

CONTENTS

Chapter	Page
Title Page	i
Certificate of Approval	ii
Certificate by the Supervisor	iii
Acknowledgement	iv
Declaration	v
List of Figures	vi
List of Tables	ix
Abstract	xi
Contents	xii
Chapter 1 – INTRODUCTION	1
1.1 Background	1
1.2 Objectives	5
Chapter 2 – REVIEW OF LITERATURE	6
2.1 Overview of Continuous Simulation Watershed Models	6
2.1.1 AnnAGNPS	6
2.1.2 ANSWERS-2000	7
2.1.3 HSPF	8
2.1.4 MIKE SHE	8
2.1.5 AVGWLF	9
2.1.6 ArcSWAT	10
2.2 Application of SWAT Model	10
2.3 Application of GWLF Model	24
2.4 Comparison of Watershed Models	29
2.5 Critiques on Review of Literature	38

Chapter	Page
Chapter 3 – THEORITICAL CONSIDERATIONS	40
3.1 Overview of ArcSWAT Watershed Model	40
3.1.1 Water Balance for the Land Phase of Hydrologic Cycle	40
3.1.1.1 Surface Runoff	41
3.1.1.2 Peak Runoff Rate	45
3.1.1.3 Surface Runoff Lag	45
3.1.1.4 Canopy Storage	46
3.1.1.5 Potential Evapotranspiration	46
3.1.1.6 Percolation	47
3.1.1.7 Lateral Flow	48
3.1.1.8 Lateral Lag Flow	48
3.1.1.9 Simulation of Ground Water	49
3.1.2 Calculation of Sediment Yield	52
3.1.2.1 Soil Erodibility Factor	52
3.1.2.2 Cover and Management Factor	53
3.1.2.3 Support Practice Factor	54
3.1.2.4 Topographic Factor	55
3.1.2.5 Coarse Fragment Factor	55
3.1.2.6 Sediment Lag in Surface Runoff	55
3.1.2.7 Sediment in Lateral and Groundwater Flow	56
3.1.3 Routing Phase of Hydrologic Cycle	56
3.1.3.1 Water Routing	56
3.1.3.2 Sediment Routing	59
3.1.3.3 Sensitivity Analysis of the SWAT Model	61
3.1.3.4 Calibration of the SWAT Model	61
3.2 Overview of AVGWLF Watershed Model	62
3.2.1 Simulation of Runoff	62
3.2.1.1 Estimation of Surface Runoff	63

Chapter	Page
3.2.2 Estimation of Sediment Yield	65
3.2.2.1 Universal Soil Loss Equation	66
3.2.2.2 Sediment Delivery Ratio	66
3.2.2.3 Streambank Erosion	66
Chapter 4 - MATERIALS AND METHODS	68
4.1 Description of Study Area	68
4.1.1 Location	68
4.1.3 Topography	69
4.1.3 Climate	70
4.1.4 Natural Vegetation and Cropping Pattern	70
4.1.5 Socio-economic Condition	70
4.2 Data Acquisition	71
4.3 Pre-Processing and Analysis of Hydro-Meteorological Data	72
4.4 Simulation of Streamflow and Sediment using ArcSWAT	73
4.4.1 Preparation of Input Files for ArcSWAT Model	73
4.4.1.1 Preparation of Digital Elevation Model of the Study Area	73
4.4.1.2 Preparation of Soil Map	77
4.4.1.3 Generation of Land Use/Land Cover Map	78
4.4.1.4 Discretization of Study Basin	79
4.4.1.5 Identification of Curve Numbers	82
4.4.2 Simulation of Streamflow	83
4.4.3 Selection of Calibrating Parameters for ArcSWAT Model	84
4.4.4 Calibration of ArcSWAT Model for Streamflow Simulation	86
4.4.5 Validation of the ArcSWAT model for Streamflow	89
4.4.6 Calibration of the ArcSWAT Model for Sediment Transport	89

Chapter	Page
4.4.7 Validation of ArcSWAT model for Sediment	90
4.5 Simulation of Streamflow and Sediment using AVGWLF Model	91
4.5.1 Preparation of Input Files for AVGWLF Model	91
4.5.1.1 Digital Elevation Model (DEM)	92
4.5.1.2 Sub-watersheds and Streams	92
4.5.1.3 Land use/Land cover Map	92
4.5.1.4 Soil Map	92
4.5.1.5 Curve Number	93
4.5.1.6 Evapotranspiration Cover Coefficients	93
4.5.1.7 Cropping Management and Erosion Control Practice Factors	93
4.5.1.8 Weather Data	94
4.5.2 Base Simulation of Streamflow and Sediment by AVGWLF Model	95
4.5.2.1 Calibration and Validation of AVGWLF Model for Streamflow	96
4.5.2.2 Calibration and Validation of AVGWLF Model for Sediment	97
4.6 Performance Evaluation of the Models using Statistical Indicators	98
4.6.1 Mean Absolute Error	98
4.6.2 Root Mean Square Error	99
4.6.3 RMSE-Observation Standard Deviation Ratio	99
4.6.4 Percent Bias	99
4.6.5 Coefficient of Determination	100
4.6.6 Nash-Sutcliffe Efficiency	100
4.6.7 Student's t-test	101
4.7 Performance Evaluation of the Models using Graphical Indicators	102

Chapter	Page
4.8 Comparative Evaluation of ArcSWAT and AVGWLF Models Performance	102
4.9 Simulation of Best Management Practices	103
4.9.1 Identification of Critical Sub-Watershed	103
4.9.2 Modeling of Best Management Practices	104
 Chapter 5 - RESULTS AND DISCUSSION	 109
5.1 Watershed Characteristics	109
5.1.1 Rainfall Characteristics	109
5.1.2 Temperature and Relative Humidity Characteristics	111
5.1.3 Streamflow Characteristics	112
5.1.4 Topographic Characteristics	115
5.1.5 Soil Characteristics	117
5.1.6 Land Use/Land Cover Characteristics	120
5.2 Calibration and Validation of ArcSWAT Model	120
5.2.1 Streamflow Parameters for Calibration	120
5.2.2 Calibrated Streamflow Parameters	122
5.2.3 Performance of the ArcSWAT Model in Streamflow Simulation	124
5.2.3.1 Performance Evaluation Using Statistical Indicators	124
5.2.3.2 Performance Evaluation Using Graphical Indicators	126
5.2.4 Sediment Parameters for Calibration	134
5.2.5 Performance of the ArcSWAT Model in Sediment Simulation	135
5.2.5.1 Performance Evaluation Using Statistical Indicators	135
5.2.5.2 Performance Evaluation Using Graphical Indicators	137
5.3 Calibration and Validation of AVGWLF Model	145
5.3.1 Calibrated Streamflow Parameters for Streamflow Simulation	145

5.3.2 Performance of the AVGWLF Model in Streamflow Simulation	146
5.3.2.1 Performance Evaluation Using Statistical Indicators	147
5.3.2.2 Performance Evaluation Using Graphical Indicators	155
5.3.3 Calibrated Parameters for Sediment Simulation	155
5.3.4 Performance of the AVGWLF Model in Sediment Simulation	155
5.3.4.1 Performance Evaluation Using Statistical Indicators	157
5.3.4.2 Performance Evaluation Using Graphical Indicators	159
5.4 Relative Performance of ArcSWAT and AVGWLF Models	159
5.4.1 Relative Performance of the Models for Simulating Streamflow	159
5.4.1.1 Comparison of the Models Performance Based on Statistical Indicators	161
5.4.1.2 Comparison of Models Performance based on Graphical Indicators	159
5.4.2 Relative Performance of the Models for Simulating Monthly Sediment Yield	166
5.4.2.1 Comparison of Models Performance based on Statistical Indicators	166
5.4.2.2 Comparison of Models Performance based on Graphical Indicators	167
5.5 Simulation Results of Best Management Practices	170
5.5.1 Critical Sub-Watersheds in the Study Area	170
5.5.2 Evaluation of Best Management Practices	172
Chapter 6 - SUMMARY AND CONCLUSIONS	178
Chapter 7 – SCOPE FOR FUTURE STUDY	191
References	193
