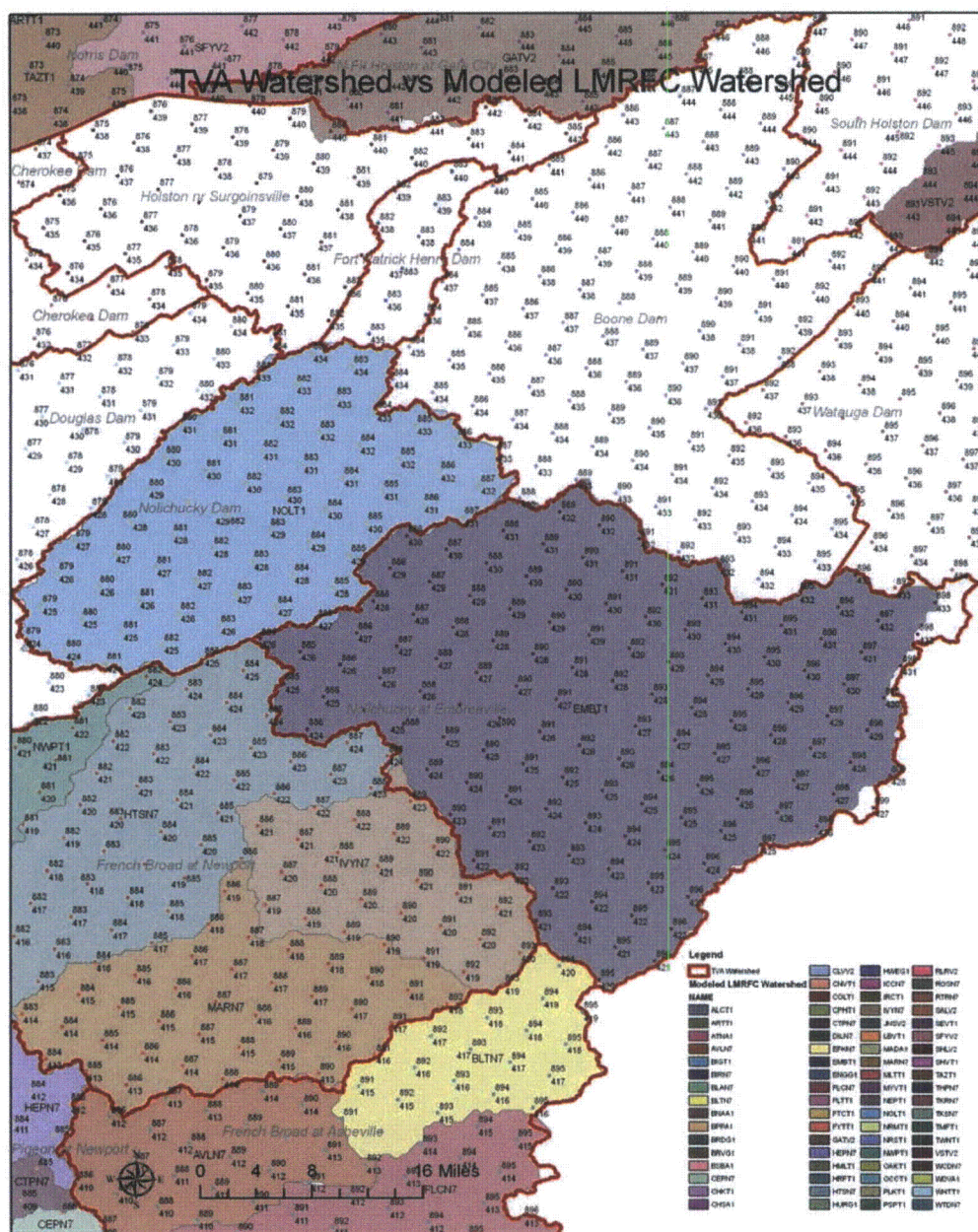
### *Reference Files for this validation:*

- *HRAP Grid to Subbasin Index (DBF File Watersh.dbf)*
- *HRAP Grid Centroids (ESRI Shape File nws\_precip\_allpoint\_conversion.shp)*
- *Original TVA Watershed Subbasin Boundaries (ESRI Shape File AboveGuntersvilleDrainageAreas\_May14\_2008.shp)*
- *Revised TVA Watershed Subbasin Boundaries (ESRI Shape File Watersheds\_12Dig\_Modified\_10292008.shp) with Subbasin 47 subdivided into 47A and 47B*
- *LMRFC Modeled Basins (ESRI Shape File modeled\_tva\_basins.shp)*
- *HRAP Grid to Modeled Basin Index for Basins NOLT1 and EMBT1 (HRAP Files NOLT1.hrap and EMBT1.hrap)*



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**Figure A-3: “Nolichucky Dam” and “Nolichucky at Embreeville” Subbasins (TVA versus LMRFC)**

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### A.2.3 Validation of Aggregation of Hourly Precipitation Data

MAPX was developed by averaging Hourly Precipitation Data by Subbasin. The previous validation procedures demonstrated that the Hourly Precipitation Data were read correctly and the HRAP Grid to Subbasin Index was generated correctly. The next validation procedure ensured that the aggregation of Hourly Precipitation Data was also calculated correctly. (Please note that this validation was done based on the original 46 subbasins. The aggregation of Hourly Precipitation Data for subbasins 47A and 47B used the same Precipitation GIS Utility, so the change of subbasin boundaries didn't affect the conclusion. However, to double check this, basin average hourly precipitations for two sample storm events for subbasins 47A and 47B were averaged using the number of contributing HRAP Grids as weight. The resulting average MAPX matched the one for the whole subbasin 47 as obtained in Revision 0 (see Excel spreadsheet MAPX\_Compare\_Rev0\_Rev1\_NickajackDam.xls, Attachment A-9-15). So the results were consistent.)

To do so, MAPX for each subbasin for 5/5/2003 12:00 and 9/16/2004 18:00 were manually calculated. The results were then compared to MAPX obtained from the GIS Precipitation Utility. To facilitate the hand calculation of average precipitation for all 46 subbasins from 3880 contributing HRAP Grids, the following steps were taken for each extracted gridded precipitation data.

1. Precipitation value for each grid cell was extracted using "Raster to Point" GIS tool. Visual review of each point (grid centroid) verified that the point value matched the grid value. (The "Raster to Point" GIS tool worked correctly.)
2. Each point was assigned a subbasin name based on the relationship between the point and subbasin using the "Identity" GIS tool. Visual review of each point verified that each point was assigned to the right subbasin. (The "Identity" GIS tool worked correctly.)
3. The attribute table of points that contains XY coordinates, precipitation values, and the subbasin names were exported as Excel spreadsheet. The data were sorted by subbasin and XY coordinates in Excel. Manual review of each point verified that the grid value and subbasin name in the Excel spreadsheet matched the values in the point shape file. (The "Export" procedure worked correctly.)
4. Average precipitation values (MAPX) were calculated in Excel for each subbasin by averaging precipitation values of the points belonging to each subbasin.
5. Manual review of each subbasin verified that the average precipitation values calculated manually in Excel matched the results from the Precipitation GIS Utility.

The manual calculation confirmed that the aggregation of hourly precipitation data was correct.

Figure A-4 showed how some of the manual validation was done: Each geometric center point/centroid has been manually checked to make sure that its precipitation value (seen as labeled numbers in the figure) matched the grid value (shown as tooltip in the text box); was assigned the correct subbasin (as indicated by subbasin labels); was correctly exported to Excel for manual calculation of average precipitation.



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**Figure A-4: Manual Checking**

## Reference Files for this validation:

- Utility MAPX Results for 5/5/2003 (Excel File  
Watershed\_Hourly\_Precip\_05022003\_05082003\_R000A.xls)
- Raw Precipitation Data for 5/5/2003 12:00 (XMRG File xmrg0505200312z)
- ESRI ASCII Raster File for 5/5/2003 12:00 (ASC File xmrg0505200312z.asc)
- ESRI Grid for 5/5/2003 12:00 (ESRI Raster File p\_0505200312)
- TVA Watershed Subbasin Boundaries (ESRI Shape File  
AboveGuntersvilleDrainageAreas\_May14\_2008.shp)
- Point Data Converted from the ESRI Grid with Subbasin Designation for 5/5/2003 12:00 (ESRI  
Shape File p0505200312\_watershed.shp)
- Detailed Precipitation Data Grid-by-Grid Exported from the Point Data and the Average  
Precipitation by Subbasin Calculated in Excel for 5/5/2003 12:00 (Excel File  
p0505200312\_watershed.xls)

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- *Utility MAPX Results for 9/16/2004 (Excel File Watershed\_Hourly\_Precip\_09152004\_09212004\_R000A.xls)*
- *Raw Precipitation Data for 9/16/2004 18:00 (XMRG File xmrg0916200418z)*
- *ESRI ASCII Raster File for 9/16/2004 18:00 (ASC File xmrg0916200418z.asc)*
- *ESRI Grid for 9/16/2004 18:00 (ESRI Raster File p\_0916200418)*
- *Point Data Converted from the ESRI Grid with Subbasin Designation for 9/16/2004 18:00 (ESRI Shape File p0916200418\_watershed.shp)*
- *Detailed Precipitation Data Grid by Grid Exported from the Point Data and the Average Precipitation by Subbasin Calculated in Excel for 9/16/2004 18:00 (Excel File p0916200418\_watershed.xls)*
- *Comparison of MAPX for Subbasin 47 Nickajack Dam and the divided Subbasins 47A and 47B (Excel File MAPX\_Compare\_Rev0\_Rev1\_NickajackDam.xls)*

### **A.2.4 Validation of MAPX Data Series Using LMRFC's MAPX for Modeled Basins**

In the previous sections, each of the three critical steps for calculating MAPX--reading of the raw precipitation data, developing HRAP Grid to Subbasin Index, and aggregation of precipitation data by subbasin--were validated. To go one step further, a final validation was run to compare MAPX data series for TVA Subbasins developed by the Precipitation GIS Utility with MAPX data series for LMRFC Modeled Basins that was provided by LMRFC. Since TVA Subbasins do not match LMRFC Modeled Basins exactly, comparison was done for subbasins that were similar: "Nolichucky Dam" or "NOLT1", and "Nolichucky at Embreeville" or "EMBT1". Comparison of MAPX generated by the Precipitation GIS Utility and the one provided by LMRFC for these two subbasins for May 2-8 2003 and September 15-21 2004 revealed that the MAPX numbers were very close (most differences were within 0.001 inch).



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**Table A-1: Comparison of MAPX for Nolichucky Dam Subbasin from 5/2/2003 to 5/8/2003 and from 9/15/2004 to 9/21/2004 (the Precipitation GIS Utility versus LMRFC)**

Date/Time (GMT)	MAPX in Millimeter	MAPX in Inch	MAPX in Inch, shift one hour, rounded to 0.001	LMRFC MAPX	Difference	% Difference
<b>May-03</b>						
502200300	0.02283333					
	3	0.00089895	0.006	0.006	0	0.00%
502200301	0.15716666					
	7	0.006187664	0.005	0.005	0	0.00%
502200302	0.13233333					
	3	0.005209974	0.007	0.007	0	0.00%
502200303	0.18033333					
	3	0.007099738	0.005	0.005	0	0.00%
502200304	0.12083333					
	3	0.004757218	0.002	0.003	-0.001	-33.33%
502200305	0.0605	0.00238189	0	0	0	-
502200306	0	0	0	0	0	-
502200307	0	0	0	0	0	-
502200308	0	0	0	0	0	-
502200309	0	0	0	0	0	-
502200310	0	0	0	0	0	-
502200311	0	0	0	0	0	-
502200312	0	0	0	0	0	-
502200313	0	0	0	0	0	-
502200314	0	0	0	0	0	-
502200315	0	0	0	0	0	-
502200316	0	0	0	0	0	-
502200317	0	0	0	0	0	-
502200318	0	0	0.294	0.294	0	0.00%
502200319	7.46666666					
	7	0.293963255	0.355	0.356	-0.001	-0.28%
502200320	9.01083333					
	3	0.354757218	0.01	0.01	0	0.00%
502200321	0.26366666					
	7	0.010380577	0	0	0	-
502200322 ~ 505200308 MAPX Comparison from 5/2/2003 22:00 to 5/5/2003 08:00 were omitted from the table because there were no rainfalls.						
505200309	0	0	0.014	0.014	0	0.00%
505200310	0.35583333					
	3	0.014009186	0.033	0.032	0.001	3.13%
505200311	0.84166666					
	7	0.033136483	0.089	0.088	0.001	1.14%
505200312	2.2515	0.088641732	0.048	0.049	-0.001	-2.04%
505200313	1.22483333					
	3	0.048221785	0.043	0.043	0	0.00%
505200314	1.0995	0.043287402	0.1	0.101	-0.001	-0.99%
505200315	2.542	0.10007874	0.03	0.031	-0.001	-3.23%

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505200316	0.76166666	7	0.029986877	0.002	0.002	0	0.00%
	0.06116666						
505200317		7	0.002408136	0.012	0.012	0	0.00%
505200318	0.304		0.011968504	0	0	0	-
505200319		0	0	0	0	0	-
505200320		0	0	0.004	0.005	-0.001	-20.00%
	0.11283333						
505200321		3	0.004442257	0.028	0.031	-0.003	-9.68%
	0.72283333						
505200322		3	0.028458005	0.111	0.113	-0.002	-1.77%
505200323	2.8205		0.111043307	0.248	0.253	-0.005	-1.98%
	6.30716666						
506200300		7	0.248313648	0.335	0.341	-0.006	-1.76%
506200301		8.52	0.335433071	0.223	0.224	-0.001	-0.45%
	5.66016666						
506200302		7	0.222841207	0.15	0.154	-0.004	-2.60%
506200303	3.8175		0.150295276	0.051	0.052	-0.001	-1.92%
506200304	1.2915		0.050846457	0.018	0.018	0	0.00%
	0.45233333						
506200305		3	0.017808399	0.018	0.019	-0.001	-5.26%
	0.45966666						
506200306		7	0.018097113	0.038	0.038	0	0.00%
	0.96483333						
506200307		3	0.037985564	0.006	0.006	0	0.00%
	0.14266666						
506200308		7	0.005616798	0	0	0	-
506200309		0	0	0	0	0	-
506200310		0	0	0	0	0	-
506200311		0	0	0	0	0	-
506200312		0	0	0.007	0.007	0	0.00%
	0.18933333						
506200313		3	0.007454068	0.031	0.032	-0.001	-3.13%
506200314	0.7845		0.030885827	0.047	0.047	0	0.00%
	1.18166666						
506200315		7	0.04652231	0.079	0.08	-0.001	-1.25%
	1.99416666						
506200316		7	0.078510499	0.047	0.047	0	0.00%
506200317	1.1905		0.046870079	0.063	0.065	-0.002	-3.08%
	1.59016666						
506200318		7	0.062604987	0	0	0	-
	0.00633333						
506200319		3	0.000249344	0	0	0	-
506200320		0	0	0	0	0	-
506200321		0	0	0	0	0	-
506200322		0	0	0	0	0	-
506200323		0	0	0	0	0	-
507200300		0	0	0	0	0	-
507200301		0	0	0	0	0	-
507200302		0	0	0	0	0	-

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507200303	0	0	0	0	0	-
507200304	0	0	0	0	0	-
507200305	0	0	0	0	0	-
507200306	0	0	0	0	0	-
507200307	0	0	0.016	0.016	0	0.00%
	0.40066666					
507200308	7	0.015774278	0.047	0.047	0	0.00%
507200309	1.202	0.047322835	0.091	0.093	-0.002	-2.15%
	2.30133333					
507200310	3	0.090603675	0.043	0.043	0	0.00%
	1.08416666					
507200311	7	0.042683727	0.028	0.028	0	0.00%
	0.72316666					
507200312	7	0.028471129	0.02	0.021	-0.001	-4.76%
	0.51133333					
507200313	3	0.020131234	0	0	0	-
507200314	0	0	0.001	0.001	0	0.00%
507200315	0.0205	0.000807087	0	0	0	-
	0.01033333					
507200316	3	0.000406824	0	0	0	-
507200317	0	0	0	0	0	-
507200318	0	0	0	0	0	-
507200319	0.012	0.000472441	0.032	0.033	-0.001	-3.03%
	0.80733333					
507200320	3	0.031784777	0	0	0	-
507200321	0	0	0	0	0	-
507200322	0	0	0	0	0	-
507200323	0	0	0	0	0	-
508200300	0	0	0	0	0	-
508200301	0	0	0.001	0.001	0	0.00%
508200302	0.014	0.000551181	0.008	0.008	0	0.00%
	0.20083333					
508200303	3	0.007906824	0	0	0	-
Sep-04						
916200404	0	0	0	0	0	-
	0.00833333					
916200405	3	0.000328084	0	0	0	-
916200406	0	0	0	0	0	-
916200407	0	0	0	0	0	-
916200408	0	0	0.001	0.001	0	0.00%
	0.03183333					
916200409	3	0.001253281	0	0	0	-
	0.01133333					
916200410	3	0.000446194	0	0	0	-
916200411	0	0	0	0	0	-
916200412	0	0	0	0	0	-
916200413	0	0	0.002	0.002	0	0.00%
916200414	0.039	0.001535433	0.001	0.001	0	0.00%

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916200415	0.03183333	3	0.001253281	0	0	0	-
	0.00283333						
916200416	0.10633333	3	0.000111549	0.004	0.004	0	0.00%
916200417	0.15416666	3	0.004186352	0.006	0.006	0	0.00%
916200418	0.05266666	7	0.006069554	0.002	0.002	0	0.00%
916200419	0.00466666	7	0.002073491	0	0	0	-
916200420	0.03383333	7	0.000183727	0.001	0.001	0	0.00%
916200421	0.13316666	3	0.001332021	0	0	0	-
916200422		0	0	0	0	0	-
916200423		0	0	0.005	0.005	0	0.00%
917200400	0.005242782	7	0.005242782	0.037	0.038	-0.001	-2.63%
917200401	0.9375	0.036909449	0.14	0.143	-0.003	-2.10%	
917200402	3.554	0.13992126	0.202	0.207	-0.005	-2.42%	
917200403	5.12883333	3	0.201922572	0.212	0.217	-0.005	-2.30%
917200404	5.39566666	7	0.212427822	0.526	0.521	0.005	0.96%
917200405	13.3631666	7	0.526108924	0.207	0.205	0.002	0.98%
917200406	5.24516666	7	0.206502625	0.349	0.352	-0.003	-0.85%
917200407	8.87266666	7	0.349317585	0.074	0.074	0	0.00%
917200408	1.8785	0.073956693	0	0	0	-	
917200409	0.00033333	3	1.31234E-05	0	0	0	-
917200410		0	0	0.03	0.032	-0.002	-6.25%
917200411	0.76183333	3	0.029993438	0.007	0.007	0	0.00%
917200412	0.1845	0.00726378	0.047	0.047	0	0.00%	
917200413	1.19533333	3	0.047060367	0.107	0.108	-0.001	-0.93%
917200414	2.719	0.107047244	0.067	0.066	0.001	1.52%	
917200415	1.71066666	7	0.067349081	0.043	0.043	0	0.00%
917200416	1.0815	0.04257874	0.038	0.038	0	0.00%	
917200417	0.97033333	3	0.0382021	0.105	0.105	0	0.00%
917200418	2.65466666	7	0.104514436	0.223	0.224	-0.001	-0.45%
917200419	5.66833333	3	0.22316273	0.08	0.078	0.002	2.56%
917200420	2.02666666	7	0.079790026	0.006	0.006	0	0.00%

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	0.14883333					
<b>917200421</b>	3	0.00585958	0	0	0	-
<b>917200422</b>	0	0	0	0	0	-
<b>917200423</b>	0	0	0	0	0	-
<b>918200400</b>	0	0	0	0	0	-
<b>918200401</b>	0	0	0	0	0	-
<b>918200402</b>	0	0	0	0	0	-
<b>918200403</b>	0	0	0	0	0	-
<b>918200404</b>	0	0	0	0	0	-
<b>918200405</b>	0	0	0	0	0	-
<b>918200406</b>	0.0055	0.000216535	0	0	0	-

## NOTES:

- 1) For simplicity, MAPX comparison from 5/2/2003 22:00 to 5/5/2003 08:00, from 5/8/2003 04:00 to 5/8/2003 23:00, from 9/15/2004 00:00 to 9/16/2004 03:00, and from 9/18/2004 07:00 to 9/21/2004 23:00 were omitted from the table because there were no rainfalls for these dates. All numbers would be zero (except the percentage difference).
- 2) MAPX derived by the Precipitation GIS Utility (column 4) were shifted one hour early, essentially making the Date/Time stamp in the first column referring to the START of rainfall instead of the END of rainfall.

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**Table A-2: Comparison of MAPX for Nolichucky at Embreeville Subbasin from 5/2/2003 to 5/8/2003 and from 9/15/2004 to 9/21/2004 (the Precipitation GIS Utility versus LMRFC)**

Date/Time (GMT)	MAPX in Millimeter	MAPX in Inch	MAPX in Inch, shift one hour, rounded to 0.001	LMRFC MAPX	Difference	% Difference
<b>May-03</b>						
502200300	0.105923077	0.0041702	0.043	0.043	0	0.00%
502200301	1.098	0.043228346	0.016	0.017	-0.001	-5.88%
502200302	0.413538462	0.016281042	0.001	0.001	0	0.00%
502200303	0.024384615	0.000960024	0.003	0.003	0	0.00%
502200304	0.068692308	0.002704422	0.003	0.003	0	0.00%
502200305	0.070230769	0.002764991	0	0	0	-
502200306	0.001923077	7.57117E-05	0	0	0	-
502200307	0	0	0	0	0	-
502200308	0	0	0	0	0	-
502200309	0	0	0	0	0	-
502200310	0	0	0	0	0	-
502200311	0.001923077	7.57117E-05	0	0	0	-
502200312	0	0	0	0	0	-
502200313	0	0	0	0	0	-
502200314	0	0	0	0	0	-
502200315	0	0	0	0	0	-
502200316	0	0	0	0	0	-
502200317	0	0	0	0	0	-
502200318	0	0	0.018	0.018	0	0.00%
502200319	0.462692308	0.018216233	0.189	0.192	-0.003	-1.56%
502200320	4.793076923	0.188703816	0.11	0.109	0.001	0.92%
502200321	2.784307692	0.109618413	0.008	0.007	0.001	14.29%
502200322	0.199384615	0.007849788	0	0	0	-
<b>502200323 ~</b>						
505200302	MAPX Comparison from 5/2/2003 23:00 to 5/5/2003 02:00 were omitted from the table because there were virtually no rainfalls.					
505200303	0	0	0.001	0.001	0	0.00%
505200304	0.017846154	0.000702604	0	0	0	-
505200305	0	0	0	0	0	-
505200306	0.001923077	7.57117E-05	0	0	0	-
505200307	0.001923077	7.57117E-05	0	0	0	-
505200308	0.001923077	7.57117E-05	0	0	0	-
505200309	0	0	0.006	0.006	0	0.00%
505200310	0.154461538	0.006081163	0.003	0.003	0	0.00%
505200311	0.077461538	0.003049667	0.071	0.07	0.001	1.43%
505200312	1.797769231	0.070778316	0.034	0.034	0	0.00%
505200313	0.868153846	0.034179285	0.063	0.062	0.001	1.61%
505200314	1.601615385	0.063055724	0.121	0.122	-0.001	-0.82%
505200315	3.075461538	0.121081163	0.137	0.137	0	0.00%

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505200316	3.477769231	0.136920048	0.019	0.019	0	0.00%
505200317	0.484769231	0.019085403	0.036	0.036	0	0.00%
505200318	0.920307692	0.036232586	0.004	0.004	0	0.00%
505200319	0.105923077	0.0041702	0	0	0	-
505200320	0	0	0.032	0.032	0	0.00%
505200321	0.813230769	0.032016959	0.16	0.161	-0.001	-0.62%
505200322	4.060538462	0.159863719	0.149	0.15	-0.001	-0.67%
505200323	3.779692308	0.148806784	0.284	0.285	-0.001	-0.35%
506200300	7.215846154	0.284088431	0.347	0.347	0	0.00%
506200301	8.813615385	0.346992732	0.144	0.144	0	0.00%
506200302	3.649076923	0.143664446	0.163	0.164	-0.001	-0.61%
506200303	4.146615385	0.163252574	0.157	0.157	0	0.00%
506200304	3.984384615	0.156865536	0.088	0.087	0.001	1.15%
506200305	2.241769231	0.088258631	0.042	0.042	0	0.00%
506200306	1.065923077	0.041965475	0.053	0.053	0	0.00%
506200307	1.343461538	0.052892187	0.035	0.035	0	0.00%
506200308	0.879538462	0.034627498	0.003	0.003	0	0.00%
506200309	0.081769231	0.003219261	0	0	0	-
506200310	0.001923077	7.57117E-05	0.011	0.011	0	0.00%
506200311	0.272538462	0.010729861	0.007	0.007	0	0.00%
506200312	0.173461538	0.006829194	0.01	0.01	0	0.00%
506200313	0.262153846	0.010321018	0.039	0.039	0	0.00%
506200314	0.996923077	0.03924894	0.074	0.074	0	0.00%
506200315	1.876230769	0.073867353	0.137	0.137	0	0.00%
506200316	3.475923077	0.136847365	0.058	0.058	0	0.00%
506200317	1.464923077	0.057674137	0.147	0.147	0	0.00%
506200318	3.730461538	0.146868565	0.075	0.074	0.001	1.35%
506200319	1.915923077	0.075430042	0	0	0	-
506200320	0.001923077	7.57117E-05	0	0	0	-
506200321	0	0	0	0	0	-
506200322	0	0	0	0	0	-
506200323	0	0	0	0	0	-
507200300	0	0	0	0	0	-
507200301	0	0	0	0	0	-
507200302	0	0	0	0	0	-
507200303	0	0	0	0	0	-
507200304	0	0	0	0	0	-
507200305	0	0	0	0	0	-
507200306	0.001923077	7.57117E-05	0	0	0	-
507200307	0	0	0	0	0	-
507200308	0	0	0.017	0.017	0	0.00%
507200309	0.422923077	0.016650515	0.137	0.138	-0.001	-0.72%
507200310	3.474769231	0.136801938	0.017	0.016	0.001	6.25%
507200311	0.423923077	0.016689885	0.011	0.011	0	0.00%
507200312	0.274846154	0.010820715	0.092	0.092	0	0.00%
507200313	2.330461538	0.091750454	0.033	0.033	0	0.00%

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507200314	0.840076923	0.033073895	0.006	0.005	0.001	20.00%
507200315	0.141923077	0.005587523	0	0	0	-
507200316	0	0	0	0	0	-
507200317	0	0	0	0	0	-
507200318	0	0	0	0	0	-
507200319	0	0	0.01	0.01	0	0.00%
507200320	0.243307692	0.009579043	0	0	0	-
507200321	0	0	0	0	0	-
507200322	0.001923077	7.57117E-05	0	0	0	-
507200323	0	0	0	0	0	-
508200300	0	0	0	0	0	-
508200301	0	0	0	0	0	-
508200302	0.006384615	0.000251363	0.001	0.001	0	0.00%
508200303	0.015615385	0.000614779	0	0	0	-
508200304	0	0	0	0	0	-
508200305	0	0	0	0	0	-
508200306	0	0	0	0	0	-
508200307	0	0	0	0	0	-
508200308	0	0	0	0	0	-
508200309	0	0	0	0	0	-
508200310	0	0	0	0	0	-
508200311	0	0	0	0	0	-
508200312	0	0	0	0	0	-
508200313	0	0	0	0	0	-
508200314	0	0	0	0	0	-
508200315	0	0	0	0	0	-
508200316	0	0	0	0	0	-
508200317	0	0	0	0	0	-
508200318	0	0	0	0	0	-
508200319	0	0	0	0	0	-
508200320	0	0	0	0	0	-
508200321	0.003846154	0.000151423	0	0	0	-
508200322	0	0	0	0	0	-
508200323	0	0	0	0	0	-

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915200400	0	0	0	0	0	-
915200401	0	0	0	0	0	-
915200402	0.004769231	0.000187765	0	0	0	-
915200403	0	0	0	0	0	-
915200404	0	0	0	0	0	-
915200405	0	0	0	0	0	-
915200406	0	0	0	0	0	-
915200407	0	0	0	0	0	-
915200408	0	0	0	0	0	-
915200409	0	0	0	0	0	-



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915200410	0	0	0	0	0	-
915200411	0	0	0	0	0	-
915200412	0	0	0	0	0	-
915200413	0	0	0	0	0	-
915200414	0	0	0	0	0	-
915200415	0	0	0	0	0	-
915200416	0	0	0	0	0	-
915200417	0	0	0	0	0	-
915200418	0	0	0	0	0	-
915200419	0	0	0	0	0	-
915200420	0	0	0	0	0	-
915200421	0	0	0	0	0	-
915200422	0	0	0	0	0	-
915200423	0	0	0	0	0	-
916200400	0	0	0	0	0	-
916200401	0	0	0	0	0	-
916200402	0	0	0	0	0	-
916200403	0	0	0	0	0	-
916200404	0	0	0.003	0.003	0	0.00%
916200405	0.063538462	0.002501514	0	0	0	-
916200406	0	0	0	0	0	-
916200407	0	0	0	0	0	-
916200408	0	0	0	0	0	-
916200409	0.001846154	7.26832E-05	0	0	0	-
916200410	0.007692308	0.000302847	0.002	0.002	0	0.00%
916200411	0.045538462	0.001792853	0	0	0	-
916200412	0	0	0.007	0.007	0	0.00%
916200413	0.172153846	0.00677771	0.006	0.006	0	0.00%
916200414	0.159538462	0.006281042	0	0	0	-
916200415	0.000230769	9.0854E-06	0.001	0.001	0	0.00%
916200416	0.013615385	0.000536039	0.009	0.009	0	0.00%
916200417	0.227461538	0.008955179	0.008	0.008	0	0.00%
916200418	0.193153846	0.007604482	0.001	0.001	0	0.00%
916200419	0.013769231	0.000542096	0	0	0	-
916200420	0.007769231	0.000305875	0.004	0.004	0	0.00%
916200421	0.106307692	0.004185342	0.004	0.004	0	0.00%
916200422	0.111846154	0.004403392	0.017	0.017	0	0.00%
916200423	0.421384615	0.016589945	0.051	0.051	0	0.00%
917200400	1.299769231	0.051172017	0.194	0.19	0.004	2.11%
917200401	4.915846154	0.19353725	0.344	0.343	0.001	0.29%
917200402	8.733692308	0.343846154	0.279	0.278	0.001	0.36%
917200403	7.095692308	0.279357965	0.334	0.333	0.001	0.30%
917200404	8.478538462	0.333800727	0.563	0.565	-0.002	-0.35%
917200405	14.30876923	0.563337371	0.368	0.365	0.003	0.82%
917200406	9.337307692	0.367610539	0.536	0.537	-0.001	-0.19%
917200407	13.62192308	0.536296184	0.45	0.453	-0.003	-0.66%

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917200408	11.41815385	0.449533616	0.217	0.194	0.023	11.86%
917200409	5.520769231	0.217353119	0.067	0.059	0.008	13.56%
917200410	1.708230769	0.06725318	0.155	0.157	-0.002	-1.27%
917200411	3.943769231	0.155266505	0.28	0.279	0.001	0.36%
917200412	7.123230769	0.280442156	0.092	0.086	0.006	6.98%
917200413	2.332538462	0.091832223	0.058	0.058	0	0.00%
917200414	1.469692308	0.057861902	0.046	0.046	0	0.00%
917200415	1.174461538	0.046238643	0.018	0.017	0.001	5.88%
917200416	0.465615385	0.018331314	0.034	0.034	0	0.00%
917200417	0.856	0.033700787	0.058	0.059	-0.001	-1.69%
917200418	1.482153846	0.058352514	0.152	0.154	-0.002	-1.30%
917200419	3.850846154	0.151608116	0.173	0.176	-0.003	-1.70%
917200420	4.387461538	0.172734706	0.025	0.025	0	0.00%
917200421	0.644076923	0.025357359	0.002	0.002	0	0.00%
917200422	0.059230769	0.00233192	0.006	0.006	0	0.00%
917200423	0.145769231	0.005738946	0.008	0.008	0	0.00%
918200400	0.194076923	0.007640824	0.004	0.004	0	0.00%
918200401	0.105076923	0.004136887	0.005	0.005	0	0.00%
918200402	0.12	0.004724409	0.001	0.001	0	0.00%
918200403	0.033846154	0.001332526	0.001	0.001	0	0.00%
918200404	0.017153846	0.000675348	0.001	0.001	0	0.00%
918200405	0.033615385	0.00132344	0.001	0.001	0	0.00%
918200406	0.024615385	0.00096911	0.001	0.001	0	0.00%
918200407	0.017692308	0.000696548	0	0	0	-
918200408	0.009692308	0.000381587	0	0	0	-
918200409	0.007538462	0.00029679	0.001	0.001	0	0.00%
918200410	0.013461538	0.000529982	0	0	0	-
918200411	0.008	0.000314961	0	0	0	-
918200412	0.008230769	0.000324046	0	0	0	-

## NOTES:

- 1) For simplicity, MAPX comparison from 5/2/2003 23:00 to 5/5/2003 06:00, and from 9/18/2004 13:00 to 9/21/2004 23:00 were omitted from the table because there were virtually no rainfalls. All numbers would be zero (except the percentage difference).
- 2) MAPX derived by the Precipitation GIS Utility (column 4) were shifted one hour early, essentially making the Date/Time stamp in the first column referring to the START of rainfall instead of the END of rainfall.

Comparison was also done for TVA subbasin "Blue Ridge" which corresponds to two LMRFC modeled basins "BRDG1" and "HURG1". However, one HRAP Grid (861, 380) is in TVA Blue Ridge Subbasin, but not in the two LMRFC modeled basins BRDG1 and HURG1 that are used to calculate the combined (weighted) LMRFC MAPX. The weight used for a modeled basin in the calculation is the number of HRAP grids that belong to that basin. e.g. BRDG1 contains 9 HRAP Grids and HURG1 contains 27 HRAP Grids so their weights are 9 and 27, respectively (or 0.25 and 0.75, respectively, when divided by the total number of HRAP Grids).

Again the MAPXs were almost identical. Most differences were within 0.001 inch. Most percentage differences were well within 10%. A few percentage differences that were greater than 10% were related to the time periods that had very small rainfall depths. The insignificant differences of MAPXs were

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caused by the slight difference in subbasin boundaries. As a matter of fact, when the Precipitation GIS Utility was used to process LMRFC modeled basins instead of the TVA subbasins, it produced exactly the same MAPX as provided by LMRFC for the above four modeled basins and for the above two storm events.

Validation of MAPX developed by the Precipitation GIS Utility using LMRFC supplied MAPX for Modeled Basins demonstrated that MAPX data series was valid.

### *Reference Files for this validation:*

- *Utility MAPX Results from 5/2/2003 to 5/8/2003 (Excel File Watershed\_Hourly\_Precip\_05022003\_05082003\_R000A.xls)*
- *Utility MAPX Results from 9/15/2004 to 9/21/2004 (Excel File Watershed\_Hourly\_Precip\_09152004\_09212004\_R000A.xls)*
- *MAPX Provided by LMRFC for NOLT1, EMBT1, BRDG1, and HURG1 Modeled Basins from 1/1/1997 to 6/30/2008 (MAPX Files: NOLT1.mapx01, EMBT1.mapx01, BRDG1.mapx01, and HURG1.mapx01)*
- *Comparison of MAPXs for "Nolichucky Dam" (NOLT1), "Nolichucky at Embreeville" (EMBT1), and "Blue Ridge" (BRDG1 and HURG1) Watersheds (Excel Files: MAPX\_Compare\_Utility\_RFC\_Nolichucky\_Dam\_May2003\_Sept2004.xls, MAPX\_Compare\_Utility\_RFC\_Nolichucky\_at\_Embreeville\_May2003\_Sept2004.xls, MAPX\_Compare\_Utility\_RFC\_BlueRidge\_May2003\_Sept2004.xls)*
- *Utility MAPX Results from 5/2/2003 to 5/8/2003 for LMRFC Modeled Basins (Excel File Basin\_Hourly\_Precip\_05022003\_05082003\_R000A.xls)*
- *Utility MAPX Results from 9/15/2004 to 9/21/2004 for LMRFC Modeled Basins (Excel File Basin\_Hourly\_Precip\_09152004\_09212004\_R000A.xls)*
- *Comparison of MAPX for Basins NOLT1, EMBT1, BRDG1 and HURG1 (Excel Files: MAPX\_Compare\_Utility\_RFC\_NOLT1\_May2003\_Sept2004.xls, MAPX\_Compare\_Utility\_RFC\_EMBT1\_May2003\_Sept2004.xls, MAPX\_Compare\_Utility\_RFC\_BRDG1\_May2003\_Sept2004.xls, MAPX\_Compare\_Utility\_RFC\_HURG1\_May2003\_Sept2004.xls)*

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**Table A-3: Comparison of MAPX for Blue Ridge Subbasin from 5/2/2003 to 5/8/2003 and from 9/15/2004 to 9/21/2004 (the Precipitation GIS Utility versus LMRFC)**

Date/Time (GMT)	MAPX in Millimeter	MAPX in Inch	MAPX in Inch, shift one hour, rounded to 0.001	LMRFC MAPX for BRDG1: 9 Grids	LMRFC MAPX for HURG1: 27 grids	Combined (Weighted) LMRFC MAPX	Difference	% Difference
<b>May-03</b>								
502200300	0.964324324	0.037965525	0.088	0.065	0.099	0.091	-0.003	-3.30%
502200301	2.235945946	0.088029368	0.007	0.007	0.008	0.008	-0.001	-12.50%
502200302	0.188378378	0.007416472	0.146	0.099	0.165	0.149	-0.003	-2.01%
502200303	3.701891892	0.145743775	0.009	0	0.013	0.01	-0.001	-10.00%
502200304	0.235405405	0.009267929	0	0	0	0	0 -	
502200305	0	0	0	0	0	0	0 -	
502200306	0	0	0	0	0	0	0 -	
502200307	0	0	0	0	0	0	0 -	
502200308	0	0	0	0	0	0	0 -	
502200309	0	0	0	0	0	0	0 -	
502200310	0	0	0	0	0	0	0 -	
502200311	0	0	0	0	0	0	0 -	
502200312	0	0	0	0	0	0	0 -	
502200313	0	0	0	0	0	0	0 -	
502200314	0	0	0	0	0	0	0 -	
502200315	0	0	0	0	0	0	0 -	
502200316	0	0	0	0	0	0	0 -	
502200317	0.006756757	0.000266014	0.031	0	0.043	0.032	-0.001	-3.13%
502200318	0.793513514	0.03124069	0.018	0	0.024	0.018	0	0.00%
502200319	0.453243243	0.017844222	0	0	0	0	0 -	
502200320	0	0	0	0	0	0	0 -	
502200321	0	0	0.021	0.015	0.023	0.021	0	0.00%
502200322	0.534594595	0.021047031	0.001	0	0.002	0.002	-0.001	-50.00%
502200323	0.028648649	0.0011279	0.034	0.036	0.033	0.034	0	0.00%
503200300	0.862162162	0.033943392	0.113	0.077	0.127	0.115	-0.002	-1.74%
503200301	2.877567568	0.113290062	0.034	0.038	0.032	0.034	0	0.00%
503200302	0.861621622	0.033922111	0	0	0	0	0 -	
503200303	0.007027027	0.000276655	0	0	0	0	0 -	
503200304	0	0	0	0	0	0	0 -	
503200305	0	0	0	0	0	0	0 -	
503200306	0	0	0	0	0	0	0 -	
503200307	0	0	0	0	0	0	0 -	
503200308	0	0	0	0	0	0	0 -	
503200309	0	0	0	0	0	0	0 -	
503200310	0	0	0	0	0	0	0 -	
503200311	0	0	0	0	0	0	0 -	
503200312	0	0	0	0	0	0	0 -	
503200313	0	0	0	0	0	0	0 -	
503200314	0	0	0	0	0	0	0 -	
503200315	0	0	0	0	0	0	0 -	

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503200316	0	0	0	0	0	0	0 -	
503200317	0	0	0	0	0	0	0 -	
503200318	0	0	0	0	0	0	0 -	
503200319	0	0	0.002	0.002	0.003	0.003	-0.001	-33.33%
503200320	0.061891892	0.002436689	0.034	0.002	0.046	0.035	-0.001	-2.86%
503200321	0.863243243	0.033985954	0	0	0	0	0 -	
503200322								

~ MAPX Comparison from 5/3/2003 22:00 to 5/5/2003 09:00 were omitted from the table because there were virtually no rainfalls.

505200309								
505200310	0.006756757	0.000266014	0	0	0	0	0 -	
505200311	0.006756757	0.000266014	0.005	0.017	0	0.004	0.001	25.00%
505200312	0.123243243	0.004852096	0.025	0.028	0.023	0.024	0.001	4.17%
505200313	0.622972973	0.024526495	0.078	0.101	0.066	0.075	0.003	4.00%
505200314	1.972432432	0.07765482	0.194	0.245	0.174	0.192	0.002	1.04%
505200315	4.930810811	0.19412641	0.443	0.44	0.448	0.446	-0.003	-0.67%
505200316	11.24486486	0.442711215	0.45	0.482	0.437	0.448	0.002	0.45%
505200317	11.42918919	0.449968078	0.129	0.156	0.114	0.125	0.004	3.20%
505200318	3.265135135	0.128548627	0.096	0.076	0.104	0.097	-0.001	-1.03%
505200319	2.427297297	0.095562886	0.343	0.256	0.376	0.346	-0.003	-0.87%
505200320	8.711891892	0.34298787	0.184	0.143	0.2	0.186	-0.002	-1.08%
505200321	4.669189189	0.183826346	0	0	0	0	0 -	
505200322	0	0	0.002	0.007	0	0.002	0	0.00%
505200323	0.041351351	0.001628006	0.055	0.053	0.056	0.055	0	0.00%
506200300	1.384594595	0.054511598	0.003	0	0.004	0.003	0	0.00%
506200301	0.068648649	0.002702703	0	0	0	0	0 -	
506200302	0	0	0.197	0.242	0.183	0.198	-0.001	-0.51%
506200303	5.016486486	0.197499468	0.232	0.233	0.231	0.232	0	0.00%
506200304	5.89	0.231889764	0.06	0.075	0.055	0.06	0	0.00%
506200305	1.535405405	0.060449032	0.236	0.257	0.229	0.236	0	0.00%
506200306	5.994054054	0.23598638	0.108	0.151	0.092	0.107	0.001	0.93%
506200307	2.744864865	0.108065546	0.07	0.095	0.061	0.07	0	0.00%
506200308	1.786216216	0.070323473	0.028	0.046	0.02	0.027	0.001	3.70%
506200309	0.7	0.027559055	0.026	0.031	0.024	0.026	0	0.00%
506200310	0.662702703	0.026090658	0.038	0.098	0.015	0.036	0.002	5.56%
506200311	0.967567568	0.038093211	0.028	0.01	0.035	0.029	-0.001	-3.45%
506200312	0.715675676	0.028176208	0.008	0.023	0.003	0.008	0	0.00%
506200313	0.21	0.008267717	0.045	0.058	0.039	0.044	0.001	2.27%
506200314	1.130810811	0.044520111	0.102	0.047	0.122	0.103	-0.001	-0.97%
506200315	2.590810811	0.102000426	0.036	0.014	0.044	0.037	-0.001	-2.70%
506200316	0.911081081	0.035869334	0.182	0.181	0.182	0.182	0	0.00%
506200317	4.631081081	0.182326027	0.052	0.045	0.055	0.053	-0.001	-1.89%
506200318	1.321891892	0.052042988	0.042	0.053	0.037	0.041	0.001	2.44%
506200319	1.055135135	0.041540753	0.035	0.016	0.042	0.036	-0.001	-2.78%
506200320	0.887837838	0.034954246	0	0	0	0	0 -	
506200321	0	0	0.001	0	0.001	0.001	0	0.00%
506200322	0.014324324	0.00056395	0	0	0	0	0 -	
506200323	0	0	0	0	0	0	0 -	
507200300	0	0	0	0	0	0	0 -	
507200301	0	0	0	0	0	0	0 -	

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507200302	0	0	0	0	0	0	0 -	
507200303	0	0	0.001	0	0.002	0.002	-0.001	-50.00%
507200304	0.037027027	0.001457757	0	0	0	0	0 -	
507200305	0	0	0.011	0.019	0.009	0.012	-0.001	-8.33%
507200306	0.291891892	0.011491807	0.459	0.427	0.469	0.459	0	0.00%
507200307	11.65837838	0.458991275	0.814	0.73	0.847	0.818	-0.004	-0.49%
507200308	20.66594595	0.813619919	0.054	0.061	0.052	0.054	0	0.00%
507200309	1.36972973	0.053926367	0.311	0.148	0.373	0.317	-0.006	-1.89%
507200310	7.904594595	0.311204512	0.088	0.154	0.063	0.086	0.002	2.33%
507200311	2.238378378	0.088125133	0.418	0.592	0.355	0.414	0.004	0.97%
507200312	10.62621622	0.418354969	0.252	0.259	0.253	0.255	-0.003	-1.18%
507200313	6.396216216	0.251819536	0	0	0	0	0 -	
507200314	0	0	0	0	0	0	0 -	
507200315	0	0	0	0	0	0	0 -	
507200316	0	0	0	0	0	0	0 -	
507200317	0	0	0	0	0	0	0 -	
507200318	0	0	0.001	0	0.001	0.001	0	0.00%
507200319	0.019459459	0.00076612	0	0	0	0	0 -	
507200320	0	0	0.007	0.004	0.008	0.007	0	0.00%
507200321	0.184594595	0.007267504	0.005	0	0.007	0.005	0	0.00%
507200322	0.136486486	0.005373484	0.004	0	0.006	0.005	-0.001	-20.00%
507200323	0.112702703	0.004437114	0.004	0	0.006	0.005	-0.001	-20.00%
508200300	0.102162162	0.004022132	0	0	0	0	0 -	

## Sep-04

916200400	0	0	0.002	0	0.002	0.002	0	0.00%
916200401	0.04027027	0.001585444	0	0	0	0	0 -	
916200402	0	0	0	0	0	0	0 -	
916200403	0	0	0	0	0	0	0 -	
916200404	0.003783784	0.000148968	0.002	0.007	0.001	0.003	-0.001	-33.33%
916200405	0.056486486	0.002223877	0.008	0.024	0.003	0.008	0	0.00%
916200406	0.207297297	0.008161311	0.002	0.003	0.002	0.002	0	0.00%
916200407	0.062162162	0.002447329	0.001	0	0.002	0.002	-0.001	-50.00%
916200408	0.033243243	0.001308789	0.002	0.001	0.002	0.002	0	0.00%
916200409	0.040810811	0.001606725	0.002	0.005	0.001	0.002	0	0.00%
916200410	0.041891892	0.001649287	0	0	0	0	0 -	
916200411	0.001891892	7.44839E-05	0.009	0.015	0.007	0.009	0	0.00%
916200412	0.239189189	0.009416897	0.062	0.052	0.066	0.063	-0.001	-1.59%
916200413	1.576486486	0.062066397	0.029	0.024	0.03	0.029	0	0.00%
916200414	0.732162162	0.028825282	0.113	0.086	0.123	0.114	-0.001	-0.88%
916200415	2.863783784	0.112747393	0.005	0.003	0.006	0.005	0	0.00%
916200416	0.122972973	0.004841456	0.012	0.003	0.016	0.013	-0.001	-7.69%
916200417	0.316216216	0.012449457	0.053	0.045	0.056	0.053	0	0.00%
916200418	1.344054054	0.052915514	0.213	0.21	0.212	0.212	0.001	0.47%
916200419	5.403243243	0.212726112	0.351	0.253	0.387	0.354	-0.003	-0.85%
916200420	8.926486486	0.351436476	0.162	0.115	0.178	0.162	0	0.00%
916200421	4.108378378	0.16174718	0.217	0.212	0.216	0.215	0.002	0.93%
916200422	5.505405405	0.216748244	0.289	0.185	0.327	0.292	-0.003	-1.03%
916200423	7.350540541	0.28939136	0.894	0.558	1.018	0.903	-0.009	-1.00%

# TVA

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		Checked	L.S.

917200400	22.71621622	0.894339221	0.865	0.789	0.898	0.871	-0.006	-0.69%
917200401	21.96864865	0.864907427	0.409	0.402	0.407	0.406	0.003	0.74%
917200402	10.38540541	0.408874229	0.277	0.272	0.277	0.276	0.001	0.36%
917200403	7.025675676	0.276601405	0.239	0.361	0.197	0.238	0.001	0.42%
917200404	6.067567568	0.238880613	0.007	0.017	0.002	0.006	0.001	16.67%
917200405	0.177027027	0.006969568	0.015	0.003	0.02	0.016	-0.001	-6.25%
917200406	0.391351351	0.015407534	0.005	0.001	0.006	0.005	0	0.00%
917200407	0.121081081	0.004766972	0.018	0.01	0.021	0.018	0	0.00%
917200408	0.457297297	0.018003831	0.06	0.016	0.077	0.062	-0.002	-3.23%
917200409	1.523783784	0.059991488	0.046	0.017	0.057	0.047	-0.001	-2.13%
917200410	1.157027027	0.045552245	0.05	0.022	0.061	0.051	-0.001	-1.96%
917200411	1.279189189	0.050361779	0.032	0.017	0.039	0.034	-0.002	-5.88%
917200412	0.824054054	0.032443073	0.03	0.017	0.036	0.031	-0.001	-3.23%
917200413	0.772432432	0.030410726	0.033	0.029	0.036	0.034	-0.001	-2.94%
917200414	0.842432432	0.033166631	0.026	0.061	0.016	0.027	-0.001	-3.70%
917200415	0.667297297	0.026271547	0	0	0	0	0 -	

## NOTES:

- 1) For simplicity, MAPX comparison from 5/3/2003 22:00 to 5/5/2003 09:00, from 5/8/2003 01:00 to 5/8/2003 23:00, from 9/15/2004 00:00 to 9/15/2004 23:00, and from 9/17/2004 16:00 to 9/21/2004 23:00 were omitted from the table because there were virtually no rainfalls. All numbers would be zero (except the percentage difference).
- 2) MAPX derived by the Precipitation GIS Utility (column 4) were shifted one hour early, essentially making the Date/Time stamp in the first column referring to the START of rainfall instead of the END of rainfall.

## **TVA**

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<b>Subject:</b> Processing and Validation of National Weather Service's NEXRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins	<b>Prepared</b>		Y.Y.
	<b>Checked</b>		L.S.

### **A.3 Conclusions**

The gridded hourly precipitation data extracted by the Precipitation GIS Utility from the raw NWS binary precipitation data were checked against the data converted by NWS supplied C program and they matched. So the procedure to read binary hourly precipitation data in XMRG format is correct.

Manual visual inspection of HRAP Grid Centroids and TVA Subbasins, and comparison of HRAP Grid to TVA Subbasin Index and HRAP Grid to LMRFC Modeled Basin Index revealed that HRAP Grid to Subbasin Index is correct.

Manual aggregation of precipitation data confirmed that precipitation data were correctly aggregated by subbasin.

Finally MAPX for TVA subbasins developed by the Precipitation GIS Utility were checked against MAPX for Modeled Basins provided by LMRFC. The numbers matched closely when similar subbasins were compared to each other. Most absolute differences were within 0.001 inch. Most percentage differences were well within 10%. A few percentage differences that were greater than 10% were related to the time periods that had very small rainfall depths. The difference of MAPX was caused by the slight difference of subbasin delineation between TVA and LMRFC; otherwise, the numbers would have matched exactly.

Based on the above validation results, it is concluded that the MAPX data series for TVA subbasins is valid.



## TVA

Calculation No.	CDQ000020080055	Rev: 3	Plant: GEN	Page: 1
Subject: Appendix B			Prepared	CLS
			Checked	BCN

### 1. Purpose

The purpose of this appendix is to supplement the "Processing and Validation of the National Weather Service's NEXTRAD Stage III Hourly Precipitation Data for Hydrologic Analysis of TVA Subbasins" calculation (Parent Calculation to this appendix) with the processing of the hourly Radar-based Mean Areal Precipitation (MAPX) data series for the subbasins comprising the Wheeler Reservoir watershed which includes the Tims Ford Reservoir. The watershed map of the Wheeler Reservoir is included in Attachment 11 for reference. The results of this parent calculation and this appendix will be used in subsequent calculations as input data.

### 2. References

- 2.1 NWS, XMGR File Format (pdf file xmrg.pdf downloaded from NWS web site <http://www.nws.noaa.gov/oh/hrl/misc/xmrg.pdf>).
- 2.2 NWS, HRAPGRID Hydrologic Rainfall Analysis Project (HRAP) Grid System (pdf file 21hrapgrid.pdf downloaded from NWS web site [http://www.nws.noaa.gov/oh/hrl/nwsrfs/users\\_manual/part2/\\_pdf/21hrapgrid.pdf](http://www.nws.noaa.gov/oh/hrl/nwsrfs/users_manual/part2/_pdf/21hrapgrid.pdf)).
- 2.3 Wheeler Reservoir Watershed Map Development, Technical Memo EDMS# L58 090911 800.

### 3. Assumptions

No assumptions or unverified assumption are contained in this appendix.

### 4. Methodology

The Methodology utilized in this appendix is the same as described in section 6.1 of the parent calculation.

### 5. Design Input Data

5.1	Raw Hourly Precipitation Data in XMGR format from the period January 1997 through April 2008	FILEKEEPER No. 310990
5.2	HRAP Grid Centroids	Attachment 2
5.3	Wheeler Reservoir Watershed Map titled "Subbasin Areas for Tennessee River Watershed from Guntersville Reservoir Dam downstream to Wheeler Reservoir Dam."	Ref 2.3 Attachment 11
5.4	Wheeler Reservoir Subbasin and Catchment Map for the Tennessee River Watershed from Guntersville Reservoir Dam downstream to Wheeler Reservoir Dam."	Ref 2.3 (GIS Files stored with Technical Memo; EDMS# L58 090911 800)
5.5	GIS Files used to create Wheeler Reservoir watershed map (5.3 above) and the "Subbasin and Catchment" key map (5.4 above).	Ref 2.3 (GIS Files stored with Technical Memo; EDMS# L58 090911 800)

### 6. Computations and Analyses

Computations performed in this appendix were performed as described in sections 6.2, 6.3, and 6.4 of the parent calculation utilizing the *Precipitation GIS Utility* and the Design Input Data in section 5 of this appendix. The only deviation from the processes described in the parent calculation is that the subbasins developed in reference 2.3 and shown in attachment 11 were further subdivided into smaller catchments to provide results that were better suited for analysis in subsequent calculations. The "Wheeler Watershed Subbasin and Catchments Key Map" shows both the subbasins and the smaller catchments that correspond to the computations in this appendix and in attachment 10. In this key map, the subbasins that make up the Wheeler Reservoir watershed are identified by the first number, and the smaller catchments are identified by the number behind the dash.

**TVA**

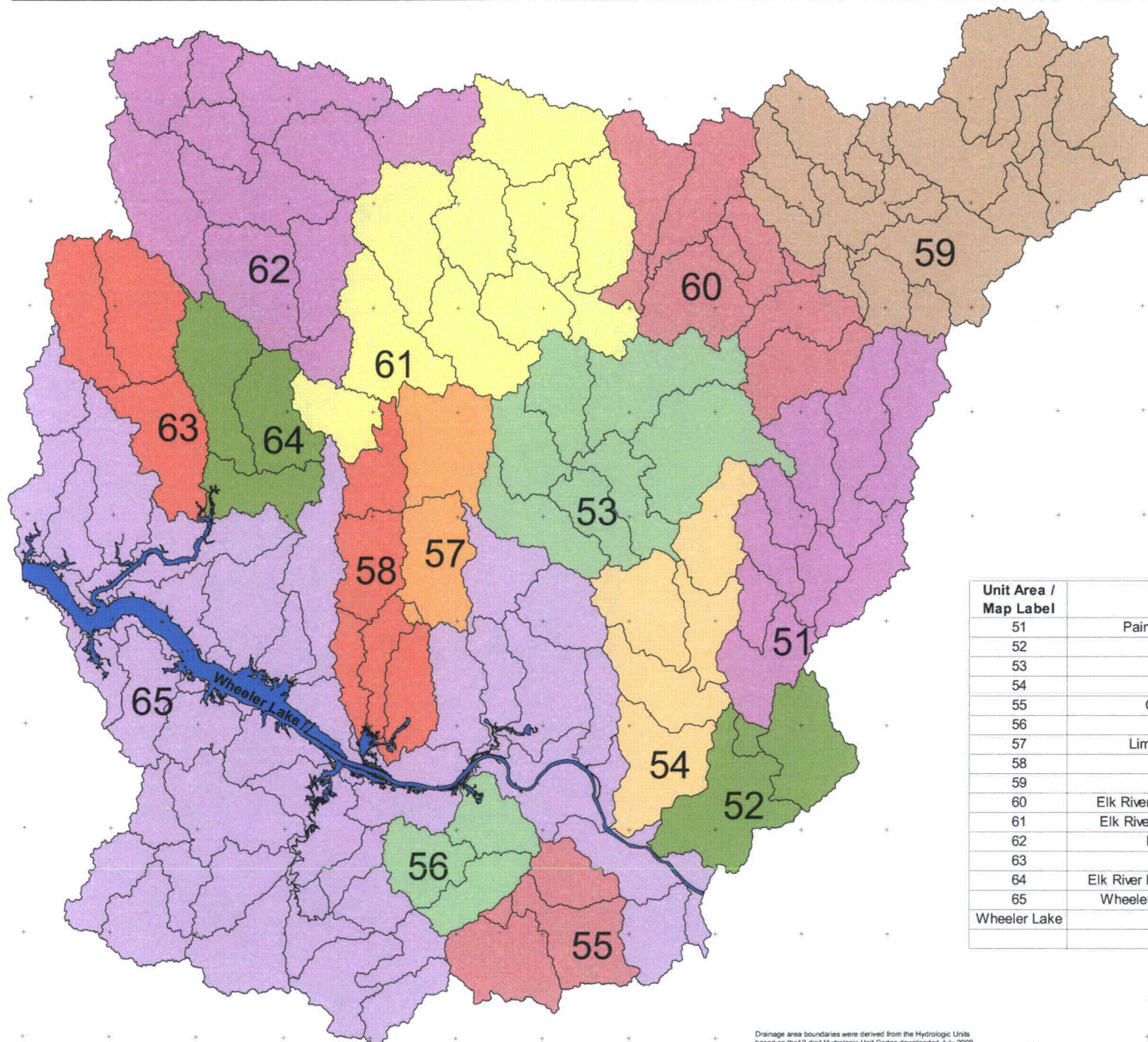
<b>Calculation No.</b> CDQ000020080055	<b>Rev: 2</b>	<b>Plant: GEN</b>	<b>Page: 2</b>
<b>Subject: Appendix B</b>		<b>Prepared</b>	<b>LAW</b>
		<b>Checked</b>	<b>EEK</b>

**7. Results/Conclusions**

The result of this appendix are the MAPX data series for the Wheeler Reservoir watershed (includes Tims Ford Reservoir) by hour and by subbasin and catchments are supplied in twelve Microsoft Excel spreadsheets. Each of these twelve spreadsheets represents one calendar year for the data available; years of 1997 thru 2008. These Microsoft Excel Spreadsheets are in electronic Attachment 10, and are suitable for use as input into subsequent calculations.

**Attachment 11**  
**Wheeler Watershed Maps**

# Sub-basin Areas for Tennessee River Watershed, from Guntersville Reservoir Dam Downstream to Wheeler Reservoir Dam



Unit Area / Map Label	Watershed Subbasin	Sq. Miles
51	Paint Rock River Near Woodville	321.1
52	Paint Rock Local	138.1
53	Flint River Near Chase	343.1
54	Flint River Local	224.8
55	Cotaco Creek @ Florette	136.2
56	Cotaco Creek Local	101.1
57	Limestone Creek Near Athens	121.3
58	Limestone Creek Local	157.4
59	Tims Ford Dam	533.2
60	Elk River Local, Tims Ford to Fayetteville	293.3
61	Elk River Local, Fayetteville to Prospect	490.2
62	Richland Creek at Mouth	488.0
63	Sugar Creek at Mouth	177.0
64	Elk River Local, Mile 16.5 to Prospect Gage	145.1
65	Wheeler Local (excludes reservoir area)	1380.0
Wheeler Lake	Wheeler Surface Area	90.9
	<b>Total</b>	<b>5140.7</b>

## Wheeler Reservoir

Sub-basin Areas for Tennessee River Watershed, from Guntersville  
Reservoir Dam Downstream to Wheeler Reservoir Dam

Barge Waggoner Sumner & Cannon, Inc.

File Name: Surface Area Map\_Albans\_09102009.PDF

Prepared by: JDE Checked by: HSS Rev: 2 Date: September 10, 2009

Drainage area boundaries were derived from the Hydrologic Units  
based on the 12-digit Hydrologic Unit Codes downloaded July 2009.  
Watershed boundaries were downloaded from USGS (<http://usgs-nrs.cr.usgs.gov/stewardship2maps.html>).  
Additional drainage area boundaries were delineated at selected stream  
gages from 1:24,000 scale USGS topographic maps.



