UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO IV SEMESTERS (FULL TIME)

M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA9104	Statistical Methods for Water Resources	3	1	0	4
2	HW9101	Advanced Groundwater Hydrology	3	0	2	4
3	HW9102	Surface Water Hydrology	3	0	0	3
4	IM9101	Integrated Water Resources Management	3	0	0	3
5	E1	Elective I	3	0	0	3
6	E2	Elective II	3	0	0	3
		TOTAL	**18**	**1**	**2**	**20**

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW9121	Advanced Hydraulics	3	0	0	3
2	HW9122	Advanced Hydrologic Analysis and Design	3	0	0	3
3	HW9123	Remote sensing and GIS for Water Resources	3	0	2	4
4	HW9124	Systems Analysis In Water Resources	3	0	0	3
5	HW9125	Seminar	0	0	2	1
6	E3	Elective III	3	0	0	3
7	E4	Elective IV	3	0	0	3
		TOTAL	**18**	**0**	**4**	**20**

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	IW 9131	Soft computing and simulation in Water Resources	3	1	0	4
2	E5	Elective V	3	0	0	3
3	E6	Elective VI	3	0	0	3
PRACTICAL						
4	HW 9132	Project Work Phase I	0	0	6	3
		TOTAL	**9**	**1**	**6**	**13**

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	HW 9141	Project Work Phase II	0	0	30	15
		TOTAL	**0**	**0**	**30**	**15**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 68

UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO VI SEMESTERS (PART TIME)

M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA9104	Statistical Methods for Water Resources	3	1	0	4
2	IM9101	Integrated Water Resources Management	3	0	0	3
3	E1	Elective I	3	0	0	3
		TOTAL	**9**	**1**	**0**	**10**

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW9122	Advanced Hydrologic Analysis and Design	3	0	0	3
2	HW9124	Systems Analysis In Water Resources	3	0	0	3
3	E2	Elective II	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW9101	Advanced Groundwater Hydrology	3	0	2	4
2	HW9102	Surface Water Hydrology	3	0	0	3
3	E3	Elective III	3	0	0	3
		TOTAL	**9**	**0**	**2**	**10**

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HW9121	Advanced Hydraulics	3	0	0	3
2	HW9123	Remote sensing and GIS for Water Resources	3	0	2	4
3	HW9125	Seminar	0	0	2	1
4	E4	Elective IV	3	0	0	3
		TOTAL	**9**	**0**	**4**	**11**

SEMESTER V

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	IW9131	Soft computing and simulation in Water Resources	3	1	0	4
2	E5	Elective V	3	0	0	3
3	E6	Elective VI	3	0	0	3
PRACTICAL						
4	HW9132	Project Work Phase I	0	0	6	3
		TOTAL	**9**	**1**	**6**	**13**

SEMESTER VI

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	HW9141	Project Work Phase II	0	0	30	15
		TOTAL	**0**	**0**	**30**	**15**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 68

ELECTIVES FOR M.E.HYDROLOGY AND WATER RESOURCES ENGINEERING

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1	CM9122	Coastal Engineering	3	0	0	3
2	HW9151	Environmental Hydraulics	3	0	0	3
3	HW9152	Flood and Drought Management	3	0	0	3
4	HW9153	Groundwater Modeling and Management	3	0	0	3
5	HW9154	Urban Water Resources Management	3	0	0	3
6	HW9155	Water Power and Dam Engineering	3	0	0	3
7	HW9156	Water Supply Distribution And Buried Pipelines	3	0	0	3
8	HW9157	River Engineering	3	0	0	3
9	IW9152	Environmental Impact Assessment of Water Resources Development	3	0	0	3
10	IW9121	Ground Water and Drainage Engineering	3	0	0	3
11	IW9153	Rehabilitation And Modernisation of Irrigation Systems	3	0	0	3
12	IW9155	Water Quality and Pollution	3	0	2	4
13	IM9151	Water Policies, Laws and Rights	3	0	0	3
14	IM9152	Watershed Conservation and Management	3	0	0	3
15	IM9153	Climate Change and Water Resources	3	0	0	3

MA 9104 STATISTICAL METHODS FOR WATER RESOURCES

L	T	P	C
3	1	0	4

OBJECTIVE:

- To provide the students the concept and an understanding of statistics, probability and random processes, needed for mathematical modeling of water resources phenomena.

UNIT I EMPIRICAL STATISTICS 9+3

Types of Sampling – Description of discrete and continuous data – Measures of Central tendency and Dispersion for grouped and ungrouped data – Measures of position – Box and Whisker plot.

UNIT II ESTIMATION THEORY 9+3

Unbiased Estimators – Methods of Moments – Maximum Likelihood Estimation – Curves fitting by Principle of least squares – Regression Lines.

UNIT III TESTING OF HYPOTHESIS 9+3

Sampling distributions – Type I and Type II errors – Tests based on Normal, t, χ^2 and F distributions for testing of mean, variance and proportions – Tests for Independence of attributes and Goodness of fit.

UNIT IV DESIGN OF EXPERIMENTS 9+3

Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

UNIT V MULTIVARIATE ANALYSIS TECHNIQUES 9+3

Covariance matrix – Correlation Matrix – Multivariate Normal density function – Principlal components – Sample variation by principal components – Principal components by graphing.

TOTAL (L: 45 + T: 15): 60 PERIODS

REFERENCES:

1. Douglas C., Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, 3rd Edition, Wiley India, 2007.
2. R.A.Johnson and D.W.Wicheren, Applied Multivariate Statistical Analysis, 5th Edition, Pearson Educations Asia, 2002.
3. Prem S. Mann, Introductory Statistics, 5th Edition, John Wiley and Sons. INC Asia 2005
4. J.E. Freund Mathematical Statistics, 5th Edition Prentice Hall of India, 2001.
5. R.E. Walpole, R.H. Myers, S.L. Myers, and K.Ye, Probability and Statistics for Engineers and Scientists, 8th Edition , Asia, 2007.

HW 9101	ADVANCED GROUNDWATER HYDROLOGY	L	T	P	C
		3	0	2	4

OBJECTIVE:

- The objective of this course is enable to the student to understand the basic empirical knowledge of the residence and movement of groundwater, as well as a number of quantitative aspects. At the end of the course, the student should be able to evaluate the aquifer parameters and groundwater resources for different hydro-geological boundary conditions.

UNIT I INTRODUCTION TO GROUNDWATER 8

Groundwater in Hydrologic Cycle – Occurrence of groundwater – Hydrogeology – Hydrometeorology – soil sample analysis - Water bearing materials - Types of aquifers – parameters of Aquifers – Determination of specific yield and permeability

UNIT II GROUNDWATER HYDRAULICS 10

Groundwater Movement - Darcy's law and its limitations - Stream lines and flow net analysis – Potential flow theory – Discharge and draw down for various condition of groundwater flow - Principles of groundwater flow and its equation – Dupuit – Forchheimer assumptions – Influent and Effluent streams - Evaluation of well loss parameters – Partial penetration of wells – Interference of wells – Collector wells and Infiltration galleries.

UNIT III PUMPING TEST ANALYSIS 10

Determining aquifer parameters for unconfined, leaky and non-leaky aquifers – steady and transient conditions - Slug test – Locating hydro geological boundaries – Image well theory – Determination of well characteristics and specific capacity of wells – Well characteristics of large diameter wells.

UNIT IV WELL DESIGN AND CONSTRUCTION 8

Well design criteria – Construction of wells – Well drilling methods – Filter design – Artificial and natural packing – Well castings and screens – Production test – Maintenance of production wells.

UNIT V SPECIAL TOPICS 9

Methods of artificial groundwater recharge – Groundwater assessment and balancing – Seawater intrusion in coastal aquifers – Land Subsidence - Wells in hard rock areas.

UNIT VI PRACTICAL 30

Geophysical survey – Aquifer parameter estimation - Infiltration test – Permeability test – Drum culture experiment – Groundwater data analysis – Groundwater Models – MODFLOW, MODPATH and MT3D - Regional Groundwater Modeling.

TOTAL (L: 45+ P:30): 75 PERIODS

REFERENCES:

1. Todd D.K., Groundwater Hydrology, John Wiley & Sons, Inc, New York, 1976.
2. Bear J., Hydraulics of Groundwater, McGraw-Hill, New York, 1979.
3. Bouwer H., Groundwater Hydrology, McGraw-Hill, New York, 1978.
4. Driscoll, Groundwater and Wells, Johnson Filtration Systems, Inc., 1986.
5. Hantush M.S., Hydraulics of wells in Advances in Hydro science, Academic Press, 1964.
6. Ojha, C.S.P, Berndtsson, R and Bhunya, P., Engineering Hydrology, Oxford University Press,New Delhi, 2008.

HW 9102	SURFACE WATER HYDROLOGY	L	T	P	C
		3	0	0	3

OBJECTIVE:

- This subject aims at making the students to understand the relevance of various components of hydrologic cycle, which are responsible for spatial and temporal distribution of water availability in any region.

UNIT - I ATMOSPHERIC WATER SYSTEM 9

Hydrologic cycle – Climate – Weather – Layers in atmosphere – Types and forms of precipitation – Hydro meteorological measurements – Cyclones – Fronts – Winds – Monsoon – Clouds – Requirements for Precipitation.

UNIT II HYDROLOGIC PROCESSES 9

Rainfall – Rain gauges – Adequacy of network – Spatial and Temporal distribution – Frequency and Intensity/duration analysis – Consistency - Missing data – Abstractions – Infiltration – Evaporation – Interception – Process, Estimation and Measurement – depression and detention storages.

UNIT III RUNOFF 9

Detailed study of runoff process; Systems approach for the rainfall-runoff relationship; Hydrograph analysis; Unit Hydrographs; Runoff routing - Concept of mathematical models; Yield estimation.

UNIT IV HYDROMETRY 9

Hydrological network; Stream flow measurement; Importance of rating curve; Flow measuring structures; Accuracy of measurement; Site selection for flow measuring structures.

UNIT V WATER CONSERVATION AND MANAGEMENT 9

Reservoir Planning – Flood control structures – Rain Water Harvesting in rural and urban areas – Retention and Detention structures.

TOTAL: 45PERIODS

REFERENCES:

1. Chow V.T., Maidment D.R., Mays L.W., Applied Hydrology, McGraw Hill Publications, New York, 1995.
2. Ragunath H.M., Hydrology, Wiley Eastern Ltd., New Delhi, 1994.
3. Ven Te Chow, Hand book of Hydrology, McGraw Hill Publications, New York, 1995.
4. Subramanya K., Hydrology,Tata McGraw Hill Co., New Delhi, 1994.
5. Vijay P.Singh., Elementary Hydrology, Prentice Hall of India, New Delhi, 1994.

IM 9101 INTEGRATED WATER RESOURCES MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- Students will be introduced to the role of disciplines of ecology and socio-economics play in management of water resources..
- They will be exposed to global food security and public-private participation issues and legal and regulatory settings, in the context of IWRM

UNIT I CONTEXT FOR IWRM 8

Water as a global issue: key challenges and needs – Definition of IWRM within the broader context of development – Complexity of the IWRM process – Examining the key elements of IWRM process.

UNIT II WATER ECONOMICS 12

Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments, policy options for water conservation and sustainable use – Case studies. Pricing: distinction between values and charges – Private sector involvement in water resources management: PPP objectives, PPP options, PPP processes, PPP experiences through case studies – Links between PPP and IWRM.

UNIT III WATER SUPPLY AND HEALTH WITHIN THE IWRM CONSIDERATION 9

Links between water and human health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Health impact assessment of water resources development.

UNIT IV AGRICULTURE IN THE CONCEPT OF IWRM 10

Water for food production: ‘blue’ versus ‘green’ water debate – Virtual water trade for achieving global water security – Irrigation efficiencies, irrigation methods and current water pricing.

UNIT V WATER LEGAL AND REGULATORY SETTINGS 6

Basic notion of law and governance: principles of international and national law in the area of water management. Understanding UN law on non-navigable uses of international water courses – Development of IWRM in line with legal and regulatory framework.

TOTAL: 45 PERIODS

REFERENCES:

1. Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.
2. Mollinga .P. etal " Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006
3. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
4. Technical Advisory Committee, Poverty Reduction and IWRM, Technical Advisory Committee Background paper no: 8. Global water partnership, Stockholm, Sweden, 2003.
5. Technical Advisory Committee, Regulation and Private Participation in Water and Sanitation section, Technical Advisory Committee Background paper No:1. Global water partnership, Stockholm, Sweden, 1998.
6. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
7. Technical Advisory Committee, Water as social and economic good: How to put the principles to practice". Technical Advisory Committee Background paper No: 2. Global water partnership, Stockholm, Sweden, 1998.
8. Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.

HW 9121 **ADVANCED HYDRAULICS** **L T P C**
3 0 0 3

OBJECTIVE:

- Application of principles of fluid mechanics to the solution of problems encountered in both natural and constructed water systems.
- Use of model studies and computers in solving a host of problems in hydraulic engineering.

UNIT I HYDRAULICS OF PIPELINES AND PIPE NETWORKS 9
Review of fluid mechanics. Reynolds transport theorem and applications. Steady flow analysis of pipe network systems. Unsteady flows - basic equations of water hammer, solution by method of characteristics. Network Analysis

UNIT II STEADY VARIED FLOWS IN OPEN CHANNELS 9
Basic concepts of uniform flow. Specific energy and specific force concepts. Dynamic equation for spatially varied flows. Flow profile computations. Introduction to HEC-RAS. Spatially varied flows and rapidly varied flows – applications.

UNIT III UNSTEADY FLOWS IN OPEN CHANNELS 9
Equations of motion. Uniformly progressive wave. Rapidly varied unsteady flow – positive and negative surges. Dam break problem.

UNIT IV SEDIMENT TRANSPORT 9
Sediment properties – inception of sediment motion – bed forms. Bed load suspended load – Total sediment transport. Design of stable channels and regime channels. Reservoir sedimentation and trap efficiency.

UNIT V FLOW MEASUREMENTS AND HYDRAULIC MODELING 9
Sharp-Crested weirs, broad-crested weirs, critical depth flumes. Recent advancement in open channel flow measurements. Physical modeling in hydraulics. Dimensional analysis. Modeling closed flows and free surface flows. Distorted models. Design of physical models.

TOTAL: 45 PERIODS

REFERENCES:

1. Wurbs R.A., and James W.P. Water Resources Engineering. Prentice Hall of India, Eastern Economic Edition. ISBN: 81-203-2151-0, New Delhi, 2007.
2. Subramanya K., Flow in Open Channels (2nd ed.) Tata McGraw Hill, ISBN 00-746-2446-6, New Delhi 2003.
3. Chaudhry M. H., Open Channel Flow. Prentice Hall of India, Eastern Economic Edition , . ISBN: 81-203-0863-8,New Delhi. 1994.
4. Chow Ven-te Open Channel Hydraulics McGraw Hill, New York NY 1959.
5. French, R. H., Open Channel Hydraulics McGraw Hill, New York NY 1985.
6. Srivastava R. Flow through Open Channels Oxford University Press New Delhi 2008.

HW 9122 ADVANCED HYDROLOGIC ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

OBJECTIVE:

- Introduce the concepts of systems approach to hydrological modeling.
- Study types and classes of hydrologic simulation models.
- Design procedures used for safe and effective passage of flood flows and discuss the design methods for airport drainage, urban storm sewers,flood control reservoir and spillway design.
- Analysis of Hydrologic time series and stochastic hydrologic models.

UNIT I HYDROLOGIC AND HYDRAULIC MODELS 12

Hydrologic investigation - systems approach – concept of a model. Classification of hydrological models, Chow-Kulandaiswamy model. Time-area methods –Unit Hydrograph – Instantaneous Unit Hydrograph. – Synthetic Unit Hydrographs. Clark model, Nash model, Tank model.

UNIT II HYDROLOGIC SIMULATION AND STREAM FLOW SYNTHESIS 8

Classification of Hydrologic Simulation Models. Single-Event Rainfall-Runoff Models. Continuous Simulation Models. Groundwater Flow Simulation Models. Streamflow Synthesis.

UNIT III HYDROLOGIC DESIGN 9

Hydraulic Structure Design Methods – Risk Analysis – Design Storms and its synthesis. Design Flows. Urban Storm Drainage Design, Airport Drainage Design, Detention Storage Design.

UNIT IV RANDOM PROCESSES 8

Classification – Stationary Random process - Components of time series – Trend Analysis – Regression – Multiple Linear Regression – Diagnostic tools.

UNIT V FORECASTING MODELS 8

Box Jenkins' models – Correlation – Auto correlation – Partial auto correlation – Yule Walker equations – AR(p) – MA(q) – ARMA(p,q) – ARIMA (p,d,q) models – model formulation – Validation – Application.

TOTAL: 45 PERIODS

REFERENCES:

1. Singh, V. P. Hydrologic Systems, Prentice-Hall Englewood Cliffs, NJ 1989.
2. Jayarami Reddy P., Stochastic Hydrology Laxmi Publications, New Delhi 1995.
3. Viessman W Jr. Introduction to Hydrology (5ed) Pearson Education, Inc. 2003.
4. Haan C.T., Statistical Methods in Hydrology Iowa State Press 2002.

HW 9123 REMOTE SENSING AND GIS FOR WATER RESOURCES

L	T	P	C
3	0	2	4

OBJECTIVE:

- To teach the principles and applications of remote sensing, GPS and GIS in the context of water resources. 2. At the end of the course, the student will appreciate the importance of remote sensing and GIS in solving the spatial problems in water resources.

UNIT I REMOTE SENSING **8**

Physics of remote sensing, electromagnetic radiation (EMR), Interaction of EMR with atmosphere, earth surface, soil, water and vegetation; Remote sensing platforms – Monitoring atmosphere, land and water resources - LANDSAT, SPOT, ERS, IKONOS and others, Indian Space Programme.

UNIT II DIGITAL IMAGE PROCESSING **8**

Satellite Data analysis - Visual interpretation – Digital image processing – Image preprocessing – Image enhancement – Image classification – Data Merging.

UNIT III GEOGRAPHIC INFORMATION SYSTEM **9**

Definition – Basic components of GIS – Map projections and co-ordinate system – Spatial data structure: raster, vector – Spatial Relationship – Topology – Geodatabase models: hierarchical, network, relational, object oriented models – Integrated GIS database -common sources of error – Data quality: Macro, Micro and Usage level components - Meta data - Spatial data transfer standards.

UNIT IV SPATIAL ANALYSIS **9**

Thematic mapping – Measurement in GIS: length, perimeter and areas – Query analysis – Reclassification – Buffering - Neighbourhood functions - Map overlay: vector and raster overlay – Interpolation – Network analysis –Digital elevation modelling. Analytical Hierarchy Process, – Object oriented GIS – AM/FM/GIS – Web Based GIS

UNIT V WATER RESOURCES APPLICATIONS **11**

Spatial data sources – 4M GIS approach water resources system – Thematic maps - Rainfall-runoff modelling – Groundwater modeling – Water quality modeling - Flood inundation mapping and Modelling – Drought monitoring – Cropping pattern change analysis –Performance evaluation of irrigation commands. Site selection for artificial recharge - Reservoir sedimentation.

UNIT VI GIS LABORATORY 30

GPS – Map projection – Transformation – Different data format – Creating spatial data – Attribute data entry – Spatial analysis – Reclassification – Overlay analysis – Interpolation – Digital Elevation Model.

TOTAL (L: 45 +P: 30): 75 PERIODS

REFERENCES:

1. Lillesand, T.M. and Kiefer, R.W., Remote Sensing and Image Interpretation III Edition. John Wiley and Sons, New York. 1993.
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems,.Oxford University Press. New York. 1998.
3. Ian Heywood Sarah, Cornelius and Steve Carver An Introduction to Geographical Information Systems. Pearson Education. New Delhi, 2002.
4. Centre for Water Resources, Change in Cropping Pattern in Drought Prone Chittar Sub-basin, Project Report, Anna University, Chennai, 2002.
6. Centre for Water Resources, Post-Project Evaluation of Irrigation Commands.

HW 9124 SYSTEMS ANALYSIS IN WATER RESOURCES

L	T	P	C
3	0	0	3

OBJECTIVE:

- Students will be introduced to application of systems concept to water resources planning and management. 2. Optimization technique for modeling water resources systems and advanced optimization techniques to cover the socio-technical aspects will be taught.

UNIT I SYSTEM CONCEPTS 7

Definition, classification, and characteristics of systems - Scope and steps in systems engineering - Need for systems approach to water resources and irrigation.

UNIT II LINEAR PROGRAMMING 9

Introduction to operations research - Linear programming, problem formulation, graphical solution, solution by simplex method - Sensitivity analysis, application to design and operation of reservoir, single and multipurpose development plans - Case studies.

UNIT III DYNAMIC PROGRAMMING 9

Bellman's optimality criteria, problem formulation and solutions - Application to design and operation of reservoirs, Single and multipurpose reservoir development plans - Case studies.

UNIT IV SIMULATION 9

Basic principles and concepts - Random variant and random process - Monte Carlo techniques - Model development - Inputs and outputs - Single and multipurpose reservoir simulation models - Case studies.

UNIT V ADVANCED OPTIMIZATION TECHNIQUES 11

Integer and parametric linear programming - Goal programming models with applications Discrete differential dynamic programming and incremental dynamic programming - Linear decision rule models with application - Stochastic dynamic programming models.

TOTAL: 45 PERIODS

REFERENCES:

1. Gupta P.K and Man Mohan, Problems in Operations Research (Methods and solutions). Sultan Chand and sons, New Delhi, 1995
2. Hiller F.S and Liebermann G.J., Operations Research CBS Publications and distributions. New Delhi, 1992.
3. Chaturvedi. M.C., Water Resources Systems Planning and Management. Tata McGraw Hill, New Delhi, 1997.
4. Mays L.W., and Tung YK, Hydro systems Engineering and Management. McGraw Hill Inc., New York, 1992.
5. Goodman Alvin S., Principles of Water Resources Planning, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1995.
6. Course material, Micro Computer Application to Systems Analysis in Irrigation Water Management, CWR, Anna University, 1992.
7. Wagner H.M., Principles of Operations Research with Application to Management Decisions, Prentice Hall, India, New Delhi, 1993.

IW 9131 SOFT COMPUTING AND SIMULATION IN WATER RESOURCES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To develop in students, skills of software usage for water resources management.
- To enable the students to understand application of the latest information technology to water resources engineering

UNIT I COMPUTING TECHNIQUES 10

Computer methods in water resources - Algorithms and Flowcharts- Computing techniques - Solution to ordinary and partial differential equation using Finite difference and Method of Characterics- Numerical integration and differentiation Design of digital models - Visual programming - Graphical user interface - Real computing -Interactive model concepts.

UNIT II ARTIFICIAL INTELLIGENCE 10

Heuristic search - Knowledge based Expert system concepts - Architecture and applications in Water Resources Management - Expert system shells - Principle of Artificial Neural Network (ANN) - Application of ANN Model to Hydrology and Crop Water Requirement model. Fuzzy Logic concepts and Applications – Genetic Algorithms

UNIT III DIGITAL DATA MANAGEMENT 10

Data base structure - Data acquisition - Data warehouse - Data retrieval-Data format Attribute - RDBMS - Data analysis - Network data sharing - Statistical Analysis (SYSTAT) - Regression - factor analysis - histogram - scatter diagram - Goodness of fit.

UNIT IV SIMULATION SOFTWARE IN WATER RESOURCES 8

Surface water models (HMS) - Storm Water Management Models (SWMM) - Water CAD, STORM CAD - Ground Water Flow models - Visual Modflow-FEFLOW

UNIT V SIMULATION MODELS IN IRRIGATION WATER MANAGEMENT 7

Soil moisture simulation models - Basin simulation models (MITSIM, VASIM, SIMYIELD) Real time operation models - Water Resources Information System, Management Information System.

TOTAL: 45 PERIODS

REFERENCES:

1. Aliev R. A, and Aliev Rashad Soft Computing and its Applications World Scientific Publications Co. Pte. Ltd. Singapore, 2001.
2. Janusz Kacprzyk *Applied Decision with Soft Computing* Springer, 2003
3. Carlos A. Coello Coello, David A Van Veldhuizen, Gary B Lamont, Evolutionary Algorthms for Solving Multi-objective problems, Springer, 2002.
4. Vijay P Singh, Hydrologic Systems: Rainfall Runoff Modeling, Prentice Hall, 1988.
5. John E. Gribbin, Introduction to hydraulics and hydrology with applications for Storm water Management. DELMAR, Thomson Learning, USA,2002.
6. Remson I, Hornberger G.M. and Moiz F.J., Numerical methods in Sub-Surface Hydrology. Wiley Inter Science, 1985
7. Kazda, I., Finite element Techniques in ground water flow studies (with Applications in Hydraulic and Geotechnical Engineering), Elsevier, 1990.

8. ABBOT M.B., Computational hydraulics Elements of the Theory of Free surface flows. Pitman Advanced publishing Program, 1999.
9 . Loucks Daniel P., Jery R Stedinger and Douglas, A. Haith, Water Resources Systems Planning and Analysis. Prentice Hall Inc., Englewood Clifts, New Jersey, 1981.

CM 9122 **COASTAL ENGINEERING**

L	T	P	C
3	0	0	3

OBJECTIVE:

- The main purpose of coastal engineering is to protect harbors and improve navigation. The students to the diverse topics as wave mechanics, wave climate, shoreline protection methods and laboratory investigations using model studies.

UNIT I INTRODUCTION TO COASTAL ENGINEERING 6

Introduction - wind and waves – Sea and Swell - Introduction to small amplitude wave theory – use of wave tables- Mechanics of water waves – Linear (Airy) wave theory.

UNIT II WAVE PROPERTIES AND ANALYSIS 7

Introduction to non-linear waves and their properties – Waves in shallow waters – Wave Refraction, Diffraction and Shoaling –Hindseast wave generation models, wave shoaling; wave refraction; wave breaking; wave diffraction random and 3D waves- Short term wave analysis – wave spectra and its utilities - Long term wave analysis- Statistics analysis of grouped wave data.

UNIT III COASTAL SEDIMENT TRANSPORT 10

Dynamic beach profile; cross-shore transport; along shore transport (Littoral transport), sediment movement

UNIT IV COASTAL DEFENSE 11

Field measurement; models, groins, sea walls, offshore breakwaters, artificial nourishment - planning of coast protection works - Design of shore defense structures – Case studies.

UNIT V MODELING IN COASTAL ENGINEERING 11

Physical modeling in Coastal Engineering – Limitations and advantages – Role of physical modeling in coastal engineering – Numerical modeling – Modeling aspects – limitations – Case studies using public domain models.

TOTAL: 45 PERIODS

REFERENCES:

1. Dean, R.G. and Dalrymple, R.A., Water wave mechanics for Engineers and Scientists, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994.
2. Ippen, A.T., Estuary and Coastline Hydrodynamics, McGraw-Hill Book Company, Inc., New York, 1978.
3. Sorenson, R.M., Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.
4. Coastal Engineering Manual, Vol. I-VI, Coastal Engineering Research Centre, Dept. of the Army, US Army Corps of Engineers, Washington DC, 2006.
6. Kamphuis, J.W., Introduction to coastal engineering and management

HW 9151	ENVIRONMENTAL HYDRAULICS	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To apply the knowledge of fluid mechanics to analyze and predict mixing in natural bodies of water.
- To study the hydrodynamic aspects of water quality management in natural bodies of water.

UNIT I FUNDAMENTAL RELATIONSHIPS FOR FLOW AND TRANSPORT 9

Concentration and units of measure – Conservation laws – Systems and Control Volume approach – Differential element approach – Sources, Sinks and box-models – Mixing.

UNIT II DIFFUSION AND DISPERSION 9

Derivation of diffusion equation – Solution of diffusion equation – Advective diffusion – Turbulent diffusion – Shear flow diffusion.

UNIT III TRANSPORT PROCESSES IN RIVERS 9

Mixing in Rivers – Continuous point discharges – Two rivers mixing – Dispersion in rivers.

UNIT IV TRANSPORT PROCESSES IN LAKES AND RESERVOIRS 9

Reservoir classification – External energy sources – Surface layer – mixing in the hypolimnion – inflows and outflows.

UNIT V TRANSPORT PROCESSES IN THE ESTUARIES 9

Classification – Forces – wind, tides, rivers – Trapping and pumping – Estuarine Circulation.

TOTAL: 45 PERIODS

REFERENCES:

1. Fischer, H.B., List, E.G., Koh, R.C.Y., Imberger, J and Brooks, N.H. Mixing in Inland and Coastal Waters Academic Press, New York, 1979.
2. Clark, M.M., Transport Modeling for Environmental Engineers and Scientists John Wiley and Sons, New York. 1996.
3. Martin J.L. and McCutcheon S.C. Hydrodynamics and Transport for Water Quality Modeling CRC Press, Inc. ISBN:0-87371-612-4, 1999.
4. Chapra, S.C. Surface Water Quality Modeling McGraw Hill Book Co. Singapore, 1997.
5. M.Thomann, R.V. and Mueller, J.A. Principles of Surface Water Quality Modeling and Control Harper and Row, New York, 1987.
6. Csanady, G.T., Turbulent Diffusion in the Environment D.Reidel Publishing Co. Holland, 1973.

HW 9152 FLOOD AND DROUGHT MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- This subject aims at making the students to understand the hydrologic extremes of floods and droughts, estimation of severity and extent of damages and the mitigation measures to combat them.

UNIT I FLOOD ESTIMATION AND ROUTING 10

Estimation of design flood – SPF/MPF empirical methods – Statistical methods – Frequency analysis – Unit hydrograph method – Flood estimation in small watersheds and mountainous region – Estimation by lumped, distributed model – Routing – Lumped – Distributed – Hydraulic and hydrological routing.

UNIT II FLOOD CONTROL AND MANAGEMENT 9

Flood control methods – Structural and non structural measures - Flood plain Zoning – Flood disaster monitoring and mitigation procedure – Methods of forecasting – Data analysis and warning – Flood fighting -Remote Sensing for flood management

UNIT III DROUGHTS 6

Definitions based on rainfall, stream flow, vegetation and comprehensive aspects - Characterisation of Drought/water shortage/aridity/desertification - NCA classification – Direct and indirect losses

UNIT IV DROUGHT ASSESSMENT 10

Drought indices - Drought severity assessment – meteorological, hydrological and agricultural aspects - IMD, Palmer, Herbst, Aridity Indices and Ramaprasad methods.

UNIT V DROUGHT MONITORING AND MANAGEMENT 10

Drought monitoring - Supply and demand oriented measures – Traditional water conservation - Drought Prone Areas Programme (DPAP) – Integrated drought management – Remote Sensing Applications for drought mitigation - NDVI concepts.

TOTAL: 45 PERIODS

REFERENCES:

1. Chow V.T., Maidment D.R., Mays L.W., Applied Hydrology, McGraw Hill Publications, New York, 1995.
2. Vijay P.Singh., Elementary Hydrology, Prentice Hall of India, New Delhi, 1994.
3. Yevjevich V., Drought Research Needs, Water Resources Publications, Colorado State University, USA, 1977.
4. Rangapathy V., Karmegam M., and Sakthivadivel R., Monograph in Flood Routing Methods as Applied to Indian Rivers, Anna University Publications, 1988.

HW 9153 GROUNDWATER MODELING AND MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- To introduce the students to the application of management models to estimate the groundwater quantity and qualities. After the completion of the course, the student should able to understand the inputs, system parameters, policy, variables and outputs of a groundwater management models.

UNIT I GROUNDWATER PROSPECTING 9

Investigation and evaluation – Geophysical methods- Electrical Resistivity methods – Interpretation of data – Seismic method – Subsurface investigation – Test drilling – Resistivity logging – Application of remote sensing techniques.

UNIT II GROUNDWATER FLOW MODEL 9

Physical models – Analog models – Mathematical modeling – Unsaturated flow models Numerical modeling of groundwater flow – Finite Differential equations - Finite difference solution – Successive over Relaxation, Alternating direction implicit procedure – Crank Nicolson equation – Iterative methods -Direct methods - Inverse problem – Finite element method

UNIT III CONTAMINANT TRANSPORT MODEL 9

Contaminant transport theory – Advection, dispersion equation – Longitudinal and transverse dispersivity – Hydrodynamic dispersion – Analytical models – Numerical simulation of solute transport – Solution methods - Sorption model – Subsurface mass transport through the vadose zone - Density driven flow - Heat transport.

UNIT IV MODEL DEVELOPMENT 9

Data requirements – Conceptual model design : Conceptualization of aquifer system – Parameters, Input-output stresses, Initial and Boundary conditions - Model design and execution : Grid design, Setting boundaries, Time discretization and Transient simulation – Model calibration : steady state and unsteady state – sensitivity analysis – Model validation and prediction – Uncertainty in the model prediction

UNIT V GROUNDWATER MANAGEMENT MODEL 9

Optimal groundwater development – Indian GEC norms – Conjunctive use models Modeling multilayer groundwater flow system -Modeling contaminant migration – Modeling fracture flow system – Artificial recharge feasibility through modeling – Simulation of movements of solutes in unsaturated zone – Stochastic modeling of groundwater flow - Groundwater contamination, restoration and management

TOTAL: 45 PERIODS

REFERENCES:

1. Anderson M.P., and Woessner W.W., Applied Groundwater Modelling : Simulation of flow and advective transport, Academic Press, Inc., 1992
2. Fetter C.W., Contaminant Hydrogeology, Prentice Hall, 1999
3. Rushton K.R., Groundwater Hydrology : Conceptual and Computational Models, Wiley, 2003
4. Elango L. and Jayakumar, R. Modelling in Hydrology, Allied Publishers Ltd., 2001
5. Remson I., Hornberger G.M. and Moltz F.J., Numerical Methods in Subsurface Hydrology, Wiley, New York, 1971
6. Robert Willis and William W.G.Yenth, Groundwater System Planning and Management, Prentice Hall, Englewood Cliffs, New Jersey, 1987.
7. Groundwater Hydraulics and Pollutant Transport, Randall J.Charbeneau, Printice Hall, 2000

HW 9154 URBAN WATER RESOURCES MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- To introduce the concepts of urbanization and its impact on the natural water cycle. At the completion of the course, the student should be able to apply appropriate management techniques for planning, operating and maintaining the different components of urban and drainage system.

UNIT I URBAN HYDROLOGIC CYCLE 9

Water in the urban eco-system – Urban Water Resources – Major problems – Urban hydrological cycle – Storm water management objectives and limitations – Storm water policies – Feasibility consideration.

UNIT II URBAN WATER RESOURCES MANAGEMENT MODELS 9

Types of models – Physically based – conceptual or unit hydrograph based – Urban surface runoff models – Management models for flow rate and volume control rate – Quality models.

UNIT III URBAN STORM WATER MANAGEMENT 9

Storm water management practices (Structural and Non-structural Management measures) – Detention and retention concepts – Modelling concept – Types of storage – Magnitude of storage – Hydraulic analysis and design guidelines – Flow and storage capacity of urban components – Temple tanks.

UNIT IV MASTER PLANS 9

Planning and organizational aspects – Inter dependency of planning and implementation of goals and measures – Socio – economics financial aspects – Potential costs and benefit measures – Measures of urban drainage and flood control benefits – Effective urban water user organizations.

UNIT V OPERATION AND MAINTENANCE 9

General approaches to operations and maintenance – Complexity of operations and need for diagnostic analysis – Operation and maintenance in urban water system – Maintenance Management System – Inventories and conditions assessment – Social awareness and involvement.

TOTAL: 45 PERIODS

REFERENCES:

1. Geiger, W.F., Marsalek, F., and Zuidena, F.C., (Ed), manual ondrainage in urbanized areas – Vol.1 and Vol.II, UNESCO, 1987.
2. Hengeveld, H. and C. De Voch.t (Ed)., Role of Water in Urban Ecology, 1982.
3. Martin, P. Wanelista and Yousef, A. Yousef., Storm Water Management, John Wiley and sons, 1993.
4. Neil S. Grigg., Urban Water Infrastructure Planning, Management and Operations, John Wiley and Sons, 1986.
5. Overtens D.E. and Meadows M.E., Storm Water Modelling, Academic Press, New York, 1976.

HW 9155 WATER-POWER AND DAM ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES:

- The student is exposed to the design aspects of hydro-power plants, various components of hydropower plants and their layout.
- Different types of dams design taking into account the suitability of the site and the different types loads that are likely to be encountered.

UNIT I HYDROELECTRIC POWER DEVELOPMENT 9

Introduction – Types of power development – Classification. Planning – Environmental Considerations - Data requirement for assessment of hydropower. Components of hydropower.

UNIT II DESIGN OF HYDROPOWER INSTALLATION 9

Components – Intake structure – water conductor systems – tunnels – surge tanks – penstocks – valves – anchor blocks.

UNIT III TYPES OF POWER HOUSE 8

Underground – semi-underground. Turbines and their foundations – structural and geotechnical aspects of power house design.

UNIT IV EMBANKMENT DAM ENGINEERING 9

Introduction. Nature and classification of engineering soils. Principles of design. Materials and construction. Internal seepage. Stability and stress. Settlement and deformation. Rockfill and rockfill embankments.

UNIT V CONCRETE DAM ENGINEERING 10

Loading: Concepts and criteria. Gravity dam analysis. Buttress dam analysis. Arch dam analysis. Design features and construction. Concrete for dams. Dam safety and instrumentation. Foundation measurements. Analysis of strain data.

TOTAL: 45 PERIODS

REFERENCES:

1. Novak, P., Moffat, A.I.B., Nalluri, C. and Narayanan, R. Hydraulic Structures Unwin Hyman Ltd., London 1989.
2. Dandekar, M.M. and Sharma, K.N. Water Power Engineering Vikas Publishing House, New Delhi 1994.
3. USBR Design of Small Dams Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 1974.
4. Sharma, H.D. Concrete Dams Metropolitan New Delhi 1981
5. Varshney, R.S. Concrete Dams Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi 1982.
6. Varshney, R.S. Hydro Power Structures – Nem Chand Bros. Roorkee 1973 Guthrie, Brown J. (ed) Hydro Electric Engineering Practice Blackie and Son, Glasgow 1970.

HW 9156 WATER SUPPLY DISTRIBUTION AND BURIED PIPELINES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To educate the students in detailed design concepts related to water transmission mains, water distribution system and buried pipes with emphasis on computer application

UNIT I WATER SUPPLY SYSTEMS 9

Water requirement – sources of water – water demand – reservoir storage – nodal hydraulic gradient level values - water supply consideration, Types of water supply systems- piping system- distribution network- labeling- network components – Network models – design – optimization in practice

UNIT II HYDRAULIC PRINCIPLES AND NETWORK PARAMETERS 10

Energy and hydraulic gradient lines – head loss in links – equivalent pipes – series – parallel pipes – path head loss and loop head loss – analysis of water distribution network- static node, dynamic node – network performance – flow analysis - Layout – in situ lining - pipes material – appurtenances – minimization of water losses – leak detection.

UNIT III STORM WATER DISTRIBUTION AND BURIED PIPES 10

Planning – runoff estimation – rainfall data analysis – storm water drain design Introduction to Buried pipes – external loads – gravity flow design, pressurized flow- rigid and flexible pipes – installation – trenchless technology

UNIT IV RELIABILITY ASSESSMENT AND DESIGN 8

Uncertainty and reliability – affecting events- assessment – reliability parameters- configurations. Design methodology - strengthening and expansion

UNIT V SOFTWARE APPLICATIONS 8

Use of software in water transmission, water distribution and sewer design – LOOP 4.0, SEWER, EPANET, BRANCH, SEWERCAD, WATERCAD, STROMNET

TOTAL: 45 PERIODS

REFERENCES:

1. Bhave P. R, Optimal design of water distribution networks, Narosa publishing House, New Delhi, 2003
2. Bajwa. G. S, Practical handbook on Public Health Engineering, Deep publishers, Shimla 2003
3. Manual on water supply and treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999
4. B.A. Hauser, practical hydraulics Hand Book, Lewis Publishers, New York, 1991
5. Moser A. P, Buried pipe Design, 3rd Edition, American Water Works Association
6. Robert van Bentum and Lan K. Smout, Buried Pipe lines for surface Irrigation, The Water, Engineering and Development Centre, Intermediate Technology Publications,UK,1994

HW 9157 **RIVER ENGINEERING**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To understand theoretical concepts of water and sediment movements in rivers
- To inculcate the benefits of fluvial system to the society

UNIT I RIVER FUNCTIONS **8**

Primary function of a river – River uses and measures – Water and Sediment loads of river – Rivers in India, Himalaya and Peninsular.

UNIT II RIVER HYDRAULICS **10**

Physical Properties and Equations – Steady flow in rivers – uniform and non uniform – Turbulence and velocity profiles – resistance co efficients – Boundary conditions and back waters – Transitions – Rating Curve – Unsteady flow in rivers : Propagative of surface waves – Characteristics, flood waves – knematic and diffusion analogy – velocity of propagation of flood waves – Flood wave –Maximum

UNIT III RIVER MECHANICS **9**

River Equilibrium : Stability of Channel – regime relations – river bend equilibrium – hydraulic geometry of downstream - Bars and meandering - River dynamics – degradation and aggradation of river bed – Confluences and branches – River Data base.

UNIT IV RIVER SURVEYS AND MODEL **9**

Mapping – Stage and Discharge Measurements – Sediments – Bed and suspended load – Physical hydraulic Similitude – Rigid and mobile bed – Mathematical – Finite one dimensional – multi – dimensional – Water Quality and ecological model

UNIT V RIVER MANAGEMENT **9**

River training works and river regulation works – Flood plain management – waves and tides in Estuaries - Interlinking of rivers – River Stabilization

TOTAL: 45 PERIODS

REFERENCES:

1 Janson PL.Ph., Lvan BendegamJvanden Berg, Mdevries A. Zanen (Editors), Principles of River Engineering – The non tidal alluvial rivers – Pitman, 1979.
2. Pierre Y. Julien ., River Mechanics ,Cambridge University Press, 2002.
3. K.L Rao , INDIA's WATER WEALTH – Orient Longman Ltd., 1979.

IW 9152	ENVIRONMENTAL IMPACT ASSESSMENT OF WATER RESOURCES DEVELOPMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students to the need, methodology, documentation and usefulness of environmental impact assessment in water resources development.

UNIT I ENVIRONMENTAL ISSUES 7

Water resources development and environmental issues – Environment in water resources project planning – Environmental regulations and requirements – The EIA (Environmental Impact Assessment) notification.

UNIT II EIA FUNDAMENTALS 8

Environmental Impact Assessment (EIA) – Environmental Impact Statement – EIA in Project Cycle – Legal and Regulatory aspects in India according to Ministry of Environment and Forests – Types and limitations of EIA – Cross sectoral issues and terms of reference in EIA –Participation of Public and Non-Governmental Organizations in environmental decision making

UNIT III ENVIRONMENTAL IMPACTS 10

Hydrological and water quality impacts – Ecological and biological impacts – Social and cultural impacts – Soil and landscape changes – Agro economic issues – Human health impacts – Ecosystem changes.

UNIT IV METHODS OF EIA 10

EIA team formation – Development of scope, mandate and study design – Base line survey – Check lists – Ad hoc procedures – Network and matrix methods – Semi-quantitative methods – ICID checklist – Economic approaches – Environmental Impact Statement (EIS) preparation.

UNIT V ENVIRONMENTAL MANAGEMENT 10

In-stream ecological water requirements - Public participation in environmental decision making – Sustainable water resources development – Ecorestoration – Hydrology and global climate change – Human ecology – Ecosystem services – Environmental monitoring programs.

TOTAL: 45 PERIODS

REFERENCES:

1. Canter, L.W., Environmental Impact Assessment. McGraw Hill International Edition, New York. 1995.
2. Barathwal, R.R., Environmental Impact Assessment. New Age International Publishers, New Delhi. 2002.
3. Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell Science London. 1999.
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Inter Science, New Jersey. 2003.
5. Arnel, N., Hydrology and global environmental change. Prentice Hall, Harlow. 2002.
6. Chari. B., Richa Sharma and S.A. Abbasi, Comprehensive Environmental Impact Assessment of Water Resources Projects : With Special Reference to Sathanur Reservoir Project (Tamil Nadu)/K. Discovery Pub., New Delhi, 2005.
7. UNEP's Environmental Impact Assessment Training Resource Manual -Second Edition, 2002.

IW 9121 GROUNDWATER AND DRAINAGE ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES:

- Students will be exposed to ground water, hydraulics of ground water related to drainage, drainage concepts, planning, design and management of drainage related work.
- They will learn about the latest developments in ground water applications to drainage on the basis of a clear understanding of the principles of drainage engineering.

UNIT I BASICS OF GROUND WATER 8

Occurrence of Ground water – Utilization – Ground water component in hydrologic cycle – Geological formations – Types of aquifers and their characteristics – Ground water movement – Darcy's Law.

UNIT II GROUND WATER HYDRAULICS RELATED TO DRAINAGE 10

Steady and unsteady flow of ground water– Ground water recharge – Dupuit-Forchheimer assumptions - Subsurface flow into drains – Steady and unsteady state drainage equations – Seepage from river into aquifers – Seepage from open channels.

UNIT III DRAINAGE PRINCIPLES AND CRITERIA 9

Factors to be considered in land drainage – Combined irrigation and drainage systems - Water balance – Equations for water balance – Drainage surveys – Agricultural drainage criteria – Effect of field drainage systems on agriculture.

UNIT IV DESIGN AND MANAGEMENT OF DRAINAGE SYSTEMS 9

Drainage materials – Surface drainage systems, their components and applications in sloping areas – Subsurface drainage systems – Mole drainage - Tube well irrigation - Drainage application and design – Management and maintenance of drainage systems.

UNIT V SALINITY CONTROL 9

Salinity in relation to irrigation and drainage – Salt balance of the root zone – Leaching process – Bio drainage – Environmental aspects of drainage.

TOTAL: 45 PERIODS

REFERENCES:

1. Todd D.K. Ground Water Hydrology, John Wiley and sons, Inc, New York, 1976.
2. Raghunath, H.M., Ground Water, 2nd edition, Wiley Eastern Ltd., New Delhi, 1987.
3. Kessler J., Drainage Principles and Applications Vol. II and IV, International Institute of Land Reclamation and Improvement, Netherlands. 1979.
4. Ritzema H.P., Drainage Principles and Applications, Publication No. 16, International Institute of Land Reclamation and Improvement, Netherlands. 1994.
5. Bhattacharya A.K. and Michael A.M., Land Drainage Principles, Methods and Applications, Konark Publishers Pvt. Ltd., New Delhi. 2003.

IW 9153 REHABILITATION AND MODERNISATION OF IRRIGATION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVE:

- To expose the students to the need and importance of the rehabilitation and modernization of irrigation systems and to train them in the related concepts and methods.

UNIT I IRRIGATION SYSTEMS 9

Historical evolution of irrigation systems in India; its importance to agricultural production. Irrigation system classification – Nature of system modernization and rehabilitation. Distinction between rehabilitation and modernization; Rehabilitation and modernization objectives – Theory and Practice.

UNIT II SYSTEM MAINTENANCE 9

Maintenance: essential, catch up, preventive and normal – Diagnostic analysis of flow, seepage and other parameters through Participatory Rural Appraisal, Rapid Rural Appraisal and Walk-through Survey – Development and maintenance programme – Kudimaramath – Turnover – WUA.

UNIT III PROBLEM IDENTIFICATION 9

System performance: history of inflow, cropping pattern, system alterations, distribution performance – Operational constraints – Management constraints – Resources constraints

UNIT IV REHABILITATION 9

Baseline survey – Deferred maintenance – Causes – Criteria used for taking rehabilitation programmes – Software and hardware improvements – Prioritization – Role of water users' association – Monitoring and evaluation.

UNIT V IMPLEMENTATION 9

Rehabilitation and modernization programmes – Periyar Vaigai Project – Walawe Project – Tank Modernization Project – Water Resources Consolidation Project. IAM WARM Project.

TOTAL: 45 PERIODS

REFERENCES:

1. CWR, Baseline Survey of Irrigation Commands, Centre for Water Resources, Anna University, Chennai. 2000.
2. IIMI and WALMI, The Case of Mahi Kadana, WALMI, Gujarat, India, 1994.
3. CSU, Diagnostic Analysis of Irrigation Systems Volume 2: Evaluation Techniques. Water Management Synthesis Project, Colorado State University, USA. 1984.
4. WAPCOS, Technical Report No. 19-A, Handbook for Improving Irrigation System Maintenance Projects, WAPCOS, New Delhi. 1989
5. CWR, Tank Modernization Project EEC Assistance: Monitoring and Evaluation. Final Reports. Centre for Water Resources, Anna University, Chennai. 2000.
6. CWR, Planning and Mobilization of Farmers Organization and Turnover. Tamil Nadu Water Resources Consolidation Project. CWR and OM, Anna University, Chennai. 1997.

IW 9155 WATER QUALITY AND POLLUTION

L	T	P	C
3	0	2	4

OBJECTIVE:

- This course introduces water quality concepts, its estimation and evaluation for irrigation purposes, besides relevant environmental problems and modeling of non-point pollution sources.
- At the end of the course, the students will understand the importance of water quality for irrigation and environment and the collection and use of water quality data.

UNIT I WATER QUALITY 10

Physical and chemical properties of water – Suspended and dissolved solids – EC and pH – Trace constituents – Principles of water quality. - Water quality investigation – Sampling design - samplers – automatic samplers - data collection platforms – Field kits and investigations – Water quality data storage, analysis and inference – Software packages

UNIT II IRRIGATION WATER QUALITY 10

Water quality standards – Water quality for irrigation – Salinity and permeability - Irrigation practices for poor quality water – Waste water irrigation: problems and prospects – Saline water irrigation – Future strategies - Water quality indices

UNIT III SOURCES OF WATER POLLUTION 10

Leaching of agrochemicals – Domestic sewage – characteristics – Water pollutants from industries – Dissolved oxygen sag curve - Non Point Source (NPS) models – Agricultural Non Point Source (AGNPS) pollution model.

UNIT IV WATER POLLUTION ABATEMENT TECHNOLOGIES 7

Flow diagram and working principle of Activated sludge process, Trickling filter – Oxidation pond – Aerated lagoons – Advantages disadvantages and suitability – Packaged treatment units, advantages, disadvantages – Reverse osmosis

UNIT V RECYCLING AND REUSE OF WASTEWATER 8

Reuse of wastewater in agriculture – prevalence and issues from around the world – Pretreatment technologies – Removal of nutrients from treated water – Economic and social dimensions. – Constructed wetlands – reed beds

UNIT VI LABORATORY 30

Determination of following water quality parameters as per standard methods. Turbidity, Solids, pH, Alkalinity, Hardness, Chlorides, Sulphates, Nitrates, Na, K, MPN, BOD and COD - Evaluation of water quality.

TOTAL (L:45+P:30): 75 PERIODS

REFERENCES:

1. George Tchobanoglous, Franklin Louis Burton, Metcalf & Eddy, H. David Stense, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, 2002.
2. Mackenzie L Davis, David A Cornwell, Introduction to Environmental Engineering, McGraw-Hill 2006.
3. Stum, M and Morgan, A., Aquatic Chemistry, Plenum Publishing company, USA, 1985.
4. Lloyd, J.W. and Heathcote, J.A., Natural inorganic chemistry in relation to groundwater resources, Oxford University Press, Oxford, 1988.
5. Newmann, E.I., Applied ecology, Blackwell Science ltd., Oxford, 1996.
6. Sithamparanathan, J., Rangasamy, A. and Arunachalam, N., Ecosystem principles and sustainable agriculture, Scitech Publishers, Chennai, 1999.
7. US EPA, APHA, AWWA, Standard methods for the examination of water and wastewater, 19th edition, 2003.

IM 9151	WATER POLICIES, LAWS AND RIGHTS	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To understand how the policies, laws and judicial approaches tackle the recent water issues.
- To help formulate recommendations/responses that could resolve/avoid disputes.
- To emphasize water as a finite common property resource that must be used in public interest.

UNIT I WATER RIGHTS: DOCTRINES/PRINCIPLES 9

Introduction – Policy, Law, Bill, Act, Rules, Notifications – Nature of Rights: Natural Rights – Customary Rights – Doctrine of Riparian Rights – Doctrine of Prior Appropriation – Doctrine of Equality – Doctrine of Equitable Apportionment – Public Trust Doctrine – Doctrine of Inter-Generational Equity –Absolute Ownership Theory

UNIT II WATER IN INDIAN CONSTITUTION AND OTHER STATUTES 9

History of Water Laws in India: Pre-Constitutional Water Laws – Constitutional Provisions: Article 14, Article 21, Directive Principles of State Policy, Fundamental Duties, State List-Entry 17 – 73rd and 74th amendments, Article 262 – Water Conflicts and Tribunals – Post-Constitutional Water Laws – National-Level Enactments.

UNIT III WATER LAWS: SURFACE WATER AND GROUNDWATER 9

Overview of State Acts with Case Laws: Irrigation: The Indian Easements Act – Land-Related Legislation –Tanks – Irrigation Management – Cess – Protection of Water Sources – Groundwater – Drinking and Domestic Water Supply – Industrial Use – Water Pollution – Torts and Crimes

UNIT IV POLICIES GOVERNING WATER 9

National Water Policy – National-Level Commissions – Irrigation Management Transfer Policies and Activities – Legal Registration of WUAs – Legal Changes in Water Allocation, Resource Mobilization and Dispute Resolution – Role of Local Institutions – Community Based Organizations – Water Policy Reforms: India, the Philippines, Bangladesh, and Indonesia

UNIT V TRANSNATIONAL LEGAL SYSTEM 9

International Law Commission – International Treaties and Protocols – Transboundary Water Conflicts: Indus Waters Treaty – India-Nepal Treaty – Indo-Bangladesh Cooperation – Sharing of Nile and Mekong River Basins

TOTAL : 45 PERIODS

REFERENCES:

1. Ali, Mohammed, George E. Radosevich and Akbar Alikhan, Water Resources Policy for Asia The Netherlands: A.A. Balkema, 1987.
2. Brewer, J., S. Kolavalli, A. H. Kalru, G. Naik, S, Ramnarayan, K.V. Raju and R. Sakthivadivel, Irrigation Management Transfer In India – Policies and Performance*,* Oxford and IBH Publishing Company, New Delhi,1999.
3. Bruns, Bryan Randolph and Ruth S. Meinzen-Dick. Ed. Negotiating Water Rights*,* Vistaar Publications, New Delhi,2000.
4. Iyer R. Ramaswamy , Towards Water Wisdom: Limits, Justice, Harmony*.* Sage Publications, New Delhi, 2007.
5. Mollinga, Peter P., and Alex Bolding, The Politics of Irrigation Reform – Contested Policy Formulation and Implementation in Asia, Africa and Latin America*,* Ashgate, England, 2004,
6. Report of the Expert Group, 'Groundwater Management and Ownership'. New Delhi: Government of India, Planning Commission, http://planningcommission.nic.in/reports/genrep/rep_grndwat.pdf, 2007.
7. Row, Sanjiva Commentaries on The Indian Easements Act, 1882 and Licences, 5th Edition,Delhi Law House, . New Delhi, 2006.
8. Singh, Chhatrapati "Water Rights in India," Ed: Chhatrapati Singh. Water Law in India*.*: The Indian Law Institute, New Delhi,1992.

IM 9152 WATERSHED CONSERVATION AND MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVE:

- To provide the technical know-how of analyzing the degradation of soil and water resources and implementation of the measures for soil and water conservation.
- To provide a comprehensive treatise on the engineering practices of watershed management for realizing the higher benefits of watershed management.

UNIT I WATERSHED CONCEPTS **7**

Introduction – Significance – Geology – Soil – Morphological Characteristics – Elements – Land Capability Classification –Delineation – Codification – Factors Influencing Watershed Development

UNIT II SOIL CONSERVATION PRACTICE **9**

Types of Erosion – Wind Erosion: Causes, Factors, Effects and Control – Water Erosion: Types, Factors, Effects – Engineering Measures for Erosion Control in Agricultural and Non-Agricultural Lands – Estimation of Soil Loss

UNIT III WATER HARVESTING AND CONSERVATION **9**

Water Harvesting Techniques – Design of Small Water Harvesting Structures – Types of Storage Structures – Yield from a Catchment – Losses of Stored Water

UNIT IV WATERSHED MANAGEMENT **10**

Strategies – Identification of Problems – Watershed Development Plan – Entry Point Activities –– Concept of Priority Watersheds – Agroforestry – Grassland Management – Wasteland Management – Watershed Approach in Government Programmes – Developing Collaborative know how – People's Participation – Evaluation of Watershed Management

UNIT V WATERSHED ASSESSMENT MODELS **10**

Regulation and Restoration – A Brief Description and Significance of Watershed Models: SWAT, TMDL, AGNPS, BASINS, CREAMS – Case Studies

TOTAL: 45 PERIODS

REFERENCES:

1. Debarry A. Paul, Watersheds, Wiley and Sons, 2004.
2. Devanport E. Thomas, Watershed Project Management Guide, Lewis Publishers, London, 2003.
3. Ghanashyam Das, Hydrology and Soil Conservation engineering, Prentice Hall of India Private Limited, New Delhi, 2000.
4.. Glenn O. Schwab, Soil and Water Conservation Engineering, John Wiley and Sons, 1981.
5. Gurmail Singh, A Manual on Soil and Water Conservation, ICAR Publication, New Delhi, 1982.
6. Suresh, R. Soil and Water Conservation Engineering, Standard Publication, New Delhi, 1982.

IM 9153 CLIMATE CHANGE AND WATER RESOURCES

L	T	P	C
3	0	0	3

OBJECTIVE:

- Understanding the climate system, being aware of the impact of climate change on society, Understanding of adaptation in relation to water and climate change.
- At the end of the course, students must be in a position to describe the possible impacts, adaptations and remedies in relation to water resources and climate change.

UNIT I EARTH'S CLIMATE SYSTEM. 10

Introduction -Climate in the Spotlight -The Spectrum of Scientific Opinion, -The Earth's Natural Greenhouse Effect - The Importance of Water - Greenhouse Gases-The Role of Carbon Dioxide, The Earth's Carbon Reservoirs, Carbon Cycling-Climate and Weather - The Earth's Climate Machine - Global Wind Systems -Trade Winds and the Hadley Cell,- The Highs and Lows of the Westerlies, -The Vital Importance of Monsoon Rains, Clouds, Storms and Climate -Cloud Formation and Climate,-Hurricanes and Global warming - Global Ocean Circulation - El Niño and its Effects,

UNIT II OBSERVED AND PROJECTED CHANGES IN CLIMATE AS THEY RELATE TO HYDROLOGY 9

Precipitation (including extremes) - water vapour - Snow and land ice - Sea level – Evapotranspiration - Soil moisture - Runoff and river discharge - Patterns of large-scale variability - Influences and feedbacks of hydrological changes on climate - Land surface effects - Feedbacks through changes in ocean circulation - Emissions and sinks affected by hydrological processes - Projected changes in climate - Patterns of large-scale variability.

UNIT III IMPACTS AND RESPONSES 10

Observed climate change impacts - effects due to changes in the cryosphere - Future changes in water availability and demand due to climate change - Climate-related drivers of freshwater systems in the future - Impacts of climate change on water stress in the future - Impacts of climate change on costs and other socio-economic aspects of freshwater - Freshwater areas and sectors highly vulnerable to climate change - Uncertainties in the projected impacts of climate change on freshwater systems.

UNIT IV CLIMATE CHANGE ADAPTATION 8

Water-related adaptation to climate change in the fields of Ecosystems and biodiversity, - Agriculture and food security, land use and forestry, Human health, water supply and sanitation, infrastructure and Economy (insurance, tourism, industry and transportation) - Adaptation, vulnerability and sustainable development

UNIT V CLIMATE CHANGE MITIGATION MEASURES 8

Sector-specific mitigation - Carbon dioxide capture and storage (CCS) , Bio-energy crops, Biomass electricity, Hydropower, Geothermal energy, Energy use in buildings, Land-use change and management, Cropland management, Afforestation and Reforestation, - Effects of water management policies and measures on GHG emissions and mitigation - Potential water resource conflicts between adaptation and mitigation - Implications for policy and sustainable development.

TOTAL: 45 PERIODS

REFERENCES:

1. Jan C. van Dam, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press, 2003.
2. IPCC fourth assessment report - The AR4 synthesis report, 2007
3. IPCC fourth assessment report –Working Group I Report, " The physical Science Basis", 2007
4. IPCC fourth assessment report - Working Group II Report, " Impacts, Adaptation and Vulnerability", 2007
5. IPCC fourth assessment report – Working Group III Report" Mitigation of Climate change", 2007
6. Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 'Climate Change and Water'. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 2008.