



NATIONAL BOARD FOR TECHNICAL EDUCATION

PLOT B BIDA ROAD, P.M.B. 2239, KADUNA, NIGERIA

HIGHER NATIONAL DIPLOMA

IN

HYDROLOGY AND WATER RESOURCES MANAGEMENT

TECHNOLOGY

CURRICULUM AND COURSE SPECIFICATIONS

JUNE, 2026

PREFACE

The transformation of Nigeria's agricultural sector remains central to the nation's aspirations for sustainable economic growth, food security, job creation, industrial development, and poverty reduction. As agriculture continues to evolve in response to technological advancements, climate change, emerging global market demands, and the need for increased productivity across agricultural value chains, it has become imperative to ensure that curricula in Nigerian tertiary institutions remain relevant, responsive, and aligned with contemporary industry requirements. It is against this backdrop that we embarked on the comprehensive review and modernization of Agricultural curricula for Nigerian tertiary institutions. The review process was designed to address identified skills gaps, integrate emerging technologies and innovations, strengthen entrepreneurship and employability competencies, promote climate-smart agriculture, and align training programmes with the industry expectations and global best practices. The successful execution of this important project was made possible through the invaluable support and commitment of key stakeholders. I wish to express profound appreciation to the Honourable Minister of Education for providing the policy direction and leadership that facilitated this initiative. I also extend sincere gratitude to the Honourable Minister of Agriculture and Food Security and the Honourable Minister of Livestock Development for their unwavering support, technical contributions, and commitment to strengthening agricultural education and workforce development in Nigeria. Special appreciation goes to the Tertiary Education Trust Fund (TETFund) for providing the special intervention grant that enabled the conduct of nationwide skills gap analyses and supported the series of national curriculum review and development workshops. The findings from the skills gap studies provided critical evidence and industry insights that guided the review process and ensured that the curricula reflect current and future workforce requirements within the agricultural sector.

I also acknowledge with gratitude the immense contributions of the Sector Skills Council for Agriculture, whose expertise and industry perspectives greatly enriched the curriculum development process. Equally commendable are the efforts of members of the Implementation Committee, resource persons, industry experts, professional bodies, French Embassy in Nigeria, regulatory agencies, academic institutions, employers, development partners, and other stakeholders who devoted their time, knowledge, and experience to the various workshops and technical sessions. The revised curricula represent a collective national effort to produce graduates equipped with relevant knowledge, practical skills, digital competencies, entrepreneurial capabilities, and professional attitudes required to drive innovation and productivity across Nigeria's agronomy, forestry, fisheries and livestock sectors. It is my expectation that Institutions offering these programmes will faithfully implement the curricula and continue to collaborate with industry to ensure sustained relevance and quality. I commend all stakeholders for their dedication and contributions to this landmark achievement and look forward to the successful implementation of these curricula for the benefit of our dear nation.

Professor Idris M. Bugaje, FNSE
Chairman, Implementation Committee

EXECUTIVE SECRETARY

National Board for Technical Education (NBTE), Kaduna

ACKNOWLEDGEMENT

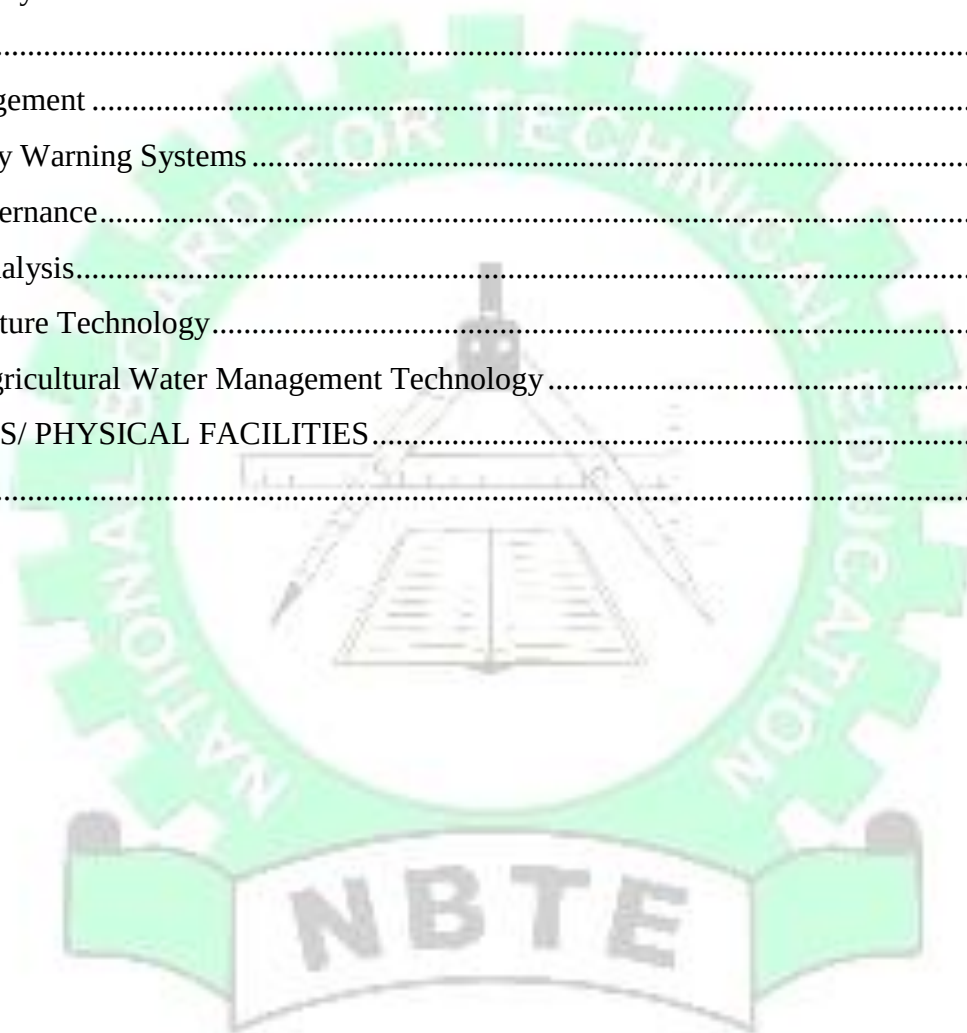
The National Board for Technical Education (NBTE) expresses its profound appreciation to all individuals and organizations whose invaluable support, expertise, and commitment made the successful review and modernization of the Agricultural Education curricula for Nigerian tertiary institutions possible. Our sincere gratitude goes to the Honourable Minister of Education for providing the policy direction and leadership that made this national initiative possible. We also appreciate the Honourable Minister of Agriculture and Food Security and the Honourable Minister of Livestock Development for their technical guidance, collaboration, and unwavering commitment to strengthening agricultural education and workforce development in Nigeria. The Board is particularly grateful to the Tertiary Education Trust Fund (TETFund) for providing the special intervention grant that funded the nationwide skills gap analyses, stakeholder engagements, curriculum review exercises, validation meetings, and development workshops. The evidence generated through these studies provided a solid foundation for developing curricula that are relevant, industry-driven, and responsive to national and global agricultural priorities.

Special appreciation is extended to the curriculum specialists, resource persons, academic experts, professional bodies, regulatory agencies, employers, industry practitioners, development partners, and representatives of public and private sector organizations who participated actively in the skills gap studies, technical sessions, validation exercises, and curriculum development workshops. Their diverse expertise and practical insights greatly enriched the quality and relevance of the curricula. We further appreciate the support of the French Embassy in Nigeria and other development partners for their collaboration in promoting excellence and innovation in technical and vocational education within the agricultural sector. Finally, NBTE expresses its gratitude to all tertiary institutions, researchers, facilitators, rapporteurs, technical staff, and administrative personnel whose commitment and hard work contributed to the successful completion of this important national assignment. The Board acknowledges that this achievement is the result of a collective effort and remains confident that the effective implementation of these curricula will contribute significantly to producing competent, innovative, and entrepreneurial graduates capable of advancing sustainable agricultural development, food security, and economic prosperity in Nigeria.

TABLE OF CONTENTS

PREFACE	ii
ACKNOWLEDGEMENT	iii
GENERAL INFORMATION	vi
CURRICULUM TABLE	ix
YEAR I SEMESTER I.....	1
Hydrology and Statistics	2
Hydrogeology	12
Hydraulics	17
Hydrometry	25
Geo Informatics Systems and Remote Sensing	31
Climate Change in Water Resources Management Technology	36
Programming and Data Analytics for Hydrologists.....	42
YEAR I SEMESTER II	47
Hydrological Modelling.....	48
Surveying and Geodetic Technology.....	56
Water Quality Assessment and Pollution Control	61
Watershed and Catchment Management Technology	67
Irrigation and Water Resources Management Technology	74
Water Supply Technology	80
Digital Water Monitoring Systems	88
YEAR II SEMESTER I	94
Water Resources Planning and Management Technology	95
Flood Hydrology and Risk Management.....	101

Drought Analysis and Management Technology	107
Wastewater Engineering	111
Gender, Equity and Inclusion in Water Resources Management	118
Networking and Real-Time Water System	123
YEAR II SEMESTER II	127
Integrated Water Resources Management	128
Hydrological Forecasting and Early Warning Systems	133
Water Economics, Policy and Governance	139
Smart Water Systems and Data Analysis	144
Climate-Resilient Water Infrastructure Technology	150
Food-Energy-Water Nexus and Agricultural Water Management Technology	155
LIST OF MINIMUM RESOURCES/ PHYSICAL FACILITIES	161
LIST OF PARTICIPANTS	173



GENERAL INFORMATION

1.0 PROGRAMME NOMENCLATURE

Higher National Diploma (HND) in Hydrology and Water Resources Management Technology.

2.0 PROGRAMME GOAL

The HND in Hydrology and Water Resources Management Technology programme is designed to produce highly skilled technologists capable of applying scientific, engineering, and technological principles to the assessment, development, management, and protection of Water Resources. The programme emphasizes practical competence, field-based learning, data-driven decision-making, and sustainable water management, in line with national development priorities and global best practices, while integrating modern competencies in integrated water-resources management and smart-water data analytics diplomates. It also seeks to develop graduates who can contribute effectively to solving Nigeria's water challenges, including water scarcity, flooding, drought, pollution, climate-change impacts, and inefficient water infrastructure.

3.0 OBJECTIVES OF THE PROGRAMME

On completion of the programme, the diplomates should be able to:

- i. Conduct hydrological and hydrogeological investigations using modern tools and techniques;
- ii. Apply modelling tools for surface-water and groundwater analysis;
- iii. Carry out water-quality assessment and pollution-control engineering for water bodies and supply systems;
- iv. Design and manage water-supply, irrigation, and wastewater-system operations;
- v. Apply watershed management, catchment restoration, and integrated land-water planning at a supervisory level;
- vi. Apply GIS, remote sensing, advanced surveying, and digital-monitoring technologies in water-resources management;
- vii. Apply climate-change science to water-resources planning and design under projected climate scenarios;
- viii. Conduct flood and drought monitoring, risk assessments, and develop mitigation strategies;
- ix. Apply integrated water-resources management (IWRM) frameworks, including multi-stakeholder engagement, governance, and adaptive management in planning and decision-making;
- x. Apply irrigation engineering and agricultural-water management with a focus on Nigerian commodity systems and water-productivity improvement;
- xi. Apply digital water-monitoring systems, including IoT, sensor networks, telemetry, and real-time data systems;
- xii. Apply smart-water systems, data analytics, and business intelligence for water-sector decision-making;
- xiii. Apply climate-resilient water-infrastructure design, including climate-screening, adaptation measures, dam safety, and coastal-water systems;
- xiv. Apply hydrological forecasting and early-warning-system design and operations;

- xv. Demonstrate professional ethics, gender inclusion, and environmental stewardship;
- xvi. Undertake research, prepare technical reports, and communicate scientific findings effectively.

4.0 ENTRY REQUIREMENTS

The minimum entry requirements for the Higher National Diploma (HND) programme in Hydrology and Water Resources Management Technology are as follows:

- i. National Diploma (ND) in Hydrology and Water Resources Management Technology, Water Resources Engineering Technology, Civil Engineering, Agricultural and Bio- Environmental Engineering Technology, Agricultural Technology, Environmental Science and Management, Geological Technology, Geological Engineering Technology, Surveying and Geo-informatics, or a closely related discipline from an NBTE-recognized institution with a minimum CGPA of 2.50 on a 4.00-point scale.
- ii. Completion of a minimum of one (1) year post-ND Industrial Training (IT) attachment in a relevant water-resource institution (Ministry of Water Resources and Sanitation, River Basin Development Authority, Nigeria Hydrological Services Agency, water utility, hydrology consultancy, digital-water enterprise, etc.), verified by a logbook and supervisor's report.
- iii. Five (5) credit-level passes in the Senior Secondary Certificate Examination (SSCE) — WAEC, NECO, SAISSCE or NABTEB — including English Language, Mathematics, Physics, Chemistry, and any one of the following: Geography, Biology, Agricultural Science, Economics, or Technical Drawing.

5.0 STRUCTURE/DURATION OF THE PROGRAMME

The Higher National Diploma in Hydrology and Water Resources Management Technology programme is structured to last for two (2) years (four semesters) of classroom work, laboratory work, field work, practicals, and workshop practices.

Each semester shall be seventeen (17) weeks, made up as follows:

- i. Fifteen (15) contact weeks of teaching (i.e., lectures and practical sessions, etc.); and
- ii. Two (2) weeks for registration, tests, quizzes, and examinations.

6.0 CURRICULUM:

The HND Hydrology and Water Resources Management Technology programme consists of three (3) main components. These are:

- i. General Studies / General Education Courses
- ii. Foundation Courses
- iii. Professional Courses

7.0 CONDITIONS FOR THE AWARD OF HIGHER NATIONAL DIPLOMA

The Higher National Diploma in Hydrology and Water Resources Management Technology shall be awarded by the Academic Board of the institution to a candidate who has satisfied the conditions for the award of the qualification, including the following:

- i. Satisfactory performance in all prescribed coursework, assignments, tests/quizzes, workshop practice, laboratory work, field trips, etc.;
- ii. Satisfactory performance in all semester examinations;
- iii. Satisfactory completion of project work/seminar;
- iv. Completion of the required minimum credit units.

7.1 Grading of Courses:

Courses shall be graded as follows:

MARK RANGE	LETTER GRADE	WEIGHTING
75% and above	A	4.00
70% – 74%	AB	3.50
65% – 69%	B	3.25
60% – 64%	BC	3.00
55% – 59%	C	2.75
50% – 54%	CD	2.50
45% – 49%	D	2.25
40% – 44%	E	2.00
Below 40%	F	0.0

7.2 Classification of Diploma

Distinction	– CGPA 3.50 – 4.00
Upper Credit	– CGPA 3.00 – 3.49
Lower Credit	– CGPA 2.50 – 2.99
Pass	– CGPA 2.00 – 2.49

8.0 ACCREDITATION OF PROGRAMME

The HND programme shall be accredited by the National Board for Technical Education (NBTE) before diplomates can be awarded the qualification. Details about the process of accrediting a programme are available on the Board's website (web.nbte.gov.ng) or through correspondence addressed to:

The Executive Secretary

National Board for Technical Education (NBTE)

Plot 'B' Bida Road

P.M.B. 2239, Kaduna, Nigeria.

9.0 PRACTICAL LOGBOOK

A practical logbook to be kept by each student shall contain a day-to-day record, weekly summaries, and a semester summary of all practical activities from day one to the end of the programme. This shall be checked, marked, endorsed, and recorded by the lecturers concerned at the end of every week.

10.0 FINAL YEAR PROJECT

Final-year students of the programme are expected to carry out project work, either on an individual basis or in groups (with a maximum of two students per group). The project topics should be related to Hydrology and Water Resources Management Technology and should serve as useful tools for research and development. Projects should be properly supervised, and reports should be well presented.

11.0 STAFFING REQUIREMENTS

11.1 Core Teaching Staff

A minimum of four (4) qualified lecturers with relevant HND/B.Sc/M.Sc/M.Tech qualifications in Hydrology and Water Resources Management Technology, Water Resources Engineering, Environmental Science/Engineering, Agricultural Engineering, Geology, and other related disciplines is required.

11.2 Headship of the Department (HOD)

The Head of Department shall possess HND/B.Sc and M.Sc/M.Tech qualifications in a relevant field and shall not be below the rank of Senior Lecturer. He or she shall also be registered with a relevant professional body.

11.3 Technical Staff

The technical staff disposition shall include:

- i. Technologist – HND or equivalent in Hydrology and Water Resources Management Technology and any other related field.
- ii. Technician – ND in Hydrology and Water Resources Management Technology and any other related field.
- iii. Laboratory/Field Assistant – At least SSCE (science based).

12.0 CERTIFICATION

A diplomate of this programme shall be awarded a Higher National Diploma (HND) in Hydrology and Water Resources Management Technology.

13.0 CAREER OPPORTUNITIES

The HND Hydrology and Water Resources Management Technology programme prepares students for careers in the following areas:

- i. Oil and Gas Sector
- ii. Private Industry and Professional Consulting Firms
- iii. National Maritime Academy
- iv. National Inland Waterways Authority
- v. River Basin Development Authorities

- vi. State Water Corporations/Boards
- vii. Water-Drilling Companies
- viii. Water-Resource Consulting Firms
- ix. National Emergency Management Agency.
- x. Federal/State Ministries of Water Resources and Rural Development
- xi. Federal/State Environmental Protection Agencies
- xii. Watershed Management Agencies/Commissions
- xiii. NGOs (JICA, UNESCO, WaterAid, UNICEF, World Bank)
- xiv. Hydropower Stations
- xv. National Water Resources Institute
- xvi. Erosion and Sedimentation Control Agencies
- xvii. Water-based Security Outfits
- xviii. Nigerian Hydrological Services Agency (NIHSA)
- xix. Nigeria Erosion and Watershed Management Project (NEWMAP)
- xx. Niger Delta Development Commission (NDDC)
- xxi. Federal and State Ministries of Works and Housing
- xxii. Nigerian Maritime Administration and Safety Agency (NIMASA)
- xxiii. Nigeria Integrated Water Resources Management Commission
- xxiv. Federal and State Ministries of Agriculture and Food Security
- xxv. National Environmental Standards and Regulations Enforcement Agency (NESREA)
- xxvi. National Agency for the Great Green Wall (NAGGW)
- xxvii. Academic Institutions

14.0 GUIDANCE NOTES FOR TEACHERS OF THE PROGRAMME

14.1 The new curriculum is drawn in a unit-course system. This is to enable students to select courses relevant to their future careers. In designing the curriculum, the principle of flexibility has been adopted. This is to enable the department to make necessary adjustments to meet local needs and conditions.

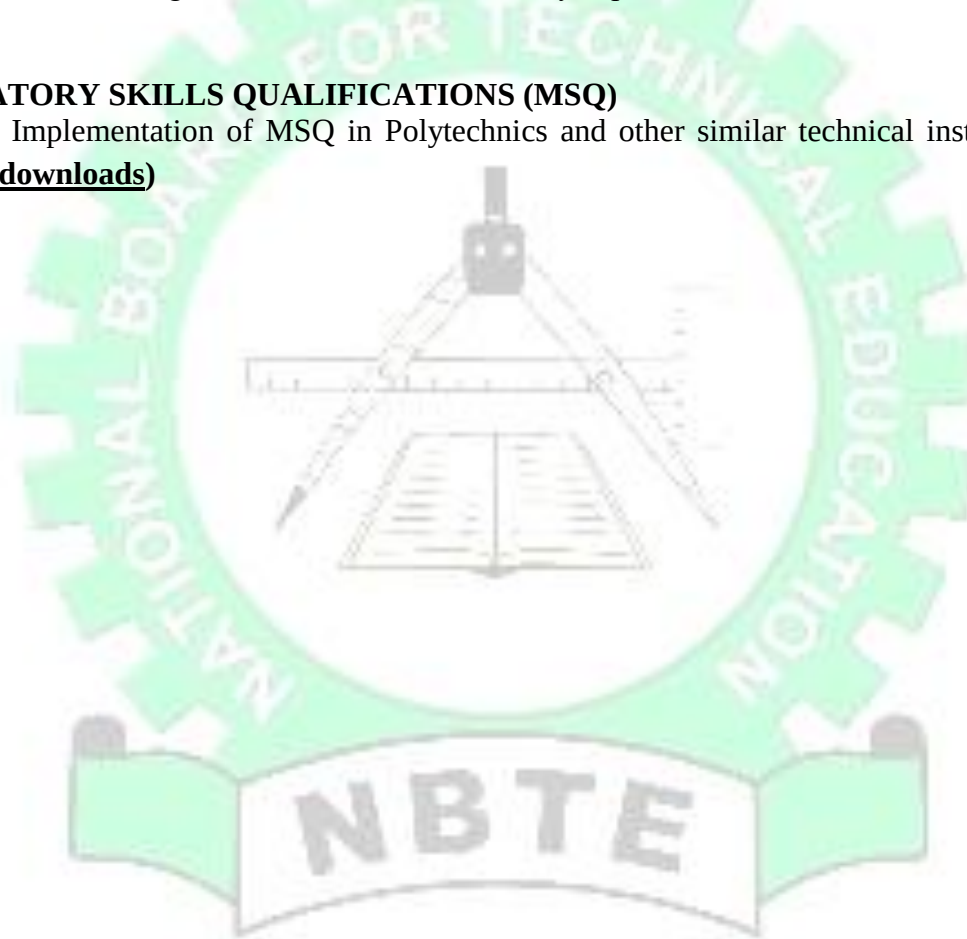
14.2 The curriculum is designed to provide the teacher with the flexibility to adopt teaching methods that will ensure the effective delivery of the programme. Teachers are therefore encouraged to adopt a combination of teaching methods such as lectures, demonstrations, laboratory work, fieldwork, and industrial visits.

14.3 As the success of the credit unit system depends on the articulation of programmes between the institutions and industry, the curriculum content has been written using the behavioural objectives, so that is clear to all, the specific Learning objective of the student who successfully completed some of the courses or the diplomates of the programme. There is a slight departure in the presentation of the performance-based

curriculum, which states the specific Learning objective for the students categorically; also, there is a deliberate attempt to further involve the staff of the department teaching by having another column called Teaching activities. This is to ensure that the lecturers deliver the required learning objectives. There is a third column for the Resources required for each learning objective. Each department is expected to develop its own curriculum to facilitate learning from this minimum guide curriculum and ensure that the resources required are available. The Academic Board of the institution may vet departmental submissions on the final curriculum. We aim to continue to see to it that a solid internal evaluation system exists in each institution for ensuring minimum standards and quality of education in the programmes offered throughout the TVET Institutions. The teaching of the theory and practical work should, as much as possible, be integrated. Practical exercises, especially those in professional courses and laboratory work, should not be taught in isolation from the theory if possible. For each course, there should be a balance of theory to practice in the ratio 20:80.

15.0 GUIDELINES ON MANDATORY SKILLS QUALIFICATIONS (MSQ)

Please see the Guidelines for the Implementation of MSQ in Polytechnics and other similar technical institutions in Nigeria, available on the NBTE website (web.nbte.gov.ng/downloads)



CURRICULUM TABLE

HND I - SEMESTER I

S/N	COURSE CODE	COURSE TITLE	L	T	P	CH	CU
1.	GNS 301	Use Of English III	2	0	0	2	2
2.	MSQ 311	Principles of Quality Assurance Assessment	1	0	1	2	2
3.	HWR 311	Hydrology and Statistics	1	0	3	4	4
4.	HWR 312	Hydrogeology	1	0	3	4	4
5.	HWR 313	Hydraulics	1	0	3	4	4
6.	HWR 314	Hydrometry	1	0	3	4	4
7.	HWR 315	Geo Informatics System and Remote Sensing	1	0	3	4	4
8.	HWR 316	Climate Change in Water Resources Management Technology	1	0	3	4	4
9.	HWR 317	Programming and Data Analytics for Hydrologists	2	0	2	4	4
TOTAL			11	0	21	32	32

HND I - SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L	T	P	CH	CU
1.	GNS 302	Communication in English III	2	0	0	2	2
2.	ENT 326	Practice of Entrepreneurship I	2	0	2	4	4
3.	MSQ 321	Practice of Quality Assurance Assessment	1	0	1	2	2
4.	HWR 321	Hydrological Modelling	1	0	3	4	4
5.	HWR 322	Surveying and Geodetic Technology	1	0	3	4	4
6.	HWR 323	Water-Quality Assessment and Pollution Control	1	0	3	4	4
7.	HWR 324	Watershed and Catchment Management Technology	1	0	3	4	4
8.	HWR 325	Irrigation and Water Resources Management Technology	1	0	3	4	4
9.	HWR 326	Water Supply Technology	1	0	3	4	4
10.	HWR 327	Digital Water Monitoring Systems	1	0	3	4	4
TOTAL			12	0	24	36	36

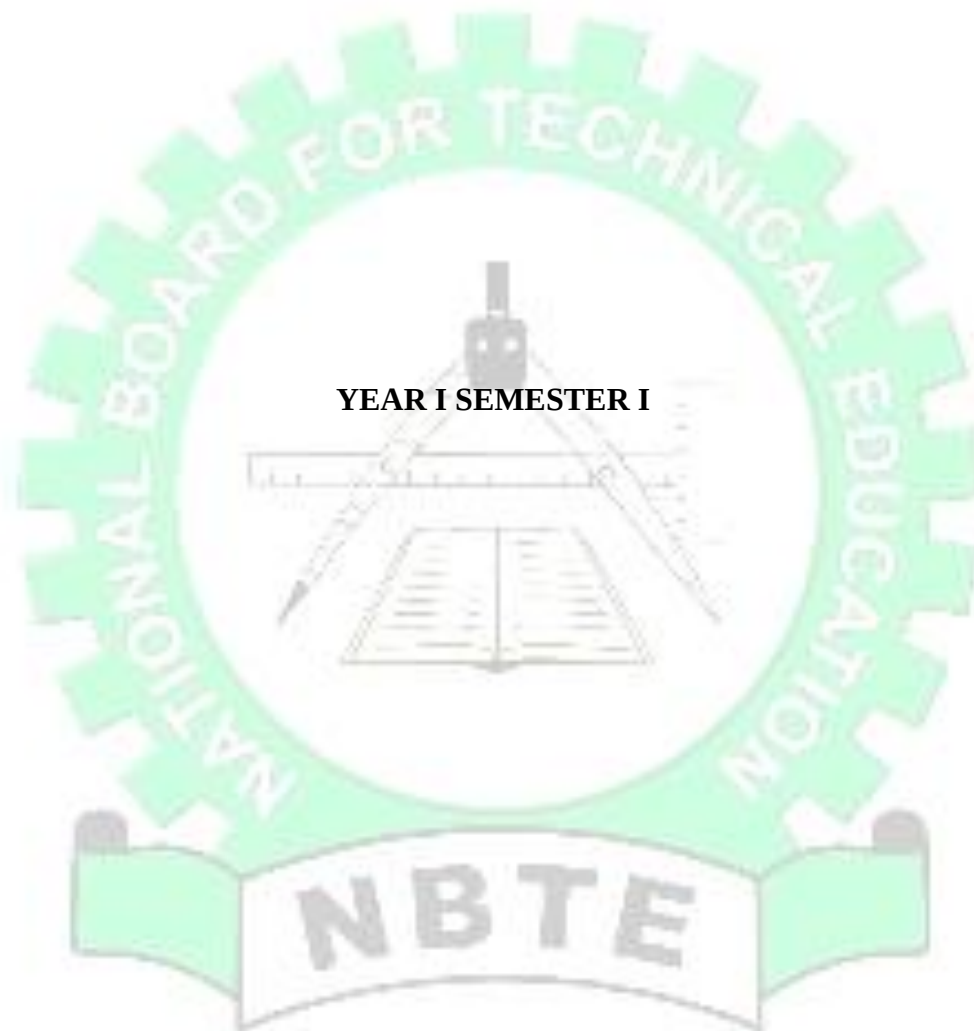
HND II - SEMESTER I

S/N	COURSE CODE	COURSE TITLE	L	T	P	CH	CU
1.	ENT 416	Practice of Entrepreneurship II	2	0	2	4	4
2.	HWR 411	Water Resources Management Technology	1	0	3	4	4
3.	HWR 412	Flood Hydrology and Risk Management	1	0	3	4	4
4.	HWR 413	Drought Analysis and Management Technology	1	0	3	4	4
5.	HWR 414	Wastewater Engineering	1	0	3	4	4
6.	HWR 415	Gender, Equity and Inclusion in Water Resources Management	1	0	1	2	2
7.	HWR 416	Networking and Real-Time Water Systems	1	0	3	4	4
TOTAL			8	0	18	26	26

HND II - SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L	T	P	CH	CU
1.	HWR 421	Integrated Water Resources Management (IWRM)	1	0	3	4	4
2.	HWR 422	Hydrological Forecasting and Early Warning Systems	1	0	3	4	4
3.	HWR 423	Water Economics, Policy and Governance	1	0	2	3	3
4.	HWR 424	Smart Water Systems and Data Analysis	1	0	3	4	4
5.	HWR 425	Climate-Resilient Water Infrastructure Technology	1	0	3	4	4
6.	HWR 426	Food-Energy-Water Nexus and Agricultural Water Management	1	0	2	3	3
7.	HWR 427	Final Project	0	0	4	4	4
TOTAL			6	0	20	26	26

L = Lectures (hours/week) P = Practical (hours/week) T = Tutorial (hours/week) CH = Contact Hours (hours/week) CU = Credit Units



HYDROLOGY AND STATISTICS

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: HYDROLOGY AND STATISTICS	COURSE CODE: HWR 311	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with the knowledge and skills of advanced hydrological processes and statistical analysis.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know advanced precipitation analysis; 2.0 Understand advanced evapotranspiration and energy balance; 3.0 Know infiltration and runoff modelling; 4.0 Apply streamflow hydrology and floods; 5.0 Apply water balance at multiple scales; 6.0 Apply probability theory, frequency analysis, regression and correlation analysis in hydrology; 7.0 Know time-series analysis, uncertainty and risk analysis.		

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: HYDROLOGY AND STATISTICS			COURSE CODE: HWR 311		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with the knowledge and skills of advanced hydrological processes and statistical analysis.						
GENERAL OBJECTIVE 1.0: Know advanced precipitation analysis						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1	1.1Explain the following terms: i. Hydrology ii. Hydrological processes iii. Hydrological cycle 1.2 Explain spatial and temporal variability of precipitation. 1.3 Explain storm analysis and probable maximum	• Explain the following terms: -Hydrology -Hydrological processes -Hydrological cycle. • Discuss variability. • Describe PMP. • Differentiate between design storms • Discuss network QA	Advanced hydrology textbooks, Computer Projector Internet, White marker board	• Visit meteorological station for data collection. • Analyse spatial variability across stations. • Compute PMP using statistical method. • Develop a design storm for a 100-yr return period • Apply double-	Guide students to: • Visit meteorological station for data collection. • Analyse spatial variability across stations. • Compute PMP using statistical method. • Develop a design storm for a 100-yr return period • Apply double-mass and inter-station consistency checks.	Multi-station data, Statistical software, Design templates Etc.

	precipitation (PMP). 1.4 Distinguish between Probable Maximum Storm (PMS) and design storms. 1.5 Describe how to apply rainfall data quality assurance at network scale.			mass and inter-station consistency checks.		
GENERAL OBJECTIVE 2.0: Understand advanced evapotranspiration and energy balance						
2-3	2.1 Explain full Penman-Monteith Eto computation 2.2 Describe surface energy balance (Bowen ratio, eddy covariance intro) 2.3 Describe lysimeter measurement and theory 2.4 Explain remote-sensing ET (SSEBop, METRIC introduction)	• Explain full Penman-Monteith Eto computation • Discuss surface energy balance (Bowen ratio, eddy covariance intro) • Explain lysimeter measurement and theory • Discuss remote-sensing ET (SSEBop, METRIC introduction)	ET textbooks (FAO-56, FAO-66), Projector Computer Projector Internet, White marker board Etc	• Visit Met. Station for data collection. • Compute Penman-Monteith ETo for one full season • Apply energy-balance method using net radiation • Inspect a lysimeter installation and read it. • Browse	Guide students to: • Visit Met. Station for data collection. • Compute Penman-Monteith ETo for one full season. • Apply energy-balance method using net radiation. • Inspect a lysimeter installation and read it. • Browse SSEBop ET products for Nigeria.	FAO-56, Net radiometer, lysimeter, SSEBop portal

				SSEBop ET products for Nigeria.		
GENERAL OBJECTIVE 3.0: Know infiltration and runoff modelling.						
4-6	3.1 Explain the following: - Horton, - Philip, - Green-Ampt infiltration models (rigorous). 3.2 Describe runoff-generation mechanisms (Hortonian, saturated, subsurface). 3.3 Explain unit hydrograph theory and synthetic UH 3.4 Explain baseflow separation methods	- Discuss the following: -Horton, -Philip, -Green-Ampt infiltration models (rigorous). - Explain runoff-generation mechanisms (Hortonian, saturated, subsurface). - Explain unit hydrograph theory and synthetic UH. - Explain baseflow separation methods.	Hydrology textbooks, Projector Computer Projector Internet, White marker board.	- Fit field data to Horton, Philip, Green-Ampt infiltration models - Identify runoff mechanisms in 3 storm events. - Derive unit hydrograph for the campus catchment. - Apply 3 baseflow-separation methods.	Guide students to: - Fit field data to Horton, Philip, Green-Ampt infiltration models - Identify runoff mechanisms in 3 storm events - Derive unit hydrograph for the campus catchment - Apply 3 baseflow-separation methods.	Field data, Calculators, software Computer Graph sheet Drawing Set
GENERAL OBJECTIVE 4.0: Apply streamflow hydrology and floods						
7-8	4.1 Explain flood-frequency analysis (Gumbel, GEV, LP3) 4.2 Describe flood-	Explain flood-frequency analysis (Gumbel, GEV, LP3)	Flood hydrology textbooks, Projector Computer	Apply Gumbel, GEV, LP3 to one Nigerian river	Guide students to: Apply Gumbel, GEV, LP3 to one Nigerian river	Flow data, statistical software, calculators Computer

	routing 4.3 Explain low-flow analysis. 4.4 Explain ecological and environmental flows	- Describe flood-routing (Muskingum, kinematic, dynamic) - Explain low-flow analysis. - Explain ecological and environmental flows	Projector Internet, White marker board	- Apply Muskingum routing on supplied event - Compute 7Q10 low-flow for one station - Estimate ecological flows for one river	- Apply Muskingum routing on supplied event - Compute 7Q10 low-flow for one station - Estimate ecological flows for one river	Drawing set
GENERAL OBJECTIVE 5.0: Apply water balance at multiple scales						
9-10	5.1 Explain catchment water balance. 5.2 Explain basin and regional water balance. 5.3 Describe storage-change quantification (GRACE intro). 5.4 Discuss application of climate-change studies.	- Discuss catchment water balance. - Explain basin and regional water balance. - Discuss storage-change quantification (GRACE intro) - Discuss application of climate-change studies.	Water-balance manuals, Projector Computer Projector Internet, White marker board	- Conduct catchment water balance for the campus. - Conduct basin balance for one Nigerian basin. - Browse GRACE / GLDAS data for Nigeria. - Demonstrate project water-balance changes under one climate scenario.	Guide students to: - Conduct catchment water balance for the campus. - Conduct basin balance for one Nigerian basin. - Browse GRACE / GLDAS data for Nigeria. - Demonstrate project water-balance changes under one climate scenario.	Catchment data, Basin data, GRACE portal, Scenario data
GENERAL OBJECTIVE 6.0: Apply probability theory, frequency analysis, regression and correlation analysis in hydrology.						

11-12	6.1 Explain the concepts of probability and their applications in hydrological studies. 6.2 Describe the role of statistical analysis in hydrology and Water Resources management. 6.3 Distinguish between probability distributions commonly used in hydrology (Normal, Log-Normal, Gumbel, Pearson Type III, etc.). 6.4 Explain the principles and importance of frequency analysis in estimating hydrological extremes. 6.5 Describe return period, recurrence interval, and	• Discuss the concepts of probability and their applications in hydrological studies. • Explain the role of statistical analysis in hydrology and Water Resources management. • Differentiate between probability distributions commonly used in hydrology (Normal, Log-Normal, Gumbel, Pearson Type III, etc.). • Explain the principles and importance of frequency analysis in estimating hydrological extremes. • Describe return	Projector Computer Projector Internet, White marker board etc.	• Calculate probabilities associated with hydrological events using appropriate statistical methods. • Analyse rainfall, streamflow, and flood data using frequency analysis techniques. • Estimate return periods and design values for hydrological events such as floods and droughts. • Fit appropriate probability distributions to hydrological datasets. • Develop regression	Guide Student to: • Calculate probabilities associated with hydrological events using appropriate statistical methods. • Analyse rainfall, streamflow, and flood data using frequency analysis techniques. • Estimate return periods and design values for hydrological events such as floods and droughts. • Fit appropriate probability distributions to hydrological datasets. • Develop regression models for predicting hydrological variables. • Perform correlation analysis between hydrological parameters such as rainfall and runoff. • Use statistical software or spreadsheets to conduct hydrological data analysis. • Interpret statistical outputs and present	Flow data, statistical software, calculators Computer Drawing set
-------	--	---	---	--	--	--

	exceedance probability. 6.6 Explain the concepts of correlation and regression and their significance in hydrological investigations. 6.7 Interpret correlation coefficients and regression equations in hydrological data analysis. 6.8 Describe the limitations and assumptions of statistical methods used in hydrology.	period, recurrence interval, and exceedance probability. • Explain the concepts of correlation and regression and their significance in hydrological investigations. • Interpret correlation coefficients and regression equations in hydrological data analysis. • Discuss the limitations and assumptions of statistical methods used in hydrology.		models for predicting hydrological variables. • Perform correlation analysis between hydrological parameters such as rainfall and runoff. • Use statistical software or spreadsheets to conduct hydrological data analysis. • Interpret statistical outputs and present findings in tables, graphs, and technical reports. • Evaluate the reliability and accuracy of regression and frequency	findings in tables, graphs, and technical reports. • Evaluate the reliability and accuracy of regression and frequency analysis results. • Apply statistical techniques to support hydrological design and Water Resources decision-making.	
--	---	--	--	--	---	--

				analysis results. • Apply statistical techniques to support hydrological design and Water Resources decision-making.		
GENERAL OBJECTIVE 7.0: Know time-series analysis, uncertainty and risk analysis.						
13-15	7.1 Explain time-series data. 7.2 Explain time-series importance in hydrological studies. 7.3 Describe the components of a hydrological time series, including trend, seasonality, cyclic variation, and random variation. 7.4 Explain the principles and applications of time-series	• Explain time-series data. • Explain time-series importance in hydrological studies. • Describe the components of a hydrological time series, including trend, seasonality, cyclic variation, and random variation. • Explain the principles and	Projector Computer Projector Internet, White marker board	• Organize hydrological time-series data such as rainfall, streamflow, groundwater levels, and evaporation records. • Interpret hydrological time-series data such as rainfall, streamflow, groundwater levels, and evaporation records.	Guide students to: • Organize hydrological time-series data such as rainfall, streamflow, groundwater levels, and evaporation records. • Interpret hydrological time-series data such as rainfall, streamflow, groundwater levels, and evaporation records. • Identify trends, seasonal patterns, and anomalies in hydrological datasets. • Apply basic time-series analysis techniques to hydrological data.	Flow data, statistical software, calculators Computer Drawing set

	analysis in Water Resources management. 7.5 Explain uncertainty and its sources in hydrological measurements, models, and predictions. 7.6 Explain the concepts of risk, probability, and reliability in hydrological systems. 7.7 Distinguish between uncertainty analysis and risk analysis. 7.8 Explain the significance of uncertainty and risk assessment in hydrological planning and decision-making. 7.9 Explain commonly used methods for uncertainty and risk evaluation in	applications of time-series analysis in Water Resources management. • Describe uncertainty and its sources in hydrological measurements, models, and predictions. • Explain the concepts of risk, probability, and reliability in hydrological systems. • Differentiate between uncertainty analysis and risk analysis. • Discuss the significance of uncertainty and risk assessment in hydrological planning and	• Identify trends, seasonal patterns, and anomalies in hydrological datasets. • Apply basic time-series analysis techniques to hydrological data. • Generate and interpret hydrographs and time-series plots. • Quantify uncertainty associated with hydrological measurements and model outputs. • Assess the risks associated with floods, droughts, and other hydrological hazards.	• Generate and interpret hydrographs and time-series plots. • Quantify uncertainty associated with hydrological measurements and model outputs. • Assess the risks associated with floods, droughts, and other hydrological hazards. • Estimate the likelihood and consequences of hydrological events using available data. • Use spreadsheets or statistical software to perform time-series, uncertainty, and risk analyses. • Interpret the results of uncertainty and risk assessments for Water Resources planning.	
--	---	--	--	--	--

	hydrology.	decision-making. • Explain commonly used methods for uncertainty and risk evaluation in hydrology.		• Estimate the likelihood and consequences of hydrological events using available data. • Use spreadsheets or statistical software to perform time-series, uncertainty, and risk analyses. • Interpret the results of uncertainty and risk assessments for Water Resources planning.		
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

HYDROGEOLOGY

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: HYDROGEOLOGY	COURSE CODE: HWR 312	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in aquifer characterization, well hydraulics, groundwater chemistry, and resource assessment.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand aquifer characterization; 2.0 Know groundwater flow analysis; 3.0 Understand groundwater chemistry and isotopes; 4.0 Know groundwater contamination and remediation; 5.0 Understand ground Water Resources assessment.		

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: HYDROGEOLOGY			COURSE CODE: HWR 312		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in aquifer characterization, well hydraulics, groundwater chemistry, and resource assessment						
GENERAL OBJECTIVE 1.0: Understand aquifer characterization.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain geological framework and aquifer geometry. 1.2 Explain Hydrostratigraphy and aquifer mapping. 1.3 Describe pumping test analysis (Theis, Cooper-Jacob, recovery etc.). 1.4 Explain slug-test and specific-capacity methods.	• Discuss geological framework. • Describe hydrostratigraphy. • Explain pumping tests. • Explain slug tests.	Textbooks, Projector, Internet, Teacher’s manual	• Map geological framework for one Nigerian aquifer. • Build a hydrostratigraphic cross-section. • Conduct a full pumping test; analyse with Theis + and Cooper-Jacob. • Conduct slug test on campus piezometer.	Guide Students to: • Map geological framework for one Nigerian aquifer. • Build a hydrostratigraphic cross-section. • Conduct a full pumping test; analyse using Theis + and Cooper-Jacob. • Conduct slug test on campus piezometer.	Geological Maps, Pumping Equipment, Log Paper, Slug-Test Kit
GENERAL OBJECTIVE 2.0: Know groundwater flow analysis.						

4-6	2.1 Explain Darcy's law in 2D/3D. 2.2 Explain flow nets and stream functions. 2.3 Explain analytical solutions (image well, superposition, etc.). 2.4 Explain steady-state vs transient flow.	- Describe Darcy's law in 2D/3D. - Discuss flow nets and stream functions. - Explain analytical solutions (image well, superposition). - Explain steady-state vs transient flow.	Textbooks, Projector, Internet, Computer, Charts Etc.	- Apply 2D Darcy in a laboratory tank. - Construct flow nets for one aquifer cross-section. - Apply image-well theory to a problem. - Solve a transient drawdown problem.	Guide Students to: - Apply 2D Darcy in a laboratory tank. - Construct flow nets for one aquifer cross-section. - Apply image-well theory to a problem. - Solve a transient drawdown problem.	Sand Tank, Drawing Tools, Calculators, Graph sheet, Etc.
GENERAL OBJECTIVE 3.0: Understand groundwater chemistry and isotopes.						
7-9	3.1 Explain major-ion chemistry and Piper plots. 3.2 Explain chemical evolution along flow paths. 3.3 Explain environmental isotopes (introduction). 3.4 Describe groundwater dating and residence time.	- Describe major-ion chemistry and Piper plots. - Describe chemical evolution along flow paths. - Discuss environmental isotopes (introduction). - Discuss groundwater dating and residence time.	Textbooks, Projector, Internet, Computer, Chart	- Plot a Piper diagram for 5 groundwater samples. - Identify chemical evolution along a flow path. - Demonstrate one isotope-hydrology study. - Estimate residence time using a tracer concept.	Guide Students to: - Plot a Piper diagram for 5 groundwater samples. - Identify chemical evolution along a flow path. - Demonstrate one isotope-hydrology study. - Estimate residence time using a tracer concept	Sample Data, Plotting Software, Isotope Studies
GENERAL OBJECTIVE 4.0: Know groundwater contamination and remediation.						
10-12	4.1 Explain	Discuss	Textbooks,	Run a sand-tank	Guide Students to:	Sand Tank,

	contaminant-transport processes (advection, dispersion, adsorption). 4.2 Explain contaminant source identification and characterization 4.3 Describe pump-and-treat and other remediation methods. 4.4 Explain wellhead and aquifer protection.	contaminant-transport processes (advection, dispersion, adsorption). - Describe contaminant source identification and characterization - Explain pump-and-treat and other remediation met - Discuss wellhead and aquifer protection.	Projector, Internet, Graph, Charts, Teaching Manuals, Computer	tracer experiment. - Conduct source assessment at one site. - Draw a profile for 3 remediation methods. - Design wellhead protection plan.	- Carry out a sand-tank tracer experiment. - Conduct source assessment at one site. - Carry out profiling and design for 3 remediation methods - Design wellhead protection plan.	Tracer, Source Data, Plan Templates, Graph, Drawing Sets
GENERAL OBJECTIVE 5.0: Understand Ground Water Resources assessment						

13-15	5.1 Explain basin-scale aquifer storage estimation. 5.2 Explain recharge estimation methods (Single, multiple, etc.). 5.3 Explain sustainable yield and safe yield. 5.4 Describe conjunctive use of surface and groundwater hydrology.	• Discuss basin-scale aquifer storage estimation. • Discuss recharge estimation methods (Single, multiple, etc.). • Discuss sustainable yield and safe yield. • Explain conjunctive use of surface and groundwater.	Resource Assessment Manuals, Projector, Internet, Computer Etc.	• Estimate storage of one Nigerian aquifer. • Apply 3 recharge methods (Water Table Fluctuation (WTF), Chloride Mass Balance (CMB). • Compute sustainable yield. • Design conjunctive-use plan for one community.	Guide Students to: • Estimate storage of one Nigerian aquifer • Apply 3. recharge methods (WTF, CMB, Balance). • Compute sustainable yield. • Design conjunctive-use plan for one community.	Aquifer Data, Calculators, Plan Templates, Internet, Drawing Set Etc.
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

HYDRAULICS

PROGRAMME: HND HYDROLOGY AND WATER RESOURCES MANAGEMENT		
COURSE TITLE: HYDRAULICS	COURSE CODE: HWR 313	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEKS
GOAL: This course is designed to equip students with knowledge and skills in the analysis, design, operation, management of hydraulic systems and structures for effective Water Resources development and environmental management.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Apply advanced hydraulic principles to analyse flow behaviour in pipes. 2.0 Apply advanced hydraulic principles to analyse flow behaviour in open channels; 3.0 Understand the performance of hydraulic structures such as weirs, spillways, culverts, canals, and reservoirs; 4.0 Know energy losses and flow characteristics in complex hydraulic networks and conveyance systems. 5.0 Understand river flow processes, sediment transport mechanisms, and channel behaviour;		

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: HYDRAULICS			COURSE CODE: HWR 313		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in the analysis, design, operation, management of hydraulic systems and structures for effective Water Resources development and environmental management.						
GENERAL OBJECTIVE 1.0: Apply advanced hydraulic principles to analyse flow behaviour in pipes.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the principles of advanced fluid flow in closed conduits (Navier-Stokes equations). 1.2 Describe the momentum and energy equations in hydraulic engineering problems. 1.3 Explain laminar, transitional, and turbulent flow regimes.	- Discuss the principles of advanced fluid flow in closed conduits (Navier-Stokes equations) - Discuss the momentum and energy equations in hydraulic engineering problems. - Describe laminar, transitional, and turbulent flow regimes.	Textbooks, Projector, Computer, Internet, Whiteboard Marker	- Apply energy equation to a complex pipe network. - Apply momentum equation to a hydraulic jump. - Identify laminar vs turbulent in 3 laboratory setups. - Apply Buckingham Pi to derive Reynolds and Froude numbers.	Guide students to: - Apply energy equation to a complex pipe network. - Apply momentum equation to a hydraulic jump. - Identify laminar vs turbulent in 3 lab setups - Apply Buckingham Pi to derive Reynolds and Froude numbers. - Record and report	Pipe Network, Hydraulic-jump Apparatus, Calculators, Computers, Laboratory Models, Simulation software, Practical

	1.4 Describe dimensional analysis and hydraulic similitude concepts in hydraulic modeling.	Discuss dimensional analysis and hydraulic similitude concepts in hydraulic modeling.			findings.	
GENERAL OBJECTIVE 2.0: Apply advanced hydraulic principles to Analyse flow behaviour in open channels.						
4-6	2.1 Describe advanced applications of Manning's and Chezy equations in open channel flow. 2.2 Explain advanced application of Manning and Chezy equations. 2.3 Explain specific energy, critical depth gradually varied flow (GVF) profiles. 2.4 Explain rapidly varied flow (hydraulic jumps, surges).	- Discuss the Advanced applications of Manning's and Chezy equations in open channel flow. - Describe how to apply advanced applications of Manning and Chezy equations. - Describe specific energy, critical depth and gradually varied flow (GVF) profiles. - Describe how to apply rapidly varied flow (hydraulic jumps, surges).	Textbooks, Projector, Computer, Whiteboard, whiteboard Marker, Graphs	- Compute flow in 3 different channel shapes. - Compute critical depth and specific-energy curves. - Classify and plot a GVF profile. - Observe hydraulic jump - Analyse a hydraulic jump.	Guide students to: - Carry out computations. - Compute critical depth and specific-energy curves. - Classify and plot a GVF profile. - Observe hydraulic jump. Analyse hydraulic jump equations. - Record finding.	Channel Rigs, Calculators, GVF Templates, Drawing Sets, Graph Sheets
GENERAL OBJECTIVE 3.0: Understand the application of hydraulic structures such as weirs, spillways, culverts, canals, and						

reservoirs. projects.						
7-9	3.1 Explain the classification, functions, and importance of hydraulic structures. 3.2 Describe the hydraulic principles governing flow over weirs and spillways. 3.3 Describe discharge characteristics of rectangular, triangular, and trapezoidal weirs. 3.4 Explain the design considerations and operation of spillways in dams and reservoirs. 3.5 Describe different types of culverts and their hydraulic applications. 3.6 Explain the functions, components, and operation of reservoirs.	- Describe the classification, functions, and importance of hydraulic structures - Discuss the hydraulic principles governing flow over weirs and spillways - Discuss discharge characteristics of rectangular, triangular, and trapezoidal weirs. - Explain the design considerations and operation of spillways in dams and reservoirs - Explain different types of culverts and their hydraulic applications - Describe the functions, components, and operation of reservoirs	Hydraulic structures Textbooks, Projector,	- Measure discharge using different types of weirs. - Determine discharge coefficients for hydraulic structures through laboratory experiments. - Conduct flow measurements over weirs and through culverts. - Perform hydraulic calculations for the design of weirs, spillways, and culverts. - Analyse canal flow characteristics using field and laboratory data. - Prepare hydraulic profiles and cross-sections for canals and waterways. - Calculate reservoir storage capacity from contour and elevation data.	Guide the students to: - Measure discharge using different types of weirs. - Determine discharge coefficients for hydraulic structures through laboratory experiments. - Conduct flow measurements over weirs and through culverts. - Perform hydraulic calculations for the design of weirs, spillways, and culverts. - Analyse canal flow characteristics using field and laboratory data. - Prepare hydraulic profiles and cross-sections for canals and waterways. - Calculate reservoir storage capacity from contour and	Design Templates, Structure Plans, Calculators, Laboratory Models

				Develop stage-storage and stage-discharge relationships for reservoirs.	elevation data. - Develop stage-storage and stage-discharge relationships for reservoirs. - Record and report findings.	
GENERAL OBJECTIVE 4.0: Know energy losses and flow characteristics in complex hydraulic networks and conveyance systems.						
10-12	4.1 Explain the concepts of hydraulic energy, head, and energy conservation in fluid flow. 4.2 Distinguish between major and minor energy losses in hydraulic systems. 4.3 Explain the Bernoulli equation to Analyse flow in pipes and hydraulic networks. 4.4 Determine friction losses using the Darcy–Weisbach equation.	- Discuss the concepts of hydraulic energy, head, and energy conservation in fluid flow. - Differentiate between major and minor energy losses in hydraulic systems. - Describe the Bernoulli equation to Analyse flow in pipes and hydraulic networks. - Determine friction losses using the Darcy–Weisbach equation.	Textbooks, Projector, Computer, Charts, Teaching Manuals Etc.	- Measure pressure, discharge, velocity, and head losses in hydraulic systems. - Conduct laboratory experiments to determine friction losses in pipes of different diameters and materials. - Evaluate minor losses through valves, bends, fittings, enlargements, and contractions. - Interpret Hydraulic Grade Lines (HGL) and Energy Grade Lines (EGL). - Analyse flow behaviour in pipe	Guide the student to: - Measure pressure, discharge, velocity, and head losses in hydraulic systems. - Conduct laboratory experiments to determine friction losses in pipes of different diameters and materials. - Evaluate minor losses through valves, bends, fittings, enlargements, and contractions. - Plot Hydraulic Grade Lines (HGL) and Energy Grade Lines (EGL). - Analyse flow	Laboratory Computers, EPANET, Pipe Network Model

	$h_f = f \frac{L V^2}{D 2g}$ 4.5 Explain the significance of hydraulic grade lines (HGL) and energy grade lines (EGL). 4.6 Explain flow through pipes connected in series and parallel. 4.7 Explain energy losses associated with bends, valves, fittings, expansions, and contractions. 4.8 Explain steady and unsteady flow conditions in conveyance systems. 4.9 Describe water hammer and surge phenomena in pipelines.	$h_f = f \frac{L V^2}{D 2g}$ • Highlight the significance of hydraulic grade lines (HGL) and energy grade lines (EGL). • Describe flow through pipes connected in series and parallel. • Describe energy losses associated with bends, valves, fittings, expansions, and contractions. • Describe steady and unsteady flow conditions in conveyance systems. • Discuss water hammer and surge phenomena in pipelines.		systems arranged in series and parallel. • Determine discharge distribution in branched pipe networks. • Investigate the effects of flow velocity and pipe roughness on energy losses. • Measure pressure fluctuations associated with hydraulic transients. • Use hydraulic instruments such as manometers, pressure gauges, flow meters, and piezometers. • Apply hydraulic software to model • Analyse pipe networks and conveyance systems. • Compare measured and theoretical head losses in hydraulic experiments.	behaviour in pipe systems arranged in series and parallel. • Determine discharge distribution in branched pipe networks. • Investigate the effects of flow velocity and pipe roughness on energy losses. • Analyse pressure fluctuations associated with hydraulic transients. • Use hydraulic instruments such as manometers, pressure gauges, flow meters, and piezometers. • Apply hydraulic software to model. • Analyse pipe networks and conveyance systems. • Compare measured and theoretical head losses in hydraulic	
--	--	---	--	---	---	--

					experiments. ● Record and report findings.	
GENERAL OBJECTIVE 5.0: Understand river flow processes, sediment transport mechanisms, and channel behaviour						
13-15	5.1 Explain the principles of river hydraulics and open-channel flow in natural rivers. 5.2 Explain sediment properties and sediment transport processes in rivers. 5.3 Distinguish between bed load, suspended load, and wash load transport. 5.4 Explain the concepts of sediment entrainment, transport capacity, and sediment yield.	● Discuss the principles of river hydraulics and open-channel flow in natural rivers. ● Describe sediment properties and sediment transport processes in rivers. ● Differentiate between bed load, suspended load, and wash load transport. ● Highlight the concepts of sediment entrainment, transport capacity, and sediment yield.	Textbooks, Projector, Computer, Charts, Teaching Manuals Etc.	● Measure river discharge, velocity, depth, and channel geometry in the field. ● Determine sediment concentration and sediment load using field and laboratory methods. ● Analyse grain-size distribution of riverbed and suspended sediments. ● Assess riverbank erosion and channel stability conditions. ● Estimate sediment transport rates using empirical and analytical methods. ● Evaluate scour depth around hydraulic structures and river crossings.	Guide students to: ● Measure river discharge, velocity, depth, and channel geometry in the field. ● Determine sediment concentration and sediment load using field and laboratory methods. ● Analyse grain-size distribution of riverbed and suspended sediments. ● Assess riverbank erosion and channel stability conditions. ● Estimate sediment transport rates using empirical and analytical methods. ● Evaluate scour depth around hydraulic structures	Sediment Data, River Data, Calculators, Laboratory Models, Computer

					and river crossings.	
COURSE ASSESSMENT:						
Tests:	10%					
Course work:	10%					
Practical:	40%					
Examination:	40%					
Total:	100%					



HYDROMETRY

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: HYDROMETRY	COURSE CODE: HWR 314	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to enable students acquire knowledge and skills in hydrometric measurements, streamflow monitoring, sediment transport analysis, data processing, and modern hydrological monitoring technologies.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand advanced hydrometric monitoring systems and network design; 2.0 Understand advanced water level measurement techniques and instrumentation; 3.0 Know advanced discharge measurement methods and streamflow monitoring; 4.0 Know discharge computation, rating curve development and hydrometric data analysis; 5.0 Understand hydrometric station operation, maintenance and management; 6.0 Understand sediment monitoring and sediment discharge computation.		

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: HYDROMETRY			COURSE CODE: HWR 314		CONTACT HOURS: 4 HOURS/WEEK	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with the knowledge and skills of hydrometric measurements, streamflow monitoring, sediment transport analysis, data processing, and modern hydrological monitoring technologies.						
GENERAL OBJECTIVE 1.0: Understand advanced hydrometric monitoring systems and network design.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain advanced concepts of hydrometry 1.2 Describe hydrometric monitoring networks. 1.3 Explain criteria for hydrometric station design 1.4 Describe River control sections 1.5 Explain benchmark establishment and datum control 1.6 Explain	- Discuss advanced concepts of hydrometry. - Explain hydrometric monitoring networks. - Discuss criteria for hydrometric station design. - Discuss river control sections. - Describe benchmark establishment and datum control	Textbooks, Projector Graph Drawing set White board Instructional Hydrometric Maps, PowerPoint	- Identify hydrometric network components - Establish benchmarks. - Conduct site reconnaissance survey. - Carry out field survey and station design exercises.	Guide Students to: - Identify hydrometric network components. - Establish benchmarks - Conduct site reconnaissance survey - Carry out field survey and station design exercises.	Datasets, statistical tables, calculators GPS Receiver, Total Station, Automatic Level, Survey Accessories

	hydrometric network optimization.	• Explain hydrometric network optimization.				
GENERAL OBJECTIVE 2.0: Understand advanced water level measurement techniques and instrumentation						
4-6	2.1 Explain water level monitoring principles. 2.2 Describe radar level sensors. 2.3 Describe ultrasonic sensors. 2.4 Explain pressure transducers. 2.5 Explain telemetry systems. 2.6 Explain calibration procedures 2.7 Explain measurement errors.	• Explain water level monitoring principles. • Explain radar level sensors. • Discuss ultrasonic sensors. • Explain pressure transducers. • Explain telemetry systems. • Discuss calibration procedures • Explain measurement errors.	Water Level Sensors, Data Loggers, Projector White board Etc.	• Carryout the installation and calibration of automated water level sensors • Demonstrate operation of advanced sensors. • Carry out installation procedures. • Carry out installation and calibration for different sensors exercises.	Guide Students to: • Install and calibrate automated water level sensors. • Demonstrate operation of advanced sensors. • Carry out installation procedures. • Carry out Sensor installation and calibration exercise of different sensors exercises	Radar Sensors, Ultrasonic Sensors, Data Loggers, Telemetry Equipment
GENERAL OBJECTIVE 3.0: Know advanced discharge measurement methods and stream flow monitoring.						
7-9	3.1 Explain advanced discharge measurement principles. 3.2 Describe Acoustic Doppler Current Profiler (ADCP)	• Discuss advanced discharge measurement principles. • Describe Acoustic Doppler Current	ADCP Current Meter, Whiteboard, Projector Etc.	• Conduct discharge measurements using ADCP and current meters.	Guide Students to: • Conduct discharge measurements using ADCP and current meters. • Measure streamflow	ADCP, Current Meter, Boat, Streamflow Measurement Manual

	3.3 Explain velocity-area method. 3.4 Explain tracer dilution methods. 3.5 Explain slope-area methods. 3.6 Explain flood discharge measurements. 3.7 Describe measurement errors.	Profiler (ADCP) - Describe velocity-area method. - Explain tracer dilution methods. - Explain slope-area methods. - Explain flood discharge measurements. - Discuss measurement errors.		- Measure streamflow using advanced methods. - Demonstrate discharge measurement equipment. - Carry out advanced gauging methods.	using advanced methods. - Demonstrate discharge measurement equipment. - Carry out advanced gauging methods.	
GENERAL OBJECTIVE 4.0: Know discharge computation, rating curve development and hydrometric data analysis.						
10-11	4.1 Explain discharge computation methods. 4.2 Explain stage-discharge relationships. 4.3 Explain rating curve development. 4.4 Explain shifting control methods 4.5 Explain extension of rating curves. 4.6 Describe factors affecting rating curves.	- Discuss discharge computation methods. - Explain stage-discharge relationships. - Discuss rating curve development - Explain shifting control methods - Describe extension of rating curves. - Explain factors affecting rating curves. - Explain data	Computer Projector Statistical Software Graph White board	- Develop rating curves and validate hydrometric data. - Construct stage-discharge relationships and compute discharge.	Guide students to: - Develop rating curves and validate hydrometric data. - Construct stage-discharge relationships and compute discharge.	Excel HEC-RAS Hydrometric Database

	4.7 Explain data validation methods	validation methods				
GENERAL OBJECTIVE 5.0: Understand hydrometric station operation, maintenance and management						
12-13	5.1 Explain station management procedures 5.2 Describe maintenance requirements 5.3 Explain station stability assessment. 5.4 Explain quality assurance procedures. 5.5 Explain hydrometric safety procedures 5.6 Describe data archiving procedures.	• Discuss station management procedures. • Explain maintenance requirements • Discuss station stability assessment. • Explain quality assurance procedures. • Discuss hydrometric safety procedures. • Explain data archiving procedures.	Maintenance Manuals, Inspection Forms, Station Record	• Conduct station inspection and maintenance activities. • Prepare maintenance schedules and evaluate station performance. • Demonstrate station inspection and maintenance procedures.	Guide Students to: • Conduct station inspection and maintenance activities. • Prepare maintenance schedules and evaluate station performance. • Demonstrate station inspection and maintenance procedures.	Maintenance Tools, Inspection Checklist
GENERAL OBJECTIVE 6.0: Understand sediment monitoring and sediment discharge computation						
14-15	6.1 Explain sediment production processes. 6.2 Explain sediment transport mechanisms. 6.3 Describe suspended	• Discuss sediment production processes. • Discuss sediment transport mechanisms. • Explain suspended sediment sampling	Sediment Samplers, Sample Bottles, Projector White Board	• Conduct sediment sampling and laboratory analysis. • Collect sediment samples and	Guide Students to: • Conduct sediment sampling and laboratory analysis • Collect sediment samples and compute sediment discharge. • Carry out sediment	Sediment Samplers Laboratory Equipment Sample Bottles

	sediment sampling methods. 6.4 Describe bed-load sampling techniques. 6.5 Explain sediment concentration determination. 6.6 Explain sediment discharge computation. 6.7 Explain sediment rating curves.	methods. • Explain bed-load sampling techniques. • Explain sediment concentration determination. • Explain sediment discharge computation. • Discuss sediment rating curves		compute sediment discharge. • Carry out sediment transport processes and computation methods.	transport processes and computation methods.	
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

GEO INFORMATICS SYSTEMS AND REMOTE SENSING

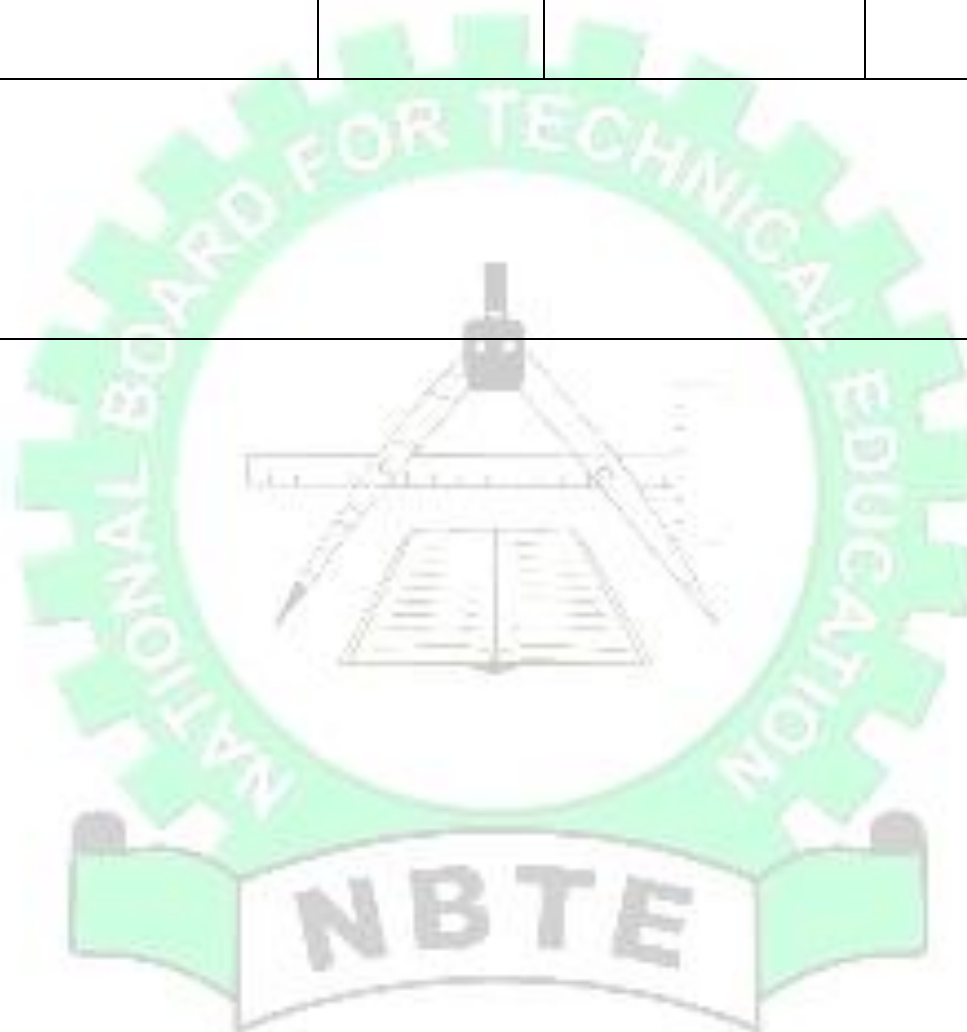
PROGRAMME: HND HYDROLOGY AND WATER RESOURCE MANAGEMENT		
COURSE TITLE: GEO- INFORMATICS SYSTEMS AND REMOTE SENSING	COURSE CODE: HWR 315	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE: ND GIS/REMOTE SENSING	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in GIS and remote-sensing for effective water-resource management technology.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand advanced GIS for water; 2.0 Understand advanced remote sensing; 3.0 Understand remote sensing for hydrology; 4.0 Know integrated GIS-RS workflows; 5.0 Understand web-GIS and dashboards.		

PROGRAMME: HND HYDROLOGY AND WATER RESOURCE MANAGEMENT						
COURSE TITLE: GIS AND REMOTE SENSING			COURSE CODE: HWR 315		CONTACT HOURS: 4 HRS/WEEK	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in GIS and remote-sensing for effective water-resource management technology.						
GENERAL OBJECTIVE 1.0: Understand advanced GIS for water						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain advanced spatial analysis (overlay, buffer, network). 1.2 Explain hydrological GIS modelling (TauDEM, ArcHydro). 1.3 Explain spatial interpolation (IDW, kriging). 1.4 Explain 3D and animation for Water Resources.	• Explain spatial analysis. • Describe hydrological modelling. • Discuss spatial interpolation. • Describe 3D and animation for Water Resources.	Textbooks, Projector, Computer, Lesson notes, Internet	• Apply overlay, buffer, network analysis in QGIS. • Install TauDEM; perform stream delineation. • Apply Interpolate rainfall using IDW and kriging. • Apply 3D visualization of a catchment.	Guide students to: • Apply overlay, buffer, network analysis in QGIS. • Install TauDEM; perform stream delineation. • Apply Interpolate rainfall using IDW and kriging. • Apply 3D visualization of a catchment.	Laboratory computers, QGIS, TauDEM, Datasets
GENERAL OBJECTIVE 2.0: Understand advanced remote sensing						

4-6	2.1 Explain image classification (supervised and unsupervised). 2.2 Discuss change detection methods. 2.3 Explain hyperspectral and radar imagery (Intro). 2.4. Discuss cloud platforms (Google Earth Engine - intro)	• Discuss advance in image classification. • Explain change detection methods. • Demonstrate advanced sensors. • Describe Google Earth Engine (GEE).	Textbooks, Projector, Computer, Lesson notes, Internet	• Conduct classification of LULC. • Perform change detection on 2-date imagery. • Perform Sentinel-1 SAR data. • Run a simple GEE script for rainfall analysis.	Guide students to: • Conduct classification of LULC. • Perform change detection on 2-date imagery. • Perform Sentinel-1 SAR data. • Run a simple GEE script for rainfall analysis.	PCs, QGIS, GEE accounts, DEM
GENERAL OBJECTIVE 3.0: Understand remote sensing for hydrology						
7-9	3.1 Describe remote sensing (CHIRPS, GPM, TRMM). 3.2 Explain soil-moisture remote sensing (SMAP, SMOS, ASCAT). 3.3 Explain Evapotranspiration (ET) remote sensing (SSEBop, METRIC, SEBAL). 3.4 Describe flood mapping with Synthetic Aperture Radar	• Explain remote sensing (CHIRPS, GPM, TRMM). • Discuss soil-moisture remote sensing (SMAP, SMOS, ASCAT). • Describe Evapotranspiration (ET) remote sensing (SSEBop, METRIC, SEBAL). • Explain flood mapping with Synthetic Aperture Radar	Textbooks, Projector, Computer, Lesson notes, Internet Etc.	• Utilize CHIRPS and validate against gauges. • Utilize SMAP to map seasonal variation. • Utilize SSEBop ET map seasonal variation. • Map a recent Nigerian flood using Sentinel-1.	Guide students to carry out: • Utilization and interpretation of CHIRPS. • Utilization and interpretation of SMAP. • Utilization and interpretation of SSEBop. • Utilization and interpretation of SAR mapping	PCs, internet, QGIS, GEE CHIRPS SMAP SSEBop etc

GENERAL OBJECTIVE 4.0: Understand integrated GIS-RS workflows						
10-12	4.1 Explain Digital Elevation Model (DEM) analysis (TauDEM, SAGA). 4.2 Discuss watershed-scale spatial analysis. 4.3 Discuss GIS-based hydrological modelling 4.4 Explain spatial decision-support systems	• Explain DEM analysis. • Discuss watershed analysis. • Discuss GIS modelling. • Explain spatial DSS.	Textbooks, Projector, Computer, Lesson notes, Internet Etc.	• Conduct full DEM analysis for one basin. • Demonstrate watershed spatial analysis • Run GIS-based SCS-CN for catchment. • Demonstrate spatial DSS for water-supply siting.	Guide students to: • Conduct DEM analysis. • Conduct spatial analysis. • Conduct modelling. • Demonstrate DSS.	Lab PCs, QGIS, modelling software DEM SAGA
GENERAL OBJECTIVE 5.0: Understand web-GIS and dashboards						
13-15	5.1 Explain the concept of Leaflet Layers basics. 5.2 Explain the concept of Open Layers basics. 5.3 Explain the concept of ArcGIS Online. 5.4 Describe web-GIS publishing. 5.5 Describe interactive	• Discuss the concept of Leaflet/Open Layers basics. • Discuss the concept ArcGIS Online/web-GIS publishing. • Explain interactive dashboards for water data. • Discuss geospatial APIs	Textbooks, Projector, Computer, Lesson notes, Internet Etc.	• Demonstrate Leaflet map of campus hydrology. • Generate a map on ArcGIS Online / QGIS Cloud. • Build an interactive dashboard. • Generate geospatial API for water data.	Guide students on the following: • Generation of Leaflet map. • Generation of ArcGIS /QGIS publishing. • Build interactive dashboards. • Generate geospatial APIs.	PCs, Leaflet maps, web-GIS accounts ArcGIS QGIS cloud

	dashboards for water data.					
5.6	Describe geospatial Application Programming Interfaces (APIs).					

COURSE ASSESSMENT:**Tests: 10%****Course work: 10%****Practical: 40%****Examination: 40%****Total: 100%**

CLIMATE CHANGE IN WATER RESOURCES MANAGEMENT TECHNOLOGY

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: CLIMATE CHANGE IN WATER RESOURCES MANAGEMENT TECHNOLOGY	COURSE CODE: HWR 316	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills of climate change and its impacts on Water Resources.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand climate-change science; 2.0 Know climate projections; 3.0 Understand climate impacts on Water Resources; 4.0 Understand the impact assessment and vulnerability; 5.0 Understand adaptation and mitigation in the water sector.		

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: CLIMATE CHANGE IN WATER RESOURCES MANAGEMENT TECHNOLOGY			COURSE CODE: HWR 316		CONTACT HOURS: 4 HOURS/WEEK	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills of climate change and its impacts on Water Resources.						
GENERAL OBJECTIVE 1.0: Understand climate-change science						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain these terms: i. Climate ii. Weather iii. Climate change iv. Greenhouse gases (GHGs) v. Global warming, Mitigation, vi. Adaptation, Vulnerability etc. 1.2 Explain the Intergovernmental Panel on Climate Change (IPCC)	• Discuss the following: - Climate, - Climate, - Weather, - Climate chang - Greenhouse gases (GHGs), - Global warming, Mitigation, - Adaptation, Vulnerability etc. • Describe the IPCC framework and the AR6 findings. • Discuss climate	IPCC AR6 Reports, Projector, Textbooks, Computer, Projector Internet, White Marker Board	• Identify IPCC, AR6 WG1 chapter on water. • Compute observed climate-change drivers. • Compute observed trends for 3 Nigerian stations. • Carryout an attribution-science study.	Guide students to: • Identify IPCC, AR6 WG1 chapter on water. • Compute observed climate-change drivers. • Carryout tabulations. • Compute observed trends for 3 Nigerian stations.	IPCC Reports, AR6, WG1 Climate Data, Calculators Graph Sheets, Drawing Sets

	framework and Sixth Assessment Report (AR6) findings. 1.3 Explain climate-change drivers (anthropogenic and natural). 1.4 Explain climate trends (global and Nigerian). 1.5 Explain the basic principles of attribution science.	change drivers. • Discuss attribution science.				
GENERAL OBJECTIVE 2.0: Know climate projections						
4-6	2.1 Explain climate projections. 2.2 Describe the Global Climate Models (GCMs) and Coupled Model Intercomparison Project (CMIP). 2.3 Describe downscaling (statistical, dynamical). 2.4 Explain uncertainty in climate projections	• Describe climate projection. • Describe how to apply the GCMs/CMIP. • Explain how to downscale data. • Describe the uncertainty and solutions in climate projections ((model uncertainty, scenario uncertainty and natural variability).	Climate-Modelling Textbooks, Projector, Internet, Data from Meteorological Stations	• Browse the CMIP6 portal and identify Nigeria-relevant GCMs. • Compare scenarios for Nigerian rainfall. • Download downscaled CORDEX data for Nigeria. • Identify uncertainty in projected	Guide students to: • Provide URLs. • Carry out comparison. • Record and report findings.	Computer, Internet, Software, CMIP6 Portal, CORDEX Data, Projection Templates

				changes. • Record findings. • Report findings.		
GENERAL OBJECTIVE 3.0: Understand climate impacts on Water Resources						
7-9	3.1 Explain the impacts of climate on precipitation and water balance. 3.2 Describe the impacts of climate on river flow and groundwater reserves 3.3 Explain the impacts of climate on extreme events 3.4 Explain the impacts of climate on water quality and ecosystems. 3.5 Describe policies to check practices that alter the climate/ecosystem.	- Describe the alteration in precipitation and water balance. - Discuss the flow impacts on river and groundwater reserves and recharge. - Describe the extreme events (floods, droughts etc). - Discuss the consequences of altered water quality and examine the role of a healthy, natural ecosystem. - Explain policies to control practices that alter the climate.	Assessment manuals, Projector Teacher's Manual, Textbooks	- Compute future precipitation changes for one station. - Estimate future river-flow change. - Draw a profile for future flood/drought risk in any region. - Estimate water-quality changes (T, DO).	Guide the students to: - Carry out computation - Carry out estimation - Carry out profiling - Conduct quality estimation.	Hydrological Data, Calculators, Templates, Graph Sheets, Drawing Sets

GENERAL OBJECTIVE 4.0: Understand the impact assessment and vulnerability						
10-12	4.1 Explain the IPCC risk framework (hazard, exposure, vulnerability). 4.2 Explain the vulnerability assessment methods. 4.3 Describe the impact-chain analysis. 4.4 Explain the socio-economic impact estimation	- Describe the IPCC framework. - Discuss vulnerability assessment methods. - Explain the impact chain analysis. - Discuss the socio-economic impact estimation	Vulnerability-Assessment Manuals, Projector, Textbooks, Journals, Internet	- Apply IPCC risk framework to one basin. - Build vulnerability index for one community. - Build impact chain for a chosen sector. - Estimate socio-economic impact for one scenario.	Guide students to: - Apply IPCC risk framework to one basin. - Build vulnerability index for one community. - Build impact chain for a chosen sector. - Estimate socio-economic impact for one scenario	Framework Templates, Index Templates, Scenario Data, Computer, Drawing Sets, Graph Sheets
GENERAL OBJECTIVE 5.0: Understand adaptation and mitigation in the water sector.						
13-15	5.1 Explain the adaptation principles and options. 5.2 Describe the mitigation options in the water sector 5.3 Explain climate-resilient infrastructure planning. 5.4 Explain climate finance for water adaptation.	- Discuss the adaptation principles and options. - Describe mitigation option in water sector. - Describe adaptive water facilities capable of withstanding extreme weather and other resilient planning.	Adaptation/Mitigation Manuals, Projector, Internet, Textbooks, Computer	- Identify 10 adaptation options for Nigerian water. - Estimate mitigation potential (low-carbon WRM). - Apply resilience checklist to one infrastructure planning. - Map climate finance sources	Guide students to: - Conduct adaptation ID. - Identify mitigation measures. - Carryout checklist. - Conduct finance mapping.	Adaptation Guides, Mitigation Tools, Checklists, Finance Directories, Field Data

		Explain climate finance.		for Nigeria.		
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



PROGRAMMING AND DATA ANALYTICS FOR HYDROLOGISTS

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: PROGRAMMING AND DATA ANALYTICS FOR HYDROLOGISTS	COURSE CODE: HWR 317	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 2 HOURS/WEEK
YEAR: I SEMESTER: I	PRE-REQUISITE:	PRACTICAL: 2 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in Python and R programming, data analysis, statistical hydrology and basic machine-learning applications for Water Resources Management		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand Python fundamentals 2.0 Know scientific Python for hydrology 3.0 Know R fundamentals for hydrology 4.0 Understand hydrology-specific libraries 5.0 Apply data analytics and intro to Machine Learning for water.		

PROGRAMME: HND HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: PROGRAMMING AND DATA ANALYTICS FOR HYDROLOGISTS			COURSE CODE: HWR 317		CONTACT HOURS: 4 HOURS/WEEK	
			CREDIT UNIT: 4		THEORETICAL: 2 HOURS/WEEK	
YEAR: I SEMESTER: I			PRE-REQUISITE: COM 111		PRACTICAL: 2 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills on Python and R programming, data analysis, statistical hydrology and basic machine-learning applications for Water Resources management.						
GENERAL OBJECTIVE 1.0: Understand Python fundamentals.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Describe Python syntax (variables, data types, operators, etc). 1.2 Describe control flow (if, for, while etc.). 1.3 Describe functions and modules. 1.4 Explain file Input/Output and basic exceptions.	- Discuss Python syntax (variables, data types, operators). - Discuss control flow (if, for, while). - Explain functions and modules. - Explain file I/O and basic exceptions.	Python tutorials, Projector Internet	- Install Python program - Write a code that will output “Water is life.” - Run the program - Build 5 small programs using control flow. - Write 5 reusable functions. - Read a Comma-Separated Values (CSV) rainfall file and compute the mean.	Guide students to: - Install Python and write “Water is life”. - Build 5 small programs using control flow. - Write 5 reusable functions. - Read a Comma-Separated Values. - CSV rainfall file and compute the mean.	Laboratory computers, Python software, Rainfall data, Excel
GENERAL OBJECTIVE 2.0: Know scientific Python for hydrology.						

4-6	2.1 Explain NumPy for arrays and computation using hydrological data. 2.2 Explain Pandas for data frames. 2.3 Describe the application of Matplotlib for plotting. 2.4 Explain application of SciPy for statistical functions.	• Discuss NumPy for arrays and computation using hydrological data. • Explain Pandas for data frames. • Discuss application of Matplotlib for plotting. • Explain the application of SciPy for statistical functions	Scientific Python guides, Projector, Computer, Internet using hydrological data	• Carry out NumPy for array operations on rainfall data. • Load CSV with Pandas; compute statistics. • Plot hydrograph and hyetograph with Matplotlib. • Carry out fitting distributions to flood data using SciPy.	Guide Students to: • Carry out NumPy for array operations on rainfall data. • Load CSV with Pandas; compute statistics. • Plot hydrograph and hyetograph with Matplotlib. • Carry out Fit distributions to flood data using SciPy	Laboratory computers with Anaconda, Rainfall data NumPy Pandas Matplotlib SciPy
GENERAL OBJECTIVE 3.0: Know R fundamentals for hydrology.						
7-9	3.1 Explain R syntax and data structures. 3.2 Explain data import and manipulation (dplyr). 3.3 Explain ggplot2 visualisation. 3.4 Discuss statistical functions in R package.	• Explain R syntax and data structures. • Describe data import and manipulation (dplyr). • Describe ggplot2 visualization. • Discuss statistical functions in R package.	R-package tutorials, R package manual Projector, Internet, Computer	• Install R and RStudio • Run 5 basic commands. • Import CSV and manipulate with dplyr • Build 5 ggplot2 visualizations • Carry out t-test, ANOVA, regression in R	Guide Students to: • Install R and RStudio. • Run 5 basic commands. • Import CSV and manipulate with dplyr. • Build 5 ggplot2 visualisations. • Run t-test, ANOVA, regression in R.	Laboratory computers with R/RStudio, Datasets Projector Internet Rainfall data
GENERAL OBJECTIVE 4.0: Understand hydrology-specific libraries.						

10-12	4.1 Describe application of hydroPy / hydropandas for hydrological data. 4.2 Describe application of pply, pyMODIS / earthengine-api for satellite data. 4.3 Describe Application of web scraping for NIHSA / NIMET data. 4.4 Describe Application of APIcalls for cloud-data services.	• Describe the application of hydroPy / hydropandas for hydrological data. • Discuss application of apply, pyMODIS / earthengine-api for satellite data. • Explain the application of web scraping for NIHSA / NIMET data. • Discuss Application of API calls for cloud-data services.	Library document, Projector, Internet, Computer	• Apply hydroPy/hydropandas to process flow data. • Download MODIS data via Python. • Scrape one Nigerian water-data webpage. • Call CHIRPS or SMAP API for rainfall data and moisture data. • Record and report findings	Guide Students to: • Use hydroPy/hydropandas to process flow data. • Download MODIS data via Python. • Scrape one Nigerian water-data webpage. • Call CHIRPS or SMAP API for rainfall data and moisture data. • Record and report findings.	Laboratory computers with internet, Library installations, Rainfall data, MODIS data, Satellite data
GENERAL OBJECTIVE 5.0: Apply data analytics and intro to ML for water.						
13-15	5.1 Explain exploratory data analysis (EDA). 5.2 Explain time-series basics. 5.3 Explain linear and logistic regression. 5.4 Explain introduction to Machine Learning for hydrological prediction.	• Discuss exploratory data analysis (EDA). • Describe time-series basics. • Discuss linear and logistic regression. • Explain introduction to ML for hydrological predictions.	Analytics manuals, Projector, Internet Computer, Charts Graphs	• Conduct EDA on a 5-year rainfall dataset. • Run time-series decomposition. • Build linear regression for rainfall-runoff. • Train a simple random forest for flood prediction using ML. • Record and report findings	Guide Students to: • Conduct EDA on a 5-year rainfall dataset • Run time-series decomposition. • Build linear regression for rainfall-runoff. • Train a simple random forest for flood prediction	Laboratory computers, Rainfall datasets, Scikit-learn

					using ML. • Record findings • Report findings	
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						





HYDROLOGICAL MODELLING

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: HYDROLOGICAL MODELLING	COURSE CODE: HWR 321	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEKS
GOAL: This course is designed to equip students with knowledge and skills necessary for hydrological models		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the principles, concepts, and applications of hydrological modelling in Water Resources management; 2.0 Understand hydrological models and their suitability for various hydrological problems; 3.0 Apply hydrological models to simulate rainfall-runoff processes, streamflow, and watershed responses; 4.0 Know the calibration, validation, and evaluation of hydrological models using observed hydrological data; 5.0 Utilize computer-based hydrological modelling tools for Water Resources Planning and Management; 6.0 Interpret results for decision-making in Water Resources engineering and environmental management. 7.0 Understand the principles and concepts of groundwater modelling. 8.0 Calibrate groundwater models. 9.0 Apply groundwater models for Water Resources assessment and management.		

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: HYDROLOGICAL MODELLING			COURSE CODE: HWR 321		CONTACT HOURS: 4 HOURS/WEEK	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills necessary for hydrological models						
GENERAL OBJECTIVE 1.0: Understand the principles, concepts, and applications of hydrological modelling in Water Resources Management.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-2	1.1 Explain the concept, purpose, and importance of hydrological modelling. 1.2 Explain model components, parameters, variables, inputs, and outputs. 1.3 Differentiate between conceptual, empirical, physical,	- Discuss the concept, purpose, and importance of hydrological modelling. - Describe model components, parameters, variables, inputs, and outputs. - Distinguish between conceptual, empirical, physical, deterministic, and stochastic models.	Textbooks, Projector, Computer, Whiteboard marker	- Collect hydrological and meteorological data for modelling applications. - Organize hydrological and meteorological data for modelling applications - Develop watershed databases using rainfall, streamflow, evaporation, and land-use data. - Delineate	Guide students to: - Collect, organize, and preprocess hydrological and meteorological data for modelling applications. - Develop watershed databases using rainfall, streamflow, evaporation, and land-use data. - Delineate watersheds and sub-basins using GIS	HEC-HMS SWAT HEC-RAS MIKE HYDRO WEAP Datasets, Calculators, Computer

	deterministic, and stochastic models.			watersheds and sub-basins using GIS and Digital Elevation Models (DEMs). • Tabulate features of 5 hydrological models. • Record findings. • Report findings.	and Digital Elevation Models (DEMs). • Tabulate features of 5 hydrological models. • Record and report findings.	
GENERAL OBJECTIVE 2.0: Understand hydrological models and their suitability for various hydrological problems.						
3-4	2.1 Explain the classification of hydrological models based on structure, scale, and application. 2.2 Describe appropriate models for different hydrological and Water Resources problems. 2.3 Describe hydrograph generation and routing concepts in hydrological models.	• Discuss hydrological models based on structure, scale, and application. • Explain appropriate models for different hydrological and Water Resources problems. • Discuss hydrograph generation and routing concepts in hydrological models.	Hydrological Software Projector Computer Internet White Board Marker	• Set up a simple rainfall–runoff model for a selected catchment. • Determine model parameters and boundary conditions. • Run hydrological simulations using appropriate software.	Guide students to: • Set up a simple rainfall–runoff model for a selected catchment. • Determine model parameters and boundary conditions. • Run hydrological simulations using appropriate software.	HEC-HMS SWAT HEC-RAS MIKE HYDRO WEAP Datasets, Calculators, Computer

GENERAL OBJECTIVE 3.0: Apply hydrological models to simulate rainfall-runoff processes, streamflow, and watershed responses.						
5	3.1 Explain rainfall–runoff transformation processes. 3.2 Describe data requirements for hydrological modelling. 3.3 Describe methods of parameter estimation and model setup.	• Discuss rainfall–runoff transformation processes. • Explain data requirements for hydrological modelling. • Explain methods of parameter estimation and model setup.	Projector Stream flow Rainfall Data Computer Whiteboard Marker	• Simulate watershed response under different rainfall conditions. • Generate hydrographs and interpret model outputs. • Perform flood and low-flow analyses using modelling results.	Guide the students to: • Simulate watershed response under different rainfall conditions. • Generate hydrographs and interpret model outputs. • Perform flood and low-flow analyses using modelling results.	HEC-HMS SWAT HEC-RAS MIKE HYDRO WEAP Datasets, Calculators, Computer
GENERAL OBJECTIVE 4.0: Know the calibration, validation, and evaluation of hydrological models using observed hydrological data.						
6-7	4.1 Explain model calibration and validation procedures. 4.2 Describe sources of modelling errors and uncertainties. 4.3 Describe model performance using statistical indicators such as: • Coefficient of Determination (R^2) • Nash–Sutcliffe	• Discuss model calibration and validation procedures. • Explain sources of modelling errors and uncertainties. • Discuss model performance using statistical indicators such as: • Coefficient of Determination (R^2) • Nash–Sutcliffe	Calibration handbooks, Projector Computer Whiteboard Marker	• Calibrate model parameters using observed streamflow data. • Validate model performance using independent datasets. • Evaluate model accuracy using statistical performance indicators.	Guide the students to: • Calibrate model parameters using observed streamflow data. • Validate model performance using independent datasets. • Evaluate model accuracy using statistical performance indicators.	HEC-HMS SWAT HEC-RAS MIKE HYDRO WEAP Datasets, Calculators, Computer

	Efficiency (NSE) • Root Mean Square Error (RMSE) • Mean Absolute Error (MAE)	Efficiency (NSE) • Root Mean Square Error (RMSE) • Mean Absolute Error (MAE)				
GENERAL OBJECTIVE 5.0: Utilize computer-based hydrological modelling tools for Water Resources planning and management.						
8-9	5.1 Explain the application of hydrological models in: - Flood forecasting - Drought assessment - Reservoir operation - Watershed management - Climate change impact studies - Water Resources planning 5.2 Describe the integration of GIS and remote sensing with hydrological modelling. 5.3 Describe emerging trends in	• Discuss the application of hydrological models in: - Flood forecasting - Drought assessment -Reservoir operation -Watershed management -Climate change impact studies -Water Resources • Explain the integration of GIS and remote sensing with hydrological modelling. • Discuss emerging trends in hydrological modelling and decision-support	Textbook Scenario manuals, Projector Computer Whiteboard Maker	• Prepare a hydrological modelling report. • Report hydrological modelling report • Interpret modelling results • Provide recommendations for Water Resources planning and management	Guide students to: • Prepare a hydrological modelling report. • Report hydrological modelling report • Interpret modelling results • Provide recommendations for Water Resources planning and management	HEC-HMS SWAT HEC-RAS MIKE HYDRO WEAP Datasets, Calculators, Computer

	hydrological modelling and decision-support systems.	systems.				
GENERAL OBJECTIVE 6.0: Interpret results for decision-making in Water Resources engineering and environmental management.						
10-11	6.1 Explain principles for interpreting hydrological model outputs and performance indicators. 6.2 Describe methods for presenting and communicating modelling results to technical and non-technical stakeholders. 6.3 Explain the role of modelling results in Water Resources planning, environmental management, and decision-making.	• Discuss principles for interpreting hydrological model outputs and performance indicators. • Explain methods for presenting and communicating modelling results to technical and non-technical stakeholders. • Discuss the role of modelling results in Water Resources planning, environmental management, and decision-making.	Textbooks Policy document White Board Marker Computer Etc.	• Analyse and interpret model outputs such as hydrographs, water balances, and simulation results. • Prepare technical reports, tables, graphs, maps, and visualizations of modelling results. • Present modelling findings and management recommendations for a selected Water Resources problem.	Guide student: • Analyse and interpret model outputs such as hydrographs, water balances, and simulation results. • Prepare technical reports, tables, graphs, maps, and visualizations of modelling results. • Present modelling findings and management recommendations for a selected Water Resources problem.	Computers, Modelling software outputs, Hydrological datasets Spreadsheet software, GIS software, Reporting templates Modelling reports,
GENERAL OBJECTIVE 7.0: Understand the principles and concepts of groundwater modelling.						
12	7.1 Explain groundwater flow	•Discuss groundwater flow	Textbooks Modelling	• Develop conceptual models of	Guide students to: • Develop conceptual	Aquifer maps, Borehole logs,

	processes, aquifer properties, and groundwater systems. 7.2 Explain conceptual, analytical, and numerical groundwater models. 7.3 Explain model assumptions, boundary conditions, and model inputs.	processes, aquifer properties, and groundwater systems. - Describe conceptual, analytical, and numerical groundwater models. - Discuss model assumptions, boundary conditions, and model inputs.	manuals, Hydrogeological references, Case studies, Graph, Internet, Computer	groundwater systems. - Identify model boundaries, layers, and aquifer characteristics. - Prepare groundwater data for modelling applications.	models of groundwater systems. - Identify model boundaries, layers, and aquifer characteristics. - Organize and prepare groundwater data for modelling applications.	Hydrogeological reports, Geological maps, Groundwater datasets, Field records, Computer
GENERAL OBJECTIVE 8.0: Calibrate groundwater models.						
13	8.1 Explain groundwater model development procedures and data requirements. 8.2 Describe calibration, validation, and sensitivity analysis methods. 8.3 Explain model uncertainty and performance evaluation	- Describe groundwater model development procedures and data requirements. - Explain calibration, validation, and sensitivity analysis methods. - Describe model uncertainty and performance evaluation techniques.	Textbooks, Modelling guidelines, Case studies, Graphs, Charts, Internet, Computer Etc.	- Construct groundwater models using appropriate modelling software. i.e ModFlow - Calibrate models - Validate models using observed groundwater-level data. - Evaluate model performance and interpret simulation results.	Guide students to: - Construct groundwater models using appropriate modelling software. i.e ModFlow - Calibrate and validate models using observed groundwater-level data. - Evaluate model performance and	Computers, Groundwater modelling software, Hydrogeological datasets, Monitoring well data, Experimental borehole data, Aquifer test data Statistical tools

	techniques.				interpret simulation results.	
GENERAL OBJECTIVE 9.0: Apply groundwater models for Water Resources assessment and management.						
14-15	9.1 Explain applications of groundwater modelling in Water Resources planning and management. 9.2 Describe groundwater recharge, abstraction, and contamination processes. 9.3 Explain the use of modelling results for decision-making and sustainable groundwater management.	- Describe applications of groundwater modelling in Water Resources planning and management. - Explain groundwater recharge, abstraction, and contamination processes. - Discuss the use of modelling results for decision-making and sustainable groundwater management.	Textbooks, Computer, Groundwater assessment reports, Environmental management manuals, Policy documents	- Simulate groundwater recharge and abstraction scenarios. - Assess impacts of pumping and land-use changes on aquifer systems. - Prepare technical reports and management recommendations from model outputs.	Guide students to: - Simulate groundwater recharge and abstraction scenarios. - Assess impacts of pumping and land-use changes on aquifer systems. - Prepare technical reports and management recommendations from model outputs.	Groundwater modelling software (MODFLOW, FEFLOW, GMS, etc), Hydrological datasets, Pumping records, Land-use maps, Groundwater monitoring data, Reporting templates, Computer
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

SURVEYING AND GEODETIC TECHNOLOGY

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: SURVEYING AND GEODETIC TECHNOLOGY	COURSE CODE: HWR 322	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in surveying and geodetic methods and Global Navigation Satellite System (GNSS).		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand advanced topographic surveying; 2.0 Understand hydrographic and bathymetric surveying; 3.0 Understand Global Navigation Satellite System Surveying; 4.0 Know Digital Elevation Model (DEM) and Global Navigation Satellite System (GNSS) elevation modelling; 5.0 Understand integration with GIS and modelling.		

PROGRAMME: HND HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: SURVEYING AND GEODETIC TECHNOLOGY			COURSE CODE: HWR 322		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE: ND Surveying		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to enable students acquire knowledge and skills in surveying and geodetic methods and Global Navigation Satellite System (GNSS).						
GENERAL OBJECTIVE 1.0: Understand advanced topographic surveying.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain use of total station and theodolite. 1.2 Explain traversing and triangulation. 1.3 Explain contouring and Digital Terrain Model (DTM) generation. 1.4 Describe cross-section and longitudinal-section surveys.	- Describe the use of the total station and theodolite. - Discuss traversing and triangulation. - Describe contouring and DTM generation. - Discuss cross-section and longitudinal-section surveys.	Textbooks, Projector, Computer, Whiteboard, Differential global positioning system (DGPS),	- Conduct total-station survey of campus area. - Perform closed traverse with adjustment. - Generate contour map from total-station data. - Carry out river cross-sections and longitudinal surveys.	Guide Students to: - Conduct total station survey of campus area. - Perform closed traverse with adjustment. - Generate contour map from total-station data. - Carry out river cross-sections and longitudinal surveys.	Total station prism, Software Survey equipment, DGPS, Map source, Computer, Internet
GENERAL OBJECTIVE 2.0: Understand hydrographic and bathymetric surveying						

4-6	2.1 Describe bathymetric survey methods. 2.2 Explain river-cross-section surveys. 2.3 Explain reservoir-capacity surveys. 2.4 Describe sediment-deposition in a river.	• Discuss bathymetric survey methods. • Discuss river-cross-section surveys • Describe reservoir-capacity surveys. • Explain sediment deposition in a river.	Textbooks, Projector, Computer, Whiteboard, Differential global positioning system (DGPS)	• Conduct a simple bathymetric survey on campus pond. • Carry out a survey on 5 river cross-sections. • Carry out a survey on any dam reservoir using different reservoir-capacity survey methods. • Map sediment deposition along a reach.	Guide Students to: • Conduct a simple bathymetric survey on campus pond. • Carry out a Survey on 5 river cross-sections. • Carry out a survey on any dam reservoir using different reservoir-capacity survey methods. • Map sediment deposition along a reach.	Echosounder, Current meter, DGPS, Graph, Marine software, Computer
GENERAL OBJECTIVE 3.0: Understand Global Navigation Satellite System (GNSS) surveying.						
7-9	3.1 Describe principles of GNSS 3.2 Explain the use of handheld GPS. 3.3 Describe differential GNSS 3.4 Explain post-processed GNSS, Precise Point Positioning (PPP)).	• Discuss GNSS principles (GPS, GLONASS, Galileo. • Describe the use of handheld GPS. • Describe differential GNSS (DGPS, Real Time Kinematic (RTK) RTK) • Discuss post-	Textbooks, Projector, Whiteboard, Computer, DGPS, Handheld GPS	• Use handheld GNSS for waypoint collection. • Compare accuracy of handheld versus survey-grade. • Conduct RTK survey of a campus area. • Process PPP data using online service.	Guide Students to: • Use handheld GNSS for waypoint collection. • Compare accuracy of handheld versus survey-grade. • Conduct RTK survey of a campus area. • Process PPP data using online	Handheld GNSS, Echosounder, Current meter, DGPS, Graph, Marine software, Computer, Survey-grade GNSS, PPP service

		processed GNSS (PPK, PPP).			service.	
GENERAL OBJECTIVE 4.0: Know Digital Elevation Model and elevation modelling.						
10-12	4.1 Explain Digital Elevation Model (DEM) generation from survey data. 4.2 Describe DEM from satellite (Shuttle Radar Topography Mission (SRTM), Advanced Land Observing Satellite (ALOS), Sentinel). 4.3 Explain DEM accuracy and validation. 4.4 Explain Unmanned Aerial Vehicle (UAV) (drone) for high-resolution DEM.	• Discuss DEM generation from survey data. • Describe DEM from satellite (SRTM, ALOS, Sentinel) • Discuss DEM accuracy and validation. • Describe UAV (drone) for high-resolution DEM.	Textbooks, Projector, Whiteboard, DGPS, DEM, UAV, SRTM	• Generate DEM from total-station survey. • Download SRTM, ALOS for a campus area. • Carry out Validation for DEM against survey points. • View UAV-generated DEM (or video).	Guide Students to: • Generate DEM from total-station survey. • Download SRTM, ALOS for a campus area. • Carry out Validation for DEM against survey points. • View UAV-generated DEM (or video).	QGIS DEM, UAV video DGPS, UAV, SRTM, Survey software
GENERAL OBJECTIVE 5.0: Know DEM and elevation modelling.						
13-15	5.1 Explain survey-data import to GIS. 5.2 Describe DEM-based hydrological analysis.	• Describe survey-data import to GIS. • Discuss DEM-based hydrological analysis.	Integration manuals, Projector, Whiteboard, Computer,	• Demonstrate how to import total-station data to QGIS. • Conduct DEM-	Guide Students to: • Demonstrate how to import total-station data to QGIS.	QGIS, 3D tools, Modelling software, HEC-HMS,

	5.3 Explain 3D visualization. 5.4 Explain integration with hydrological models.	- Describe 3D visualization. - Describe integration with hydrological models.	DEM	based watershed analysis. - Build 3D visualization of campus catchment. - Use DEM as input to HEC-HMS or SWAT.	- Conduct DEM-based watershed analysis. - Build 3D visualization of campus catchment. - Use DEM as input to HEC-HMS or SWAT.	SWAT
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

WATER QUALITY ASSESSMENT AND POLLUTION CONTROL

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: WATER QUALITY ASSESSMENT AND POLLUTION CONTROL	COURSE CODE: HWR 323	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills for water-quality assessment and pollution control.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand advanced water-quality assessment; 2.0 Know water-treatment engineering; 3.0 Understand advanced treatment processes; 4.0 Know water-quality modelling; 5.0 Know pollution control engineering.		

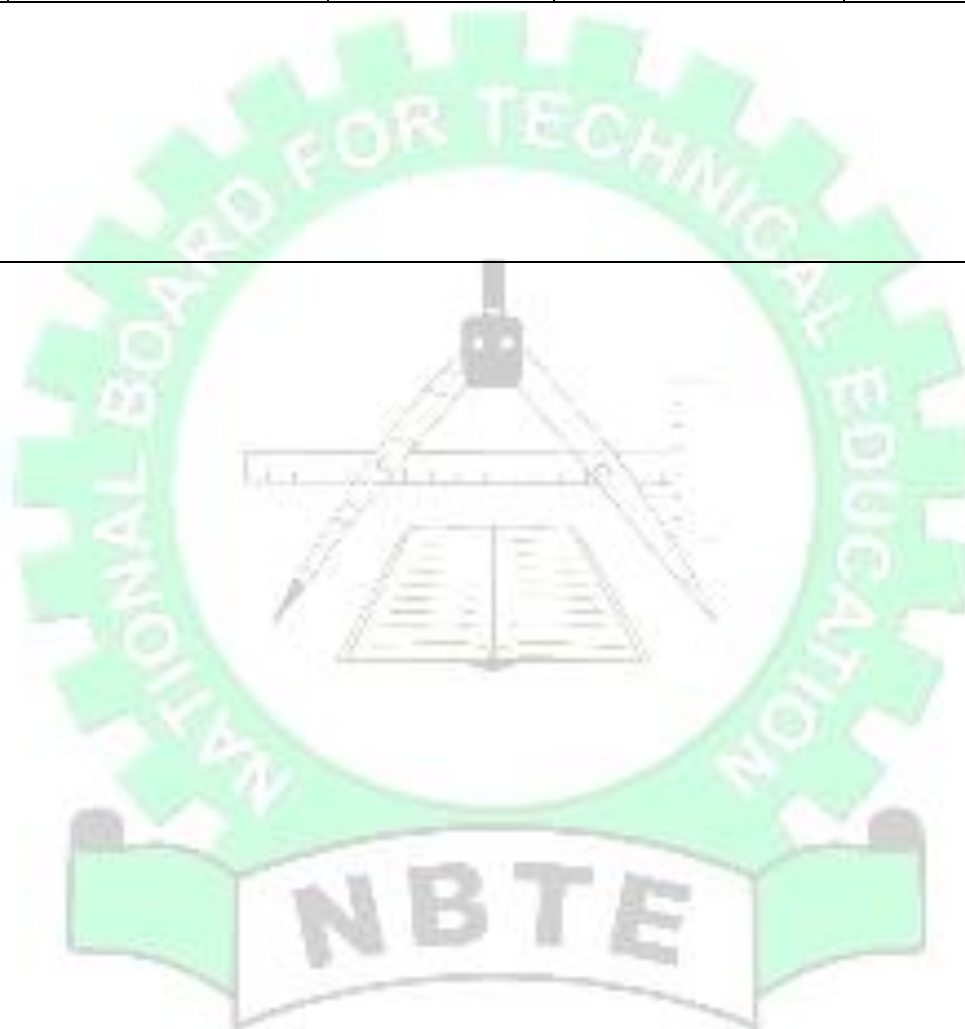
PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: WATER QUALITY ASSESSMENT AND POLLUTION CONTROL			COURSE CODE: HWR 323		CONTACT HOURS: 4 HOURS/WEEK	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills for water-quality assessment and pollution control.						
GENERAL OBJECTIVE 1.0: Understand advanced water-quality assessment						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the water quality sampling design: WHO, NSDWQ and use-specific standards 1.2 Describe the water-quality indices (CCME, NSF, others). 1.3 Explain the differences between Quality Assurance/ Quality Control (QA/QC) 1.4 Explain the	• Discuss the water quality sampling standards. • Explain the water quality indices. • State the differences with examples of QA/QC • Discuss the hydro-biological indicators.	Water-quality Textbooks, Projector White Board, NSDWQ Guideline Etc.	• Sample 5 sources; compare to NSDWQ guidelines. • Compute CCME WQI for each. • Conduct full QA/QC protocol. • Conduct macroinvertebrate sampling for water quality.	Guide students to: • Carry out water quality sampling using WQI. • Carry out QA/QC protocol on bio sampling.	Sampling Kits, NSDWQ Guidelines, WQI Templates, Bio Sampling Kits

	hydro-biological indicators					
GENERAL OBJECTIVE 2.0: Know water treatment engineering						
4-6	2.1 Explain water treatment 2.2 Explain processes of preliminary and primary water treatment 2.3 Describe the function of each unit process 2.4 Describe the process of disinfection (chlorine, UV, ozone) 2.5 Differentiate between physical, chemical, and biological processes of water treatment	- Discuss water treatment and processes of preliminary and primary treatment. - Explain the function of each unit process: - coagulation - flocculation - sedimentation - Express the process of disinfection - Discuss the physical, chemical and biological processes of water treatment	Treatment Textbooks, Projector, White Marker Board, Computer	- Visit and inspect a water-treatment plant. - Carry out preliminary/primary water treatment processes. - Carry out a jar test for coagulation - Carry out sand and membrane filters - Demonstrate chlorination and measure residual. - Identify physical, chemical and biological parameters for water treatment	Guide students to: - Inspect a water-treatment plant - Carryout Preliminary/primary water treatment processes. - Carry out jar test - Carryout Chlorination.	Water Treatment Plant, Jar Test Filters, Chlorine Kit, Water Quality Testing Kit
GENERAL OBJECTIVE 3.0: Understand advanced treatment processes						
7-9	3.1 Explain advanced treatment processes for	Explain advanced treatment processes for water quality.	Advanced Treatment Textbooks,	- Demonstrate ion-exchange. - Operate small RO	Guide students to: - Conduct ion-exchange - Operate small RO	Ion-Exchange Columns, RO Unit,

	water quality. 3.2 State conditions that require advanced treatment: • high TDS • colour, odour • taste • contaminant • saline water etc 3.3 Discuss the absorption process for the removal of taste, odour, colour, pesticides, and organic compounds 3.4 Explain the chemical oxidation processes 3.5 Explain the principle, operation and application of membrane processes: reverse osmosis (RO), nanofiltration (FO),	• Discuss conditions that require advanced treatment: ✓ high TDS ✓ colour, odour ✓ taste ✓ contaminant ✓ saline water etc • Discuss the absorption process for the removal of taste, odour, colour, pesticides, and organic compounds • Explain the chemical oxidation processes. • Explain the principle, operation and application of membrane processes: ✓ reverse osmosis (RO), ✓ nanofiltration (FO), ✓ microfiltration (MF), ✓ ultrafiltration (UF)	Projector, Computer, Charts	unit. • Browse AOP technology examples. • Carry out emerging-contaminant treatment.	unit. • Browse AOP technology examples. • Carry out emerging-contaminant treatment.	AOP literature, pH Meter, Water Quality Testing Kit
--	---	---	------------------------------------	---	---	--

	microfiltration (MF), ultrafiltration (UF)					
GENERAL OBJECTIVE 4.0: Know water-quality modeling						
10-12	4.1 Describe QUAL2K introduction. 4.2 Describe the Dissolved Oxygen modelling (DO). - Streeter-Phelps 4.3 Describe non-point-source (NPS) pollution modelling. 4.4 Explain contaminant transport in rivers	• Explain QUAL2K introduction. • Explain the Dissolved Oxygen modelling (Streeter-Phelps). • Explain non-point-source (NPS) pollution modelling. • Discuss contaminant transport in rivers.	Modelling Textbooks, Projector, Internet, Computers	• Install QUAL2K to run a river example. • Carry out Streeter-Phelps to a polluted reach • Apply NPS modelling using SWAT output. • Solve a contaminant-transport problem.	Guide students to: • Install QUAL2K to run a river example. • Carry out Streeter-Phelps to a polluted reach • Apply NPS modelling using SWAT output. • Solve a contaminant-transport problem	Laboratory PCs, QUAL2K River Data, DO Model, Water Quality Testing Kit
GENERAL OBJECTIVE 5.0: Know pollution control engineering						
13-15	5.1 Explain the pollution source-control strategies. 5.2 Describe Best Pollution Management Practices (BMPs). 5.3 Describe industrial-effluent	• Discuss source control. • Explain BMPs. • Explain industrial treatment. • Discuss the policy and regulatory compliance.	Pollution Control Textbooks, Projector, Internet, Computer, NESREA Guidelines Etc.	• Design source-control plan for an industry. • Apply BMPs to a watershed. • Design effluent treatment for an industry. • Audit compliance against NESREA	Guide students to: • Design source-control plan for an industry • Apply BMPs to a watershed. • Design effluent treatment for an industry • Audit compliance against NESREA	Plan Templates, BMP Guides, Effluent Designs, NESREA Guidelines, Constructed Wetland

	treatment. 5.4 Explain policy and regulatory compliance (NESREA).			standards.	standards	
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



WATERSHED AND CATCHMENT MANAGEMENT TECHNOLOGY

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: WATERSHED AND CATCHMENT MANAGEMENT TECHNOLOGY	COURSE CODE: HWR 324	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in the assessment, planning, conservation, restoration, and sustainable management of watersheds and catchments.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand advanced watershed and catchment processes and their influence on Water Resources; 2.0 Know watershed conditions and factors contributing to degradation; 3.0 Understand watershed conservation and restoration techniques for sustainable resource management; 4.0 Know geospatial technologies and modelling tools in watershed management; 5.0 Develop integrated watershed management plans for Water Resources sustainability; 6.0 Understand the impacts of climate change and human activities on watershed systems.		

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: WATERSHED AND CATCHMENT MANAGEMENT			COURSE CODE: HWR 324		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE: Nil		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and practical skills for the assessment, planning, conservation, restoration and sustainable management of watersheds and catchments.						
GENERAL OBJECTIVE 1.0: Understand advanced watershed and catchment processes and their influence on Water Resources.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain advanced watershed and catchment hydrological processes. 1.2 Explain interactions between surface water, groundwater, soil, and vegetation. 1.3 Describe	- Discuss advanced watershed and catchment hydrological processes. - Describe interactions between surface water, groundwater, soil, and vegetation. - Explain watershed response to climatic	Textbooks, Projector Computer White Board Marker	- Assess watershed characteristics using maps and field data. - Delineate watershed boundaries and drainage networks. - Measure watershed morphometric parameters. - Interpret hydrological behaviour of	Guide students to: - Assess watershed characteristics using maps and field data. - Delineate watershed boundaries and drainage networks. - Measure watershed morphometric parameters. - Interpret hydrological	Computer, Topographic Map, Drawing Sets, Field Data

	watershed response to climatic and environmental changes. 1.4 Outline factors controlling watershed health and functionality.	and environmental changes. • Explain factors controlling watershed health and functionality.		selected catchments.	behaviour of selected catchments.	
GENERAL OBJECTIVE 2.0: Know watershed conditions and identify factors contributing to degradation.						
4-6	2.1 Explain causes and indicators of watershed degradation. 2.2 Describe soil erosion and sedimentation processes. 2.3 Describe impacts of land-use change on watershed performance. 2.4 Describe watershed assessment and monitoring approaches.	• Discuss causes and indicators of watershed degradation. • Discuss soil erosion and sedimentation processes. • Discuss impacts of land-use change on watershed performance. • Explain watershed assessment and monitoring approaches.	Textbooks, Projector, Computer, White Board Marker	• Conduct field surveys for watershed condition assessment. • Identify erosion-prone and environmentally sensitive areas. • Estimate sediment yield using standard methods. • Prepare watershed condition assessment reports.	Guide students to: • Conduct field surveys for watershed condition assessment. • Identify erosion-prone and environmentally sensitive areas. • Estimate sediment yield using standard methods. • Prepare watershed condition assessment reports.	Total Station, Computer, Case Studies,
GENERAL OBJECTIVE 3.0: Understand watershed conservation and restoration techniques for sustainable resource management.						

7-9	3.1 Explain principles of watershed conservation and rehabilitation. 3.2 Describe structural and non-structural conservation measures. 3.3 Explain ecosystem-based watershed management approaches. 3.4 Describe best management practices for watershed protection.	• Discuss principles of watershed conservation and rehabilitation. • Describe structural and non-structural conservation measures. • Discuss ecosystem-based watershed management approaches. • Explain best management practices for watershed protection.	Textbooks, Projector, Manual, Lesson notes, Multimedia, Case study Etc.	• Design basic soil and water conservation measures. • Develop watershed restoration plans for degraded areas. • Evaluate effectiveness of conservation interventions. • Prepare conservation and rehabilitation project proposals. • Record and report findings.	Guide the students to: • Design basic soil and water conservation measures. • Develop watershed restoration plans for degraded areas. • Evaluate effectiveness of conservation interventions. • Prepare conservation and rehabilitation project proposals. • Record and report findings.	Design Templates, Watershed Data, Case Study, etc.
GENERAL OBJECTIVE 4.0: Know geospatial technologies and modelling tools in watershed management.						
10-11	4.1 Explain applications of GIS, remote sensing, and hydrological models in watershed management. 4.2 Describe spatial	• Explain applications of GIS, remote sensing, and hydrological models in watershed	Textbooks, Projector, Whiteboard Marker, Computer, Internet, GIS Software, Etc.	• Analyse watershed spatial data using GIS software. • Generate thematic maps	Guide students to: • Analyse watershed spatial data using GIS software. • Generate thematic maps for watershed planning.	Mapping Tools, Design Templates, Engagement Plans, Hydrological Models, Computer,

	data requirements for watershed analysis. 4.3 Explain watershed modelling concepts and applications. 4.4 Discuss decision-support tools for watershed planning.	management. • Describe spatial data requirements for watershed analysis. • Explain watershed modelling concepts and applications. • Discuss decision-support tools for watershed planning.		for watershed planning. • Apply remote sensing data for land-use and vegetation assessment. • Perform basic watershed modelling and scenario analysis. • Record findings • Report findings.	• Apply remote sensing data for land-use and vegetation assessment. • Perform basic watershed modelling and scenario analysis. • Record findings • Report findings.	
GENERAL OBJECTIVE 5.0: Develop integrated watershed management plans for Water Resources sustainability.						
12-13	5.1 Explain principles of integrated watershed management. 5.2 Describe stakeholder participation in watershed planning. 5.3 Describe watershed governance and	• Explain principles of integrated watershed management. • Discuss stakeholder participation in watershed planning. • Describe watershed governance and	Textbooks, Projector, Computer, Whiteboard Marker, Case Study, Internet,	• Prepare integrated watershed management plans for a catchment area. • Conduct stakeholder and resource-use assessments.	Guide the students to: • Prepare integrated watershed management catchment area. • Conduct stakeholder and resource-use assessments. • Develop watershed	Plan Templates, Workshop Materials, Checklists, Computer, Case study, Maps

	institutional frameworks. 5.4 Describe watershed management planning procedures.	institutional frameworks. • Explain watershed management planning procedures.		• Develop watershed management objectives and strategies. • Evaluate alternative watershed management options. • Record findings • Report findings.	management objectives and strategies. • Evaluate alternative watershed management options. • Record and report findings.	
GENERAL OBJECTIVE 6.0: Understand the impacts of climate change and human activities on watershed systems						
14-15	6.1 Explain climate change impacts on watershed hydrology. 6.2 Explain effects of urbanization, agriculture, and deforestation on catchment systems. 6.3 Describe watershed vulnerability and risk assessment methods.	• Discuss climate change impacts on watershed hydrology. • Discuss effects of urbanization, agriculture, and deforestation on catchment systems. • Explain watershed vulnerability and risk assessment	Textbooks, Projector, Computer, Case study, Multimedia, Map	• Assess watershed vulnerability to climate and land-use changes for a catchment area. • Analyse climate and hydrological datasets for trend detection.	Guide the students to: • Assess watershed vulnerability to climate and land-use changes for a catchment area. • Analyse climate and hydrological datasets for trend detection. • Develop adaptation and mitigation	Plan Templates, Workshop Materials, Computer, Case study, Maps, Multimedia

	6.4 Explain adaptation and resilience-building strategies.	methods. Describe adaptation and resilience-building strategies.		- Develop adaptation and mitigation measures for selected watersheds. - Prepare watershed resilience and risk management plans. - Record findings - Report findings.	measures for selected watersheds. - Prepare watershed resilience and risk management plans. - Record and report findings.	
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

IRRIGATION AND WATER RESOURCES MANAGEMENT TECHNOLOGY

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: IRRIGATION AND WATER RESOURCES MANAGEMENT TECHNOLOGY	COURSE CODE: HWR 325	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEKS
GOAL: This course is designed to equip students with knowledge and skills in advanced irrigation and Water Resources management from farm to basin scale.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand irrigation systems engineering; 2.0 Know crop water requirement; 3.0 Understand irrigation scheduling and water management; 4.0 Understand drainage and salinity management; 5.0 Understand basin-scale agricultural water management.		

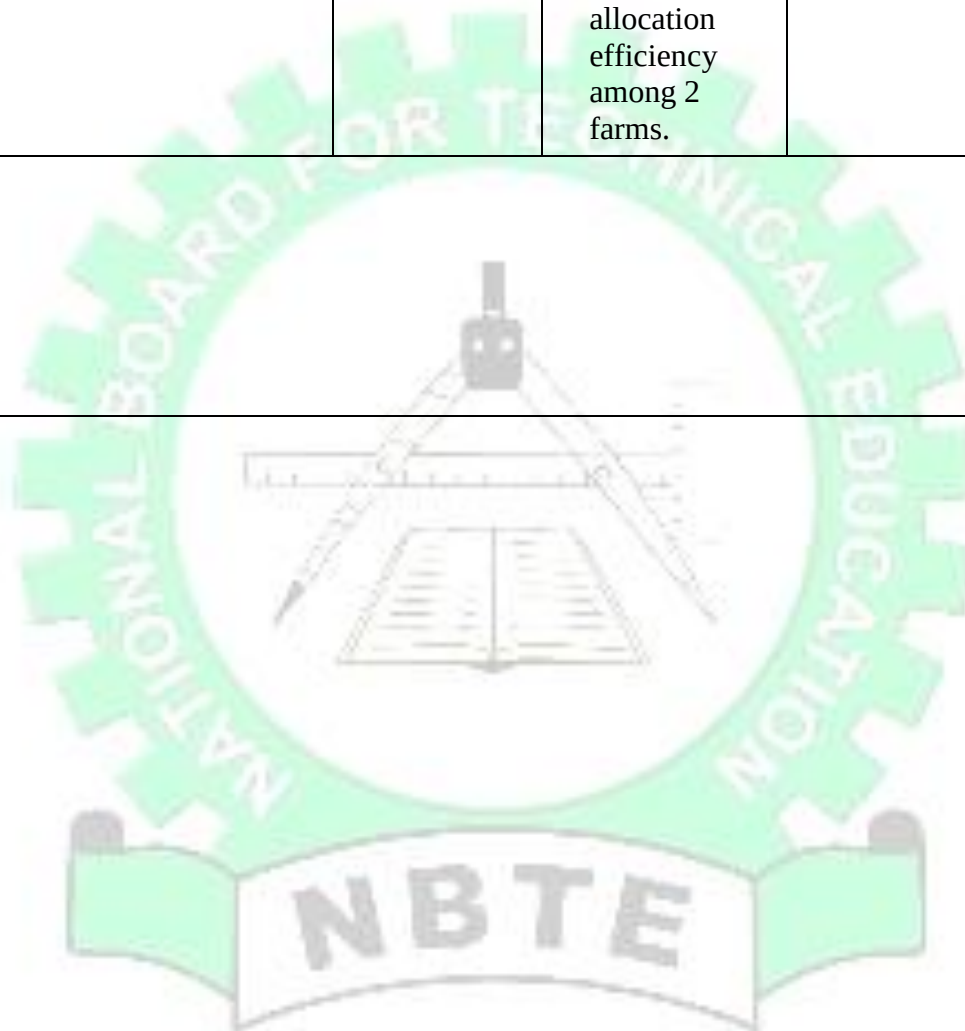
HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: IRRIGATION AND WATER RESOURCES MANAGEMENT TECHNOLOGY			COURSE CODE: HWR 325		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in irrigation and Water Resources management from farm to basin scale.						
GENERAL OBJECTIVE 1.0: Understand Irrigation systems engineering						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher’s Activities	Resources	Specific Learning Outcome	Teacher’s Activities	Resources
1-3	1.1 Explain the principle of surface irrigation design (basin, border, furrow etc) 1.2 Describe the principle of sprinkler irrigation and centre-pivot design. 1.3 Explain the principle of drip and micro-	• Explain the principle of surface irrigation design • Discuss the principle of sprinkler irrigation design. • Explain the principle of drip and micro-irrigation desig • Discuss the system selection and economic comparison.	Textbooks, Projector, Computer, Internet, White Board	• Demonstrate the design of surface irrigation for 1 ha. • Demonstrate the design of a sprinkler irrigation system for 1 ha. • Demonstrate the Design of a drip	Guide students to: • Design surface, sprinkler and drip irrigation techniques. • Carry out surface, sprinkler and drip irrigation techniques. • Analyse the three (3) irrigation systems economically.	Design Templates, Calculators, BoQ Templates, Sprinkler, Drip Kit, Demonstration Farms

	irrigation design 1.4 Explain system selection and economic comparison			irrigation system for 1 ha. • Analyse the three (3) irrigation systems economically.		
GENERAL OBJECTIVE 2.0: Understand crop water requirement						
4-6	2.1 Explain the principle of CROPWAT for ETo and ETc 2.2 Explain effective rainfall analysis 2.3 Explain irrigation requirement (net and gross). 2.4 Explain the concept of crop-water-productivity analysis	• Explain the principle of CROPWAT. • Discuss effective rainfall • Explain irrigation requirement. • Discuss crop-water-productivity.	CROPWAT Manual Textbooks, Projector, Computer, Internet, Whiteboard	• Compute ETo and ETc for 3 crops in CROPWAT. • Compute effective rainfall over a season. • Compute net and gross irrigation requirement. • Compute water productivity for 3 crops.	Guide students to: • Compute ETo and ETc for 3 crops in CROPWAT • Compute effective rainfall • Compute irrigation requirement • Compute water productivity for 3 crops	Laboratory PCs, CROPWAT Software, Crop Data, Rainfall Data, Rain Gauge
GENERAL OBJECTIVE 3.0: Understand irrigation scheduling and water management						
7-9	3.1 Explain the concept of soil-water balance scheduling.	• Discuss the concept of soil-water balance scheduling.	Scheduling Guides, Textbooks, Projector,	• Compute soil-water balance for one week.	Guide students to: • Compute soil-water balance for one week.	Demonstration Plot, Soil Moisture Sensors,

	3.2 Explain the principle of sensor-based scheduling 3.3 Describe the concept of deficit irrigation strategies. 3.4 Explain the principle of fertigation and chemigation.	- Describe the principle of sensor-based scheduling. - Explain the concept of deficit irrigation strategies. - Explain the principle of fertigation and chemigation.	Computer, Internet, Whiteboard etc.	- Analyse soil-moisture sensor and use it for scheduling. - Design deficit-irrigation schedule. - Analyse deficit-irrigation schedule. - Set up a fertigation and chemigation injector. - Operate fertigation and chemigation injector.	- Analyse soil-moisture sensor and use it for scheduling - Design deficit-irrigation schedule. - Analyse deficit-irrigation schedule. - Set up a fertigation and chemigation injector. - Operate fertigation and chemigation injector.	Fertigation and Chemigation Injector,
GENERAL OBJECTIVE 4.0: Understand drainage and salinity management						
10-12	4.1 Explain the principle of drainage system design (surface & sub-surface). 4.2 Explain the	- Explain the principle of drainage system design (surface & sub-surface). - Explain the drainage requirement	Textbooks, Projector, Computer, Internet, Whiteboard Etc.	- Design sub-surface drainage for 1 ha. - Construct sub-surface	Guide students to: - Design sub-surface drainage for 1 ha - Construct sub-surface drainage for 1 ha - Design drainage	Drainage Materials, Samples, EC meters

	drainage requirement calculation. 4.3 Explain salinity and salinity assessment. 4.4 Describe salinity-control measures (leaching, drainage).	calculation • Explain salinity and salinity assessment • Explain salinity control measures		drainage for 1 ha. • Design drainage requirements. • Calculate drainage requirements. • Conduct salinity assessment on 5 samples. • Design salinity control measures such as leaching • Construct salinity control measures such as leaching	requirements • Calculate drainage requirements • Conduct salinity assessment on 5 samples. • Design salinity control measures such as leaching. • Construct salinity control measures such as leaching	
GENERAL OBJECTIVE 5.0: Understand basin-scale agricultural water management						
13-15	5.1 Explain the concept of farm-to-basin water balance. 5.2 Describe irrigation efficiency at multiple scales.	• Explain the concept of farm-to-basin water balance • Discuss irrigation efficiency at multiple scales • Explain allocation	Textbooks, Projector, Computer, Internet, Whiteboard	• Compute farm-to-basin water balance. • Estimate irrigation efficiency at farm scheme.	Guide students to: • Compute farm-to-basin water balance. • Conduct irrigation efficiency at farm and basin scales allocation. • Design allocation	Balance Templates, Efficiency Templates, Allocation Templates, Policy

	5.3 Explain allocation efficiency among agricultural users. 5.4 Describe the concept of agri-water policy.	efficiency among agricultural users • Discuss the concept of agri-water policy.		• Estimate irrigation efficiency at basin scales. • Design allocation efficiency among 2 farms.	efficiency among 2 farms. • Construct allocation efficiency among farms.	Documents, Demonstration Farms,
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



WATER SUPPLY TECHNOLOGY

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: WATER SUPPLY TECHNOLOGY	COURSE CODE: HWR 326	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills of water-supply system design - from source to tap.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand water-supply planning and demand; 2.0 Understand water-source development design; 3.0 Understand water-treatment processes and design; 4.0 Understand methods of storage and distribution-network design; 5.0 Understand rural water supply systems; 6.0 Understand system operation and maintenance and asset management		

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: WATER SUPPLY TECHNOLOGY			COURSE CODE: HWR 326		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in water-supply system design - from source to tap.						
GENERAL OBJECTIVE 1.0: Understand water-supply planning and demand						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain water demand and consumption. 1.2 Describe categories of water demand and factors affecting them. 1.3 Describe population projection methods. 1.4 Explain peak factors and variation. 1.5 Describe Nigerian water-supply	• Explain water demand and consumption. • Discuss categories of water demand and factors affecting them. • Explain population projection methods. • Calculate per-capita demand and design period. • Explain peak factors and variation. • Discuss Nigerian	Textbooks, Projector, Water Supply Manuals. Charts, Case Studies. Calculators, Worksheets. Population Data Records,	• Calculate per-capita demand and design period. • Estimate present population and forecast 20 years population. • Compute per-capita demand for one community. • Determine peak factors	Guide students to: • Estimate present population and forecast 20-year population. • Calculate per-capita demand and design period. • Compute per-capita demand for one community. • Determine peak factors and design demand. • Identify Nigerian standards (NSDWQ, etc.)	Population Census Data, Water Demand, Standards (NSDWQ WHO), Worksheets. Design Manuals, Report Templates,

	standards.	water-supply standards.		and design demand. • Identify Nigerian standards for drinking water quality (NSDWQ, etc.) • Prepare water demand reports. • Record and report findings	• Prepare water demand reports. • Record and report findings	
GENERAL OBJECTIVE 2.0: Understand water-source development design						
4-6	2.1 Describe water sources and their characteristics. 2.2 Explain advantages and disadvantages of various water sources. 2.3 Describe water intake structures, and intake components. 2.4 Explain factors influencing intake design. 2.5 Describe surface-water intake	• Explain water sources and their characteristics. • Explain advantages and disadvantages of various water sources. • Explain functions and importance of intake systems. • Discuss river, lake, reservoir and canal intakes. • Discuss water level variation, sediment load and flow	Textbooks, Projector, Charts, Water Quality Manuals, MultiMedia Presentations, Environmental Guidelines	• Identify water sources in a locality. • Prepare source inventory reports. • Assess source characteristics. • Design surface intake for 1000 m^{3/d}. • Design borehole for 200 m^{3/d}. • Design 50,000	Guide students to: • Identify water sources in a locality. • Prepare source inventory reports. • Assess source characteristics. • Design surface intake for 1000 m^{3/d}. • Design a borehole for 200 m^{3/d}. • Design 50,000 L rainwater system • Design wellhead-protection zones.	Design Templates, Source Data Maps, GPS, Water Testing Kits, Field Notebooks,

	design. 2.6 Explain borehole development design. 2.7 Describe rainwater-harvesting system design. 2.8 Explain source-protection measures and design.	conditions. • Describe screens, gates, valves and approach channels. • Describe borehole development design. • Describe rainwater-harvesting system design. • Discuss source-protection measures and design.		L rainwater system. • Design wellhead-protection zones. • Record and report findings.	• Record findings. • Report findings.	
GENERAL OBJECTIVE 3.0: Understand water-treatment processes and design						
7-9	3.1 Explain water treatment. 3.2 Describe treatment processes. 3.3 Describe treatment plant layout. 3.4 Describe coagulation-flocculation-sedimentation design. 3.5 Describe filtration design. 3.6 Describe disinfection design. 3.7 Explain water quality standards.	• Discuss water treatment. • Explain treatment processes. • Explain treatment plant layout. • Discuss CFS design. • Explain filtration design. • Explain disinfection design. • Explain water quality standards. • Discuss small-scale treatment for rural communities.	Textbooks, Projector, Process flow Charts Plant diagrams, WHO, NSDWQ guidelines	• Conduct jar test experiments. • Measure treatment efficiency. • Operate filtration units. • Apply disinfection methods. • Design CFS for 1000 m ³ /d. • Design rapid-sand filter. • Design	Guide students to: • Conduct jar test experiments. • Measure treatment efficiency. • Operate filtration units. • Apply disinfection methods. • Design CFS for 1000 m ³ /d. • Design rapid-sand filter. • Design chlorination system. • Design bio-sand filter for a rural community. • Record and report	Jar Test Apparatus, Water Testing kits, Sand Filters, Chlorine Test Kits, Design Templates, Calculators,

	3.8 Explain small-scale treatment for rural communities.			chlorination system. • Design bio-sand filter for a rural community. • Record and report findings	findings.	
GENERAL OBJECTIVE 4.0: Understand Methods of storage and Distribution-network design						
10-11	4.1 Define water storage and distribution systems. 4.2 Describe storage facilities. 4.3 Explain distribution systems. 4.4 Describe distribution components. 4.5 Describe the pipe-network layout 4.6 Explain pipe sizing and hydraulic analysis 4.7 Explain pumps and their selection criteria 4.8 Explain reservoir	• Explain water storage and distribution systems. • State storage facilities. • Explain purposes and functions. • Discuss reservoirs, tanks and elevated storage structures. • Discuss gravity, pumping and combined systems. • Explain pipes, valves, hydrants and meters. • Explain pipe network layout. • Discuss pipe sizing and hydraulic	Textbooks, Projector, Multimedia, Case study Etc.	• Visit a water treatment plant. • Identify distribution components. • Measure the storage tank capacity. • Inspect water distribution systems. • Design a layout distribution network for one community. • Size pipes using the	Guide the students to: • Visit a water treatment plant. • Identify distribution components. • Measure the storage tank capacity. • Inspect water distribution systems. • Design a layout distribution network for one community. • Size pipes using the Hardy-Cross method. • Design a pumping station and reservoir. • Model the network in EPANET. • Record and report findings.	Lab PCs, EPANET, Design templates, Pipe fittings. Drawing instruments. Measuring tapes. Water supply schemes Etc.

	design 4.9 Describe EPANET network modelling	analysis. • Discuss pumps and selection strategies • Explain reservoir design • Describe how to use EPANET modelling software		Hardy-Cross method. • Design a pumping station and reservoir. • Model the network in EPANET. • Record and report findings.		
GENERAL OBJECTIVE 5.0: Understand Rural Water Supply System						
12-13	5.1 Explain rural water supply. 5.2 Explain rural water supply technologies. 5.3 Describe borehole drilling processes. 5.4 Describe pump test processes. 5.5 Explain Hand pump installation and maintenance. 5.6 Explain Borehole installation and maintenance. 5.7 Describe power sources for rural water supply	• Discuss rural water supply. • Describe rural water supply technologies. • Describe borehole drilling processes. • Describe pump test processes. • Explain Hand pump installation and maintenance. • Explain Borehole installation and maintenance. • Discuss power sources for rural water supply schemes.	Rural Water Manuals, Textbooks, Charts, Case Studies. O&M Manuals,	• Field trips to a rural community. • Inspect rural water facilities. • Demonstrate borehole drilling exercise. • Conduct pumping test. • Demonstrate borehole installation and maintenance. • Demonstrate hand pump installation and maintenance. • Assess community water needs.	Guide students to • carry out field trips to a rural community. • Inspect rural water facilities. • Demonstrate borehole drilling exercise. • Conduct pumping test. • Demonstrate borehole installation and maintenance. • Demonstrate hand	Boreholes, Wells, Hand pump Assembly, Questionnaires, Planning Template, Computer,

	schemes. 5.8 Explain community participation.	• Explain community participation.		• Prepare rural water supply plans. • Record and report findings.	pump installation and maintenance. • Assess community water needs. • Prepare rural water supply plans. • Record and report findings.	
GENERAL OBJECTIVE 6.0: Understand system Operation and Maintenance and asset management						
14-15	5.1 Explain the concept of operation and maintenance in water supply. 5.2 Explain maintenance scheduling. 5.3 Explain non-revenue water management. 5.4 Describe asset management and renewal. 5.5 Explain gender-inclusive WASH service.	• Discuss the concept of operation and maintenance in water supply. • Discuss Maintenance scheduling. • Explain non-revenue water management. • Discuss asset management and renewal. • Explain gender-inclusive WASH service.	Textbooks, Projector, Case Studies, O&M Manuals, etc.	• Build a maintenance schedule for a small water system. • Estimate NRW and design a reduction plan. • Build asset register and renewal plan. • Apply gender-WASH checklist to design. • Record and report findings.	Guide student to: • Build a maintenance schedule for a small water system. • Estimate NRW and design a reduction plan. • Build asset register and renewal plan. • Apply gender-WASH checklist to design. • Record and report findings.	O&M Manuals, Templates, Audit Checklists,

COURSE ASSESSMENT:

Tests:	10%
Course work:	10%
Practical:	40%
Examination:	40%
Total:	100%



DIGITAL WATER MONITORING SYSTEMS

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT		
COURSE TITLE: DIGITAL WATER MONITORING SYSTEMS	COURSE CODE: HWR 327	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: I SEMESTER: II	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in digital water monitoring, data acquisition, transmission, and analysis for Water Resources Management.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the principles and applications of advanced digital water monitoring systems; 2.0 Understand sensors and instrumentation for hydrological, meteorological, and water-quality monitoring; 3.0 Know telemetry, communication, and Internet of Things (IoT) technologies for real-time water monitoring; 4.0 Understand how to manage, process, visualize, and analyse digital water monitoring data; 5.0 Know how to integrate digital monitoring systems with GIS, remote sensing, and decision-support tools; 6.0 Know how to design, operate, and maintain advanced digital water monitoring networks.		

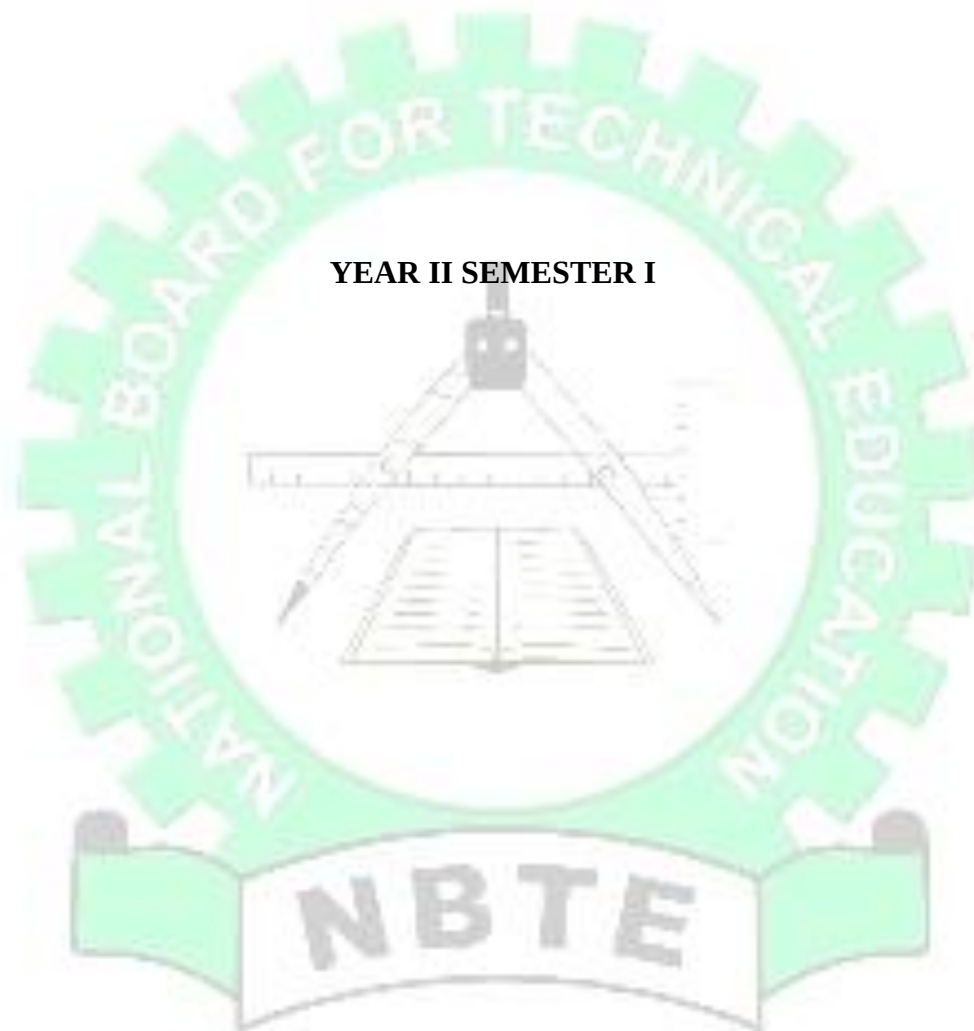
PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: DIGITAL WATER MONITORING SYSTEMS			COURSE CODE: HWR 327		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: I SEMESTER: II			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in digital water monitoring, data acquisition, transmission, and analysis for Water Resources management.						
GENERAL OBJECTIVE 1.0: Understand the principles and applications of advanced digital water monitoring systems.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the concepts and evolution of digital water monitoring systems. 1.2 Describe the components of automated monitoring networks. 1.3 Explain the roles of digital monitoring in Water Resources management.	• Discuss the concepts and evolution of digital water monitoring systems. • Outline the components of automated monitoring networks. • Discuss the roles of digital monitoring in Water Resources management. • Discuss emerging	Sensor textbooks, Projector, Computer, Internet, White board	• Assemble components of a digital monitoring station. • Configure monitoring system hardware. • Examine operational digital monitoring networks. • Prepare system	Guide students to: • Assemble components of a digital monitoring station. • Configure monitoring system hardware. • Examine operational digital monitoring networks. • Prepare system architecture diagrams for monitoring applications.	Demonstration monitoring stations. Sensors and data loggers. Computers and networking devices. Technical manuals Internet

	1.4 Explain emerging technologies in smart water monitoring.	technologies in smart water monitoring.		architecture diagrams for monitoring applications.		
GENERAL OBJECTIVE 2.0: Understand advanced sensors and instrumentation for hydrological, meteorological, and water-quality monitoring						
4-6	2.1 Explain principles of operation of digital sensors. 2.2 Explain hydrological, meteorological, groundwater, and water-quality sensors. 2.3 Explain sensor accuracy, precision, calibration, and maintenance. 2.4 Describe sensor selection criteria for monitoring applications.	• Describe the principles of operation of digital sensors. • Describe hydrological, meteorological, groundwater, and water-quality sensors. • Describe sensor accuracy, precision, calibration, and maintenance. • Explain sensor selection criteria for monitoring applications.	Textbooks Projector Computer, Whiteboard, Internet	• Install digital sensors. • Calibrate digital sensors. • Measure hydrological and water-quality parameters using digital instruments. • Perform routine maintenance of monitoring equipment. • Evaluate sensor performance and data quality.	Guide students to: • Install digital sensors. • Calibrate digital sensors. • Measure hydrological and water-quality parameters using digital instruments. • Perform routine maintenance of monitoring equipment. • Evaluate sensor performance and data quality.	Rain gauges, Water-level sensors, Flow meters Multiparameter water-quality probes Internet, Computer
GENERAL OBJECTIVE 3.0: Know telemetry, communication, and Internet of Things (IoT) technologies for real-time water monitoring						

7-9	3.1 Explain telemetry and remote data acquisition systems. 3.2 Explain communication technologies used in water monitoring. 3.3 Explain IoT concepts and applications in hydrology. 3.4 Explain data transmission reliability and security.	• Discuss telemetry and remote data acquisition systems. • Discuss communication technologies used in water monitoring. • Describe IoT concepts and applications in hydrology. • Discuss data transmission reliability and security.	Textbooks Projector Computer, Whiteboard, Internet	• Configure telemetry devices for data transmission. • Establish communication links between monitoring stations and control centres. • Integrate IoT devices into monitoring systems. • Test real-time data transmission and reception.	Guide students to: • Configure telemetry devices for data transmission. • Establish communication links between monitoring stations and control centres. • Integrate IoT devices into monitoring systems. • Test real-time data transmission and reception.	GSM/GPRS modules, IoT development kits, Wireless communication devices, Internet-enabled monitoring platforms
GENERAL OBJECTIVE 4.0: Understand how to manage, process, visualize, and analyse digital water monitoring data						
10-12	4.1 Explain principles of hydrological data management. 4.2 Explain data quality control and assurance procedures. 4.3 Explain methods of data processing and visualization.	• Describe principles of hydrological data management. • Describe data quality control and assurance procedures. • Describe methods of data processing	Textbooks Projector Computer, Whiteboard, Internet	• Organize monitoring datasets. • Perform quality control and validation of collected data. • Create charts,	Guide students to: • Download and organize monitoring datasets. • Perform quality control and validation of collected data. • Create charts, dashboards, and visualization products.	Cloud accounts, Influx dB, Dashboard tools, Computers and servers, Spreadsheet software, Database management software,

	4.4 Outline database systems for water information management.	- and visualization. - Discuss database systems for water information management.		dashboards, and visualization products. Carry out monitoring databases and archives.	Manage monitoring databases and archives.	Data visualization platforms
GENERAL OBJECTIVE 5.0: Know how to integrate digital monitoring systems with GIS, remote sensing, and decision-support tools.						
13-14	5.1 Explain the integration of monitoring systems with GIS. 5.2 Explain applications of remote sensing in water monitoring. 5.3 Explain spatial data analysis techniques. 5.4 Describe decision-support systems for Water Resources management.	- Describe the integration of monitoring systems with GIS. - Describe applications of remote sensing in water monitoring. - Describe spatial data analysis techniques. - Discuss decision-support systems for Water Resources management.	Textbooks Projector Computer, Whiteboard, Internet	- Import monitoring data into GIS platforms. Generate thematic maps from monitoring datasets. - Integrate remote sensing products with field observations. - Develop simple decision-support outputs for water management.	Guide students to: - Import monitoring data into GIS platforms. Generate thematic maps from monitoring datasets. - Integrate remote sensing products with field observations. - Develop simple decision-support outputs for water management.	GIS software, Satellite imagery, GPS receivers, Digital elevation and spatial datasets, Computers and servers
GENERAL OBJECTIVE 6.0: Know how to integrate digital monitoring systems with GIS, remote sensing, and decision-support tools						
15	6.1 Explain principles of monitoring network design.	Describe principles of monitoring network design.	Textbooks Projector Computer,	Design a digital monitoring	Guide students to: Design a digital monitoring network for a	Monitoring stations, Data loggers,

	6.2 Explain operational and maintenance requirements of monitoring systems. 6.3 Explain monitoring network performance evaluation methods. 6.4 Describe sustainability and cost considerations in monitoring programmes.	• Describe operational and maintenance requirements of monitoring systems. • Describe monitoring network performance evaluation methods. • Discuss sustainability and cost considerations in monitoring programmes.	Whiteboard, Internet	network for a watershed or catchment. • Prepare operation and maintenance schedules. • Troubleshoot monitoring system faults. • Prepare technical reports on network performance.	watershed or catchment. • Prepare operation and maintenance schedules. • Troubleshoot monitoring system faults. • Prepare technical reports on network performance.	Power supply systems (solar panels and batteries), Field maintenance tools and accessories, Computers and servers
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



WATER RESOURCES PLANNING AND MANAGEMENT TECHNOLOGY

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: WATER RESOURCES PLANNING AND MANAGEMENT TECHNOLOGY	COURSE CODE: HWR 411	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: I	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEKS
GOAL: This course is designed to equip students with knowledge and skills of water-resource planning and management		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand water-resource planning frameworks; 2.0 Understand water-demand analysis; 3.0 Understand water-supply planning; 4.0 Understand allocation and decision-support; 5.0 Understand implementation and monitoring.		

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: WATER RESOURCES PLANNING AND MANAGEMENT TECHNOLOGY			COURSE CODE: HWR 411		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: I			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and practical skills of water-resource planning and management						
GENERAL OBJECTIVE 1.0: Understand water-resource planning frameworks						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain Water Resources planning, objectives and principles. 1.2 Describe river-basin planning, approach and requirements for basin planning. 1.3 Explain the long-term master planning. 1.4 Explain National Water Resources Master Plans	•Discuss Water Resources planning, objectives, and principles. •Discuss river-basin planning, approach, and requirements for basin planning •Discuss the long-term master planning. •Discuss Nigerian water plans.	Textbooks Projector Computer, Whiteboard, Internet	• Apply IWRM cycle to a Nigerian basin. • Develop basin-planning framework. • Profile 20-year master plan. • Browse and summarise NWRMP. • Use simple cost analysis benefit table to compare two water supply	Guides the students to: • Calculate minimum environmental flow (E-flow) using Tennant method. • Outline a river basin plan using data from nearest RBDA station. • Calculate water balances using rainfall, runoff and ETo data to check if basin has deficit/surplus. • Report and record findings	Basin plans, NWRMP documents, Field trip to stream gauge station, GIS, AutoCAD, Computer

	(NWRMP)			options (new dam vs borehole scheme). • Report and record findings		
GENERAL OBJECTIVE 2.0: Understand water-demand analysis						
4-6	2.1 Explain domestic demand projection. 2.2 Describe agricultural demand projection. 2.3 Describe industrial demand projection. 2.4 Explain ecosystem-flow requirements.	• Discuss domestic demand projection. • Discuss agricultural demand projection. • Describe industrial demand projection. • Describe ecosystem-flow requirements. • Discuss detailed industrial demand projection • Discuss ecosystem-flow requirements	Demand templates, Field data, Calculators, Water board records on NRW WEAP model, Climate data from NIMET, Population data from NPC, Computer, Whiteboard marker	• Conduct domestic water demand for one town. • Project agricultural demand for a 500-ha area. • Project industrial demand for an industrial city. • Estimate ecosystem flow for one river.	Guides the students to: • Carry out a survey on 20 households to find out the per capita use vs standard. • Visit treatment plant intake to see how daily demand is recorded and peak factor measured. • Draw demand projection graph for 5 years.	Demand templates, Field data, Calculators, Water board records on NRW, WEAP model, Climate data from NIMET, Population data from NPC Drawing sets, Calculator.
GENERAL OBJECTIVE 3.0: Understand water-supply planning						
7-9	3.1 Explain water supply planning, sources and criteria for selecting sources. 3.2 Outline	• Describe water supply planning, sources, and criteria for selecting sources.	Water supply data Textbooks, Projector, Computer, Internet,	• Identify sources for one basin. • Identify components of	Guides the students to: • Draw schematic diagram of water supply system. • Use LPCD to calculate total daily demand for a	Yield data, Sizing tools, WEAP software, Calculator, Graph sheets, Drawing sets,

	components of water supply planning. 3.3 Explain the following terms: i. Design period, ii. Peak factor, iii. Litres per capita demand (LPCD), iv. Non-revenue water (NWR) 3.4 Describe yield and reliability analysis. 3.5 Explain storage and reservoir sizing. 3.6 Explain conjunctive use planning.	• Explain components of water supply planning. • Discuss the following terms: - Design period - Peak factor, - Litres per capita demand (LPCD), - Non-revenue water (NWR) • Explain yield and reliability analysis. • Describe storage and reservoir sizing. • Describe conjunctive use planning.	Water supply scheme, Charts of water demand vs supply gap, Computer, Whiteboard marker	water supply planning. • Conduct yield analysis. • Design storage and reservoir sizing. • Design conjunctive-use plan.	town. • Draw 6-step water supply planning cycle. • Design storage and reservoir. • Record and report findings.	CROPWAT 8.0 FAO, Drawing sets, Calculator,
GENERAL OBJECTIVE 4.0: Understand allocation and decision-support						
10-12	4.1 Explain water allocation, models, principles and methods. 4.2 Describe multi-criteria decision analysis. 4.3 Explain equity and gender-inclusion. 4.4 Explain trade-off	• Describe water allocation, models, principles and methods. • Discuss multi-criteria decision analysis. • Discuss equity and gender-inclusion. • Discuss trade-off	Textbooks, Projector, Video clips, Computer, Manuals, Allocation table/chart, Case study.	• Analyse allocation model (WEAP) for one basin. • Analyse MCDA to planning problem. • Conduct	Guides students to: • Design water allocation distribution for a community. • Design a flow chart of a decision tree. • Draw Priority Pyramid. • Carry out MCDA, checklist for gender responsive water design	Laboratory computer, WEAP, MCDA tools, Graph sheets, Drawing set, Internet

	analysis.	analysis.		equity/gender checklist. • Carry out trade-offs in 3 scenarios.	and trade-offs. • Construct trade-off matrix/table. • Role-play between upstream farmers and downstream town and propose a fair allocation rule to resolve conflict. • Record and report findings	
GENERAL OBJECTIVE 5.0: Understand implementation and monitoring						
13-15	5.1 Explain implementation, monitoring, evaluation (M&E) and performance indicators for water supply. 5.2 Explain why monitoring is needed 5.3 State the phases of the implementation process. 5.4 Explain institutional roles of monitoring and evaluation. 5.5 Explain financing arrangements. 5.6 Describe M&E and	• Describe implementation, evaluation, M&E and performance indicators for water supply. • Discuss why monitoring is needed and the phases of the implementation process. • Discuss institutional roles of monitoring and evaluation. • Discuss financing arrangements. • Explain M&E and adaptive	Textbook Journals, Projector, Computer Chart, Internet	• Develop implementation arrangements. • Identify institutional roles and gaps. • Identify financing for one plan. • Develop M&E framework with 15 • Identify Key Performance Indicators.	Guides students to: • Design log-frame table for water projects. • Use checklist to inspect existing borehole sites. • Design a water bill. • Prepare and compare 5-year cash flow. • Report and record findings.	Implementation templates, M&E frameworks, Water quality testing kits, GPS, Excel sheet for cash flow, Charts, Internet

	adaptive management. 5.7 Explain log-frame as a tool for monitoring project matrix.	management. • Describe log-frame as a tool for monitoring project matrix.				
--	--	--	--	--	--	--

COURSE ASSESSMENT:

Tests:	10%
Course work:	10%
Practical:	40%
Examination:	40%
Total:	100%



FLOOD HYDROLOGY AND RISK MANAGEMENT

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: FLOOD HYDROLOGY AND RISK MANAGEMENT	COURSE CODE: HWR 412	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: I	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in flood analysis, forecasting, and risk management		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand flood hydrological processes and flood-generating mechanisms; 2.0 Apply hydrological methods for flood estimation and forecasting; 3.0 Know flood hazards, vulnerability, and risks; 4.0 Know geospatial technologies and modelling tools for flood studies; 5.0 Understand structural and non-structural flood risk management measures; 6.0 Know flood preparedness, emergency response, and climate adaptation strategies.		

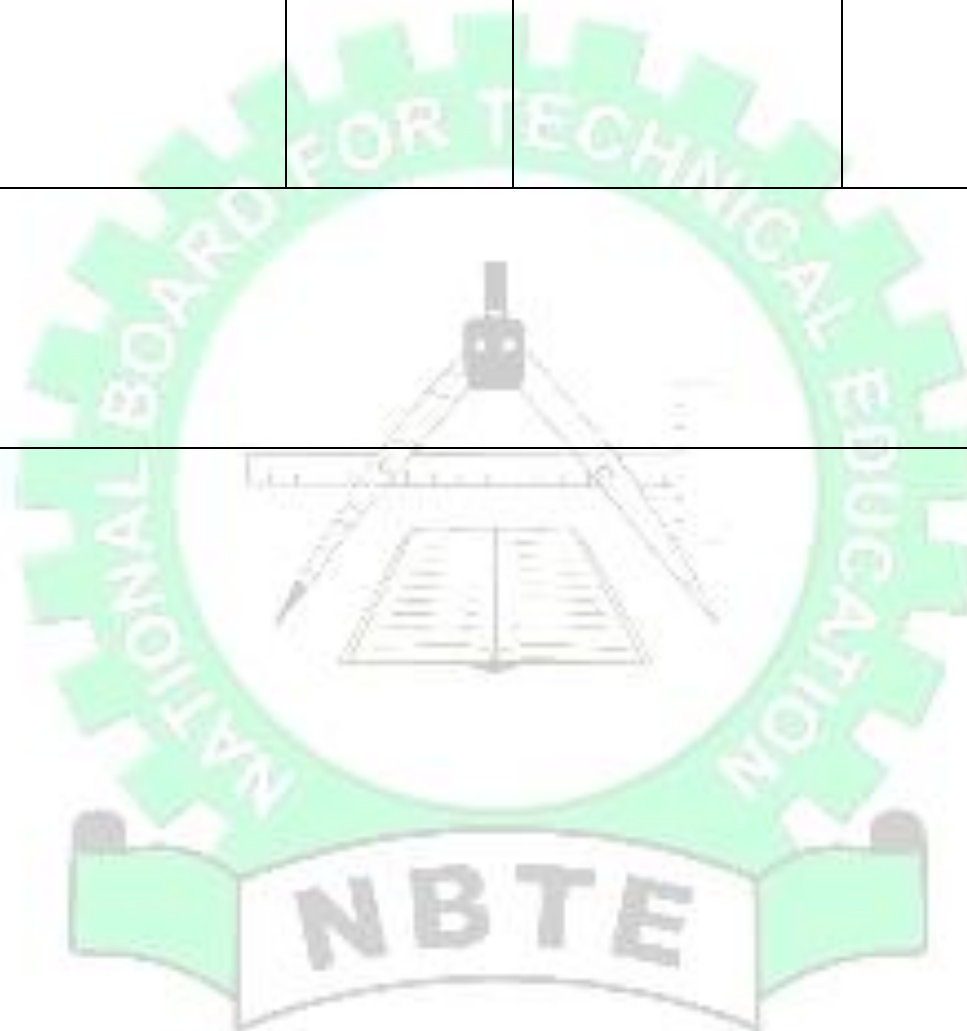
PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: FLOOD HYDROLOGY AND RISK MANAGEMENT			COURSE CODE: HWR 412		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: I			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in flood analysis, forecasting, and risk management.						
GENERAL OBJECTIVE 1.0: Understand flood hydrological processes and flood-generating mechanisms.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the hydrological processes leading to flood occurrence. 1.2 Describe different types and causes of floods. 1.3 Explain rainfall–runoff relationships in flood generation. 1.4 Describe factors influencing flood magnitude and	- Describe rainfall and streamflow records for flood studies. - Explain flood-prone areas from hydrological data. - Discuss flood hydrographs from observed data. - Describe how to interpret flood events using historical records.	Textbook Journals, Projector, Computer Chart, Internet	- Analyse rainfall and streamflow records for flood studies. - Identify flood-prone areas from hydrological data. - Prepare flood hydrographs from observed data. - Interpret flood events using historical records.	Guide students to: - Analyse rainfall and streamflow records for flood studies. - Identify flood-prone areas from hydrological data. - Prepare flood hydrographs from observed data. - Interpret flood events using historical records.	Historical rainfall datasets. Streamflow records and hydrographs. Watershed maps and topographic maps. Spreadsheet software. Hydrological field data sheets, Computer, Laboratory facilities

	frequency.					
GENERAL OBJECTIVE 2.0: Apply hydrological methods for flood estimation and forecasting.						
4-6	2.1 Describe methods of flood estimation and design flood determination. 2.2 Explain flood frequency analysis techniques. 2.3 Explain flood routing principles. 2.4 Describe flood forecasting systems and approaches.	• Explain methods of flood estimation and design flood determination. • Describe flood frequency analysis techniques. • Discuss flood routing principles. • Discuss flood forecasting systems and approaches.	Textbook Journals, Projector, Computer Chart, Internet	• Perform flood frequency analysis. • Estimate design floods for selected return periods. • Apply flood routing methods to river reaches and reservoirs. • Develop simple flood forecasting models.	Guide students to: • Perform flood frequency analysis. • Estimate design floods for selected return periods. • Apply flood routing methods to river reaches and reservoirs. • Develop simple flood forecasting models.	Rainfall and discharge datasets, Computer computer laboratory, Spreadsheet and statistical software, Flood frequency analysis tools, Hydrological modelling software
GENERAL OBJECTIVE 3.0: Know flood hazards, vulnerability, and risks.						
7-9	3.1 Explain the concepts of flood hazard, exposure, vulnerability, and risk. 3.2 Explain flood risk assessment methodologies. 3.3 Describe socio-economic and	• Discuss the concepts of flood hazard, exposure, vulnerability, and risk. • Describe flood risk assessment methodologies. • Discuss socio-economic and	Textbook Journals, Projector, Computer Chart, Internet	• Conduct flood hazard assessments. • Map vulnerable communities and infrastructure. • Estimate potential flood damages and losses. • Prepare flood risk assessment reports.	Guide students to: • Conduct flood hazard assessments. • Map vulnerable communities and infrastructure. • Estimate potential flood damages and losses. • Prepare flood risk	Flood damage records, Socio-economic datasets, Community survey forms, GIS software, Flood hazard maps, Risk assessment

	environmental impacts of floods. 3.4 Explain flood damage assessment principles.	environmental impacts of floods. • Describe flood damage assessment principles.			assessment reports.	templates, Damage curves, Mapping tools
GENERAL OBJECTIVE 4.0: Know geospatial technologies and modelling tools for flood studies.						
10-12	4.1 Explain the role of GIS and remote sensing in flood management. 4.2 Explain flood inundation modelling concepts. 4.3 Explain spatial analysis techniques for flood assessment. 4.4 Describe applications of digital elevation models in flood studies.	• Discuss the role of GIS and remote sensing in flood management. • Describe flood inundation modelling concepts. • Describe spatial analysis techniques for flood assessment. • Discuss applications of digital elevation models in flood studies	Textbook Journals, Projector, Computer Chart, Internet	• Delineate flood-prone zones using GIS. • Generate flood hazard and inundation maps. • Analyse satellite imagery for flood monitoring. • Apply hydrological and hydraulic modelling software for flood analysis.	Guide students to: • Delineate flood-prone zones using GIS. • Generate flood hazard and inundation maps. • Analyse satellite imagery for flood monitoring. • Apply hydrological and hydraulic modelling software for flood analysis.	Computers and GIS laboratory, ArcGIS or QGIS software, Satellite imagery, Digital Elevation Models (DEMs), GPS receivers, Flood modelling software such as: • HEC-HMS • SWAT • Design storm data, GIS
GENERAL OBJECTIVE 5.0: Understand structural and non-structural flood risk management measures						

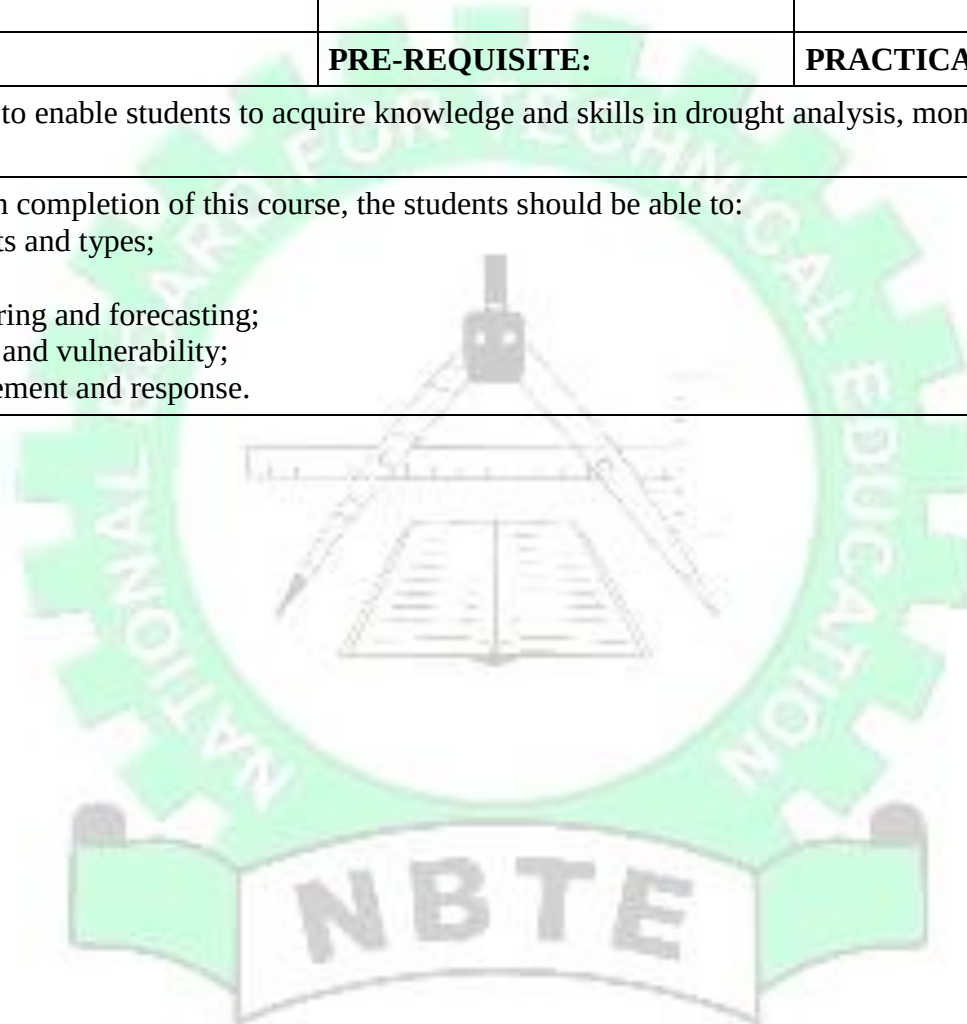
	5.1 Explain structural flood control measures. 5.2 Explain non-structural flood mitigation strategies. 5.3 Describe integrated flood management principles. 5.4 Explain floodplain management approaches.	• Discuss structural flood control measures. • Describe non-structural flood mitigation strategies. • Discuss integrated flood management principles. • Describe floodplain management approaches.	Textbook Journals, Projector, Computer Chart, Internet	• Evaluate flood control structures and their performance. • Develop flood mitigation and management plans. • Assess effectiveness of flood risk reduction measures. • Prepare floodplain management proposals.	Guide students to: • Evaluate flood control structures and their performance. • Develop flood mitigation and management plans. • Assess effectiveness of flood risk reduction measures. • Prepare floodplain management proposals.	Engineering drawings and design plans, Site assessment checklists, Flood mitigation project reports, Field inspection equipment, GIS and mapping tools Floodplain maps
GENERAL OBJECTIVE 6.0: Know flood preparedness, emergency response, and climate adaptation strategies.						
13-15	6.1 Explain flood early warning systems. 6.2 Describe flood emergency planning and response procedures. 6.3 Explain climate change impacts on flood occurrence.	• Discuss flood early warning systems. • Discuss flood emergency planning and response procedures. • Describe climate change impacts on flood occurrence. • Discuss adaptation and resilience	Textbook Journals, Projector, Computer Chart, Internet	• Design simple flood early warning frameworks. • Prepare community flood preparedness plans. • Conduct flood emergency response simulations. • Develop climate-resilient flood	Guide students to: • Design simple flood early warning frameworks. • Prepare community flood preparedness plans. • Conduct flood emergency response simulations. • Develop climate-	Flood early warning system demonstrations, Emergency response simulation tools, Communication equipment, Community preparedness templates,

	6.4 Explain adaptation and resilience strategies for flood management.	strategies for flood management.		management strategies.	resilient flood management strategies.	Climate and hydrological datasets, Scenario-planning software and exercises, Zoning templates, NIHSA portal Etc.
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



DROUGHT ANALYSIS AND MANAGEMENT TECHNOLOGY

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: DROUGHT ANALYSIS AND MANAGEMENT TECHNOLOGY	COURSE CODE: HWR 413	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: I	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEKS
GOAL: This course is designed to enable students to acquire knowledge and skills in drought analysis, monitoring, forecasting and management.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand drought concepts and types; 2.0 Know drought indices; 3.0 Understand drought monitoring and forecasting; 4.0 Understand drought-impact and vulnerability; 5.0 Understand drought management and response.		



HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: DROUGHT ANALYSIS AND MANAGEMENT TECHNOLOGY			COURSE CODE: HWR 413		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: I			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to enable students to acquire knowledge and skills in drought analysis, monitoring, forecasting, and management						
GENERAL OBJECTIVE 1.0: Understand drought concepts and types.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain drought 1.2 Describe causes of drought. 1.3 Explain the impact of drought in the Nigerian context. 1.4 Describe the history of drought in the Sahel region.	- Discuss drought. - Highlight the causes of drought. - Discuss the impact of drought in the Nigerian context. - Discuss the history of drought in the Sahel region.	Textbooks, Projector, Whiteboard, Computer, Internet	- Classify droughts from case studies. - Map drought causes in Nigeria. - Carry out Profile impacts in the Sahel and other 3 regions.	Guide Students to: - Classify droughts from case studies. - Map drought causes in Nigeria. - Carry out Profile impacts in Sahel and other 3 regions.	Case studies, Regional data records, Computer Maps, Survey data
GENERAL OBJECTIVE 2.0: Know drought indices						
4-6	2.1 Explain Standard Precipitation Index (SPI). 2.2 Explain Standardized Precipitation	- Describe Standard Precipitation Index (SPI). - Discuss Standardized Precipitation	Textbooks, Projector, Whiteboard, Computer, Internet	- Compute SPI for 3 stations over 30 years. - Compute SPEI. - Compute PDSI. - Compute NDVI-	Guide Students to: - Compute SPI for 3 stations over 30 years. - Compute SPEI. - Compute PDSI. - Compute NDVI-based	Climate data, Satellite imagery, Drought indices, Graph, Drawing sets

	Evapotranspiration Indices (SPEI). 2.3 Explain Palmer Drought Severity Index (PDSI). 2.4 Explain Vegetation Health Index (VHI) and Normalized Difference Vegetation Index (NDVI).	Evapotranspiration Indices (SPEI). • Describe Palmer Drought Severity Index (PDSI). • Discuss Vegetation Health Index (VHI) and Normalized Difference Vegetation Index (NDVI).		based VHI.	VHI.	
GENERAL OBJECTIVE 3.0: Understand drought monitoring and forecasting						
7-9	3.1 Explain monitoring networks. 3.2 Explain the Remote Sensing drought monitoring system. 3.3 Describe seasonal forecasting. 3.4 Explain early-warning systems.	• Discuss monitoring networks. • Describe the Remote Sensing drought monitoring system. • Explain seasonal forecasting. • Discuss early-warning systems.	Textbooks, Projector, Whiteboard, Computer, Internet	• Set up monitoring for one station. • Use satellite indices. • Interpret seasonal forecasts. • Browse Farming Early Warning Systems Network (FEWS NET).	Guide Students to: • Set up monitoring for one station. • Use satellite indices. • Interpret seasonal forecasts. • Forecast using Farming Early Warning Systems Network (FEWS NET).	Climate data, Google Earth Engine (GEE), Forecast portals, Computer
GENERAL OBJECTIVE 4.0: Understand drought impact and vulnerability.						
10-12	4.1 Explain drought impact assessment. 4.2 Describe	• Discuss drought impact assessment.	Textbooks, Projector, Whiteboard,	• Conduct impact assessment for historical	Guide Students to: • Conduct impact assessment for	Drought Impact Assessment templates,

	vulnerability mapping. 4.3 Explain drought-loss estimation. 4.4 Explain inclusion impact on drought.	• Explain vulnerability mapping. • Discuss drought-loss estimation. • Discuss gender inclusion impact on drought.	Computer, Internet	drought. • Build vulnerability map. • Estimate economic loss. • Conduct checklist on gender-inclusion impacts.	historical drought. • Build vulnerability map. • Estimate economic loss. • Conduct checklist on gender-inclusion impacts.	Estimation loss models, Projector, Computer, Internet
GENERAL OBJECTIVE 5.0: Understand drought management and response.						
13-15	5.1 Explain drought risk management. 5.2 Outline preparedness plans. 5.3 Describe drought-resilient water supply. 5.4 Explain policy response.	• Discuss drought risk management. • Discuss preparedness plans. • Discuss drought-resilient water supply. • Discuss policy response	Textbooks, Projector, Whiteboard, Computer, Internet	• Develop risk management plan. • Develop response plan. • Conduct a design on drought-resilient water supply. • Carry out studies on the profile	Guide Students to: • Develop a risk management plan • Develop a response plan • Conduct a design on drought-resilient water supply. • Conduct studies on the profile	Management Plan templates, Design templates, Computer, Internet, Maps
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

WASTEWATER ENGINEERING

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: WASTEWATER ENGINEERING	COURSE CODE: HWR 414	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: I	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills on wastewater engineering and treatment-plant design.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand wastewater characterization; 2.0 Know sewerage system design; 3.0 Understand primary and secondary treatment design; 4.0 Understand tertiary treatment and disinfection; 5.0 Know Major Sewer Appurtenances; 6.0 Understand decentralized and nature-based treatment; 7.0 Understand the Effects of Wastewater Pollution and Methods of Control.		

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: WASTEWATER ENGINEERING			COURSE CODE: HWR 414		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: I			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills on wastewater engineering and treatment-plant design.						
GENERAL OBJECTIVE 1.0: Understand wastewater characterization						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain wastewater. 1.2 Explain wastewater sources. 1.3 Describe physical, chemical and biological characteristics of wastewater. 1.4 Explain wastewater sampling procedure. 1.5 Explain discharge standards (NESREA)	• Explain wastewater generation and composition • Discuss domestic, industrial and storm water sources. • Describe wastewater quality parameters • Describe wastewater sampling techniques.	Textbooks, Projector, Whiteboard, Computer, Internet	• Identify wastewater sources for one community. • Collect wastewater samples. • Apply sampling protocol • Measure physical, chemical and biological characteristics (BOD, COD, TSS, N, P) on 5 samples.	Guide students to: • Identify wastewater sources for one community. • Collect wastewater samples. • Apply sampling protocol • Measure physical, chemical and biological characteristics (BOD, COD, TSS, N, P) on 5 samples. • Analyse wastewater data. • Compare to NESREA.	Sampling Kits, Cooler, Water Quality Testing Kits, NESREA Standards, Laboratory Reports,

				- Analyse wastewater data. - Compare to NESREA. - Record and report findings.	Record and report findings.	
GENERAL OBJECTIVE 2.0: Know sewerage system design						
4-6	2.1 Explain sewer, sewer layout and gradient. 2.2 Explain sewer sizing. 2.3 Describe pumping stations. 2.4 Explain how to apply storm-drainage integration.	- Describe sewer, sewer layout and gradient. - Describe sewer sizing. - Discuss pumping stations. - Explain how to apply storm-drainage integration.	Textbooks, Projector, Whiteboard, Computer, Internet	- Lay out sewer network. - Size sewers using Manning. - Design a pumping station. - Integrate storm drainage. - Record and report findings.	Guide students to: - Lay out sewer network. - Size sewers using Manning. - Design a pumping station. - Integrate storm drainage. - Record and report findings.	Design Templates, Recording Sheets, Drawing Sets, Computers, CAD software
GENERAL OBJECTIVE 3.0: Know primary and secondary treatment design						
7-8	3.1 Describe screening, grit, and sedimentation design. 3.2 Explain activated sludge design. 3.3 Explain trickling filter design.	- Explain screening, grit, and sedimentation design. - Discuss activated sludge design. - Describe trickling filter design.	Textbooks, Projector, Whiteboard, Computer, Internet	- Design primary treatment for 10000 m³/d. - Design activated sludge. - Design trickling filter.	Guide students to: - Design primary treatment for 10000 m³/d. - Design activated sludge. - Design trickling filter. - Design secondary clarifier.	Design Templates, calculators, Recording Sheets, Drawing Sets, Computer,

	3.4 Explain secondary clarifier design.	• Discuss secondary clarifier design.		• Design secondary clarifier. • Record and report findings.	• Record and report findings.	
GENERAL OBJECTIVE 4.0: Understand tertiary treatment and disinfection						
9	4.1 Explain nutrient removal. 4.2 Explain tertiary filtration. 4.3 Describe disinfection (chlorine, UV). 4.4 Explain sludge management.	• Describe nutrient removal. • Describe tertiary filtration. • Discuss disinfection (chlorine, UV). • Discuss sludge management.	Textbooks, Projector, Whiteboard, Computer, Internet	• Design nutrient-removal process for different wastewater sources. • Design a tertiary filter. • Design UV disinfection. • Design sludge digestion. • Record findings. • Report findings.	Guide students to: • Design nutrient-removal process for different wastewater sources. • Design a tertiary filter. • Design UV disinfection. • Design sludge digestion. • Record and report findings. • Report findings.	Design Templates, Calculators, Recording Sheets, Drawing Sets, Computer, CAD software
GENERAL OBJECTIVE 5.0: Know Major Sewer Appurtenances						

10	5.1 Explain sewer appurtenances. 5.2 Describe different sewer appurtenances. 5.3 Explain design considerations. 5.4 Explain maintenance requirements.	• Describe sewer appurtenances • Explain functions and importance for each appurtenance. • Discuss manholes, cleanouts, lamp holes, flushing tanks, and catch basins. • Illustrate placement and spacing requirements. • Explain inspection and cleaning procedures.	Textbooks, Projector, Whiteboard, Computer, Internet	• Write a technical report on field trip to a wastewater treatment plant. • Identify sewer appurtenances in the field. • Measure dimensions of appurtenances. • Prepare simple sewer layouts. • Record and report findings.	Guide students to: • Carry out a field trip to a wastewater treatment plant. • Identify sewer appurtenances in the field. • Measure dimensions of appurtenances. • Prepare simple sewer layouts. • Record and report findings.	Sewer systems, Measuring Tools, Drawing Materials, Wastewater Treatment Plant, Design Templates,
GENERAL OBJECTIVE 6.0: Understand decentralized and nature-based treatment						
11-12	6.1 Explain constructed wetlands (advanced) 6.2 Explain the concept of phytoremediation 6.3 State factors that influence selection of plant species. 6.4 Describe different configurations of constructed	• Describe constructed wetlands (advanced). • Discuss the concept of phytoremediation. • State factors that influence selection of plant species. • Discuss different configurations of constructed	Textbooks, Projector, Whiteboard, Computer, Internet	• Select a wastewater type (domestic, industrial, agricultural, abattoir, leather, etc). • Design a laboratory wetland setup for wastewater treatment. • Construct a	Guide a student to: • Select a wastewater type. • Design a wetland for the community. • Design a waste stabilization pond (WSP) system. • Design a laboratory setup for an anaerobic digester for biogas production. • Construct a laboratory setup for an anaerobic	Drawing Materials, Wastewater Treatment Plant, Design Templates, Constructed Wetland Model,

	wetlands. 6.5 Explain waste-stabilisation ponds. 6.6 Explain on-site treatment (septic, anaerobic digester for biogas production). 6.7 Explain the concept of water reuse.	wetlands. • Discuss waste-stabilisation ponds. • Describe on-site treatment of septic, anaerobic digester for biogas production. • Discuss the concept of water reuse.		laboratory wetland setup for wastewater treatment. • Design a waste stabilization pond (WSP) system. • Design a laboratory setup for an anaerobic digester for biogas production. • Construct a laboratory setup for an anaerobic digester for biogas production. • Design a water-reuse system. • Record and report findings	digester for biogas. • Design a water-reuse system. • Record and report findings	
GENERAL OBJECTIVE: 7.0: Understand the Effects of Wastewater Pollution and Methods of Control						
13-15	7.1 Explain environmental pollution of wastewater. 7.2 Describe the	• Describe types and sources of wastewater pollution. • Discuss health,	Textbooks, Projector, Whiteboard, Computer, Internet	• Identify wastewater pollution sources. • Monitor	Guide students to: • Identify wastewater pollution sources. • Monitor wastewater pollution indicators.	Inspection Checklists, Water Testing Kits, Environmental

	effects of wastewater pollution. 7.3 Explain wastewater pollution prevention measures. 7.4 Explain wastewater pollution control technologies.	economic, and ecological impacts. • Discuss source control and waste minimization. • Discuss wastewater treatment and environmental management systems		wastewater pollution indicators. • Evaluate wastewater pollution control measures. • Prepare wastewater pollution assessment reports. • Record and report findings.	• Evaluate wastewater pollution control measures. • Prepare wastewater pollution assessment reports. • Record and report findings.	Reports Templates,
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

GENDER, EQUITY AND INCLUSION IN WATER RESOURCES MANAGEMENT

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: GENDER, EQUITY AND INCLUSION IN WATER RESOURCES MANAGEMENT	COURSE CODE: HWR 415	CONTACT HOURS: 2 HOURS/WEEK
	CREDIT UNIT: 2	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: I	PRE-REQUISITE: Nil	PRACTICAL: 1 HOUR/WEEK
GOAL: This course is designed to equip students with knowledge and skills to address gender, equity and social inclusion in Water Resources Management.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand gender and inclusion concepts; 2.0 Know gender analysis in water; 3.0 Understand equity in water access; 4.0 Understand gender-inclusive water governance; 5.0 Understand gender mainstreaming in infrastructure.		

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: GENDER, EQUITY AND INCLUSION IN WATER RESOURCES MANAGEMENT			COURSE CODE: HWR 415		CONTACT HOURS: 2 HOURS/WEEKS	
			CREDIT UNIT: 2		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: I			PRE-REQUISITE: Nil		PRACTICAL: 1 HOUR/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and practical skills to address gender, equity and social inclusion in Water Resources Management.						
GENERAL OBJECTIVE 1.0: Understand gender and inclusion concepts						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Describe gender, sex, intersectionality, equity. 1.2 Explain global frameworks (SDG 5, CEDAW) 1.3 Explain Nigerian gender policies. 1.4 Describe the application of gender-water in development.	• Discuss the concepts in 1.1. • Describe the global frameworks. • Discuss the Nigerian gender policies. • Discuss how to apply gender-water in development.	Textbooks, Projector, Whiteboard, Computer, Internet	• Compile a glossary of 25 gender terms. • Browse SDG 5, CEDAW. • Summarise Nigerian National Gender Policy. • Profile 5 gender-water initiatives. • Record and report findings	Guide students to: • Compile glossary of 25 gender terms. • Browse SDG 5, CEDAW. • Summarise Nigerian National Gender Policy. • Profile 5 gender-water initiatives. • Record and report findings	Glossary Templates, Framework Documents, Computer, Internet,
GENERAL OBJECTIVE 2.0: Know gender analysis in water						

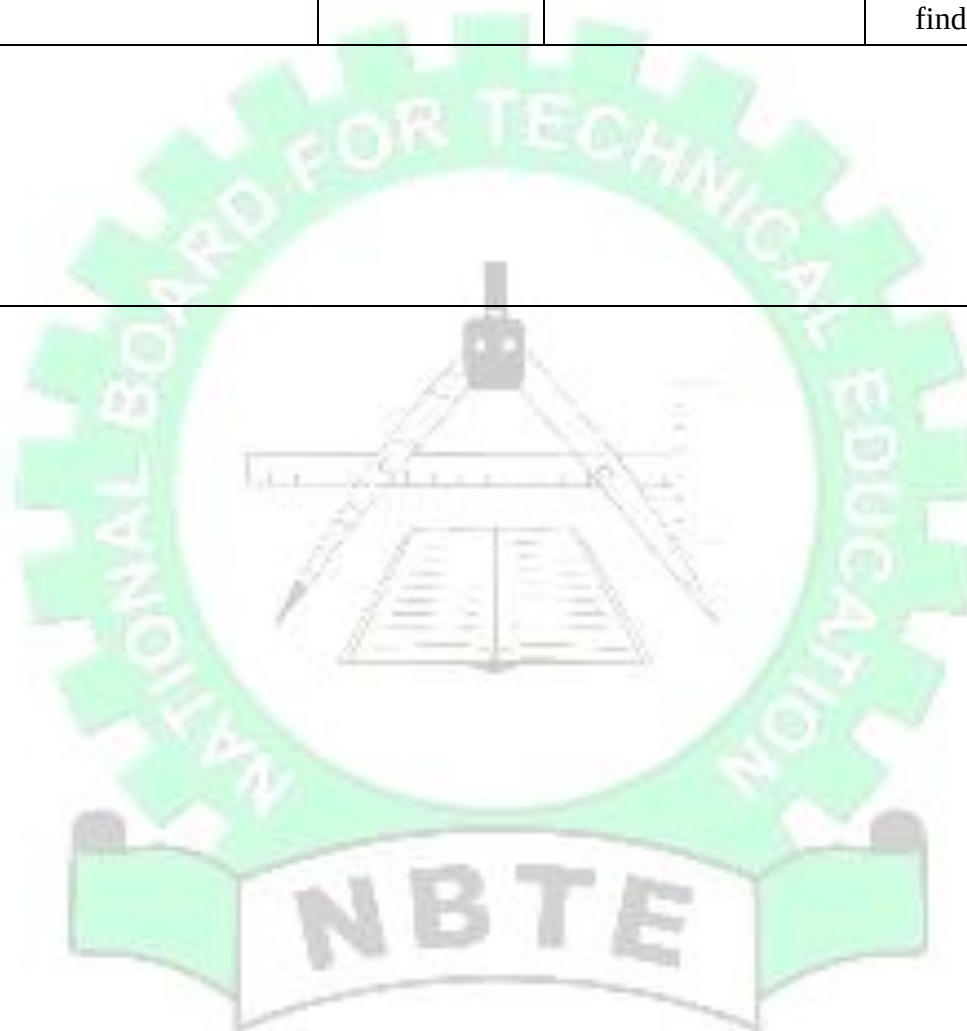
4-6	2.1 Describe gender roles in water. 2.2 Explain time-use and burden analysis. 2.3 Mention gender-disaggregated indicators. 2.4 Explain Harvard/Moser frameworks.	• Describe gender roles in water. • Describe time-use and burden analysis. • State gender-disaggregated indicators. • Discuss Harvard/Moser frameworks.	Textbooks, Projector, Whiteboard, Computer, Internet	• Conduct Focus Group Discussions on water roles in a community. • Conduct time-use analysis with 10 households. • Tabulate gender-disaggregated indicators. • Apply Harvard/Moser framework. • Record and report findings	Guide students to: • Conduct Focus Group Discussions (FGD) on water roles in a community. • Conduct time-use analysis with 10 households. • Tabulate gender-disaggregated indicators. • Apply Harvard/Moser framework. • Record and report findings	(FGD) Scripts, Time-use Templates, Computer, Internet, Video Recordings,
GENERAL OBJECTIVE 3.0: Understand the concept of equity in water access						
7-9	3.1 Explain equity principles. 3.2 Explain gender-responsive water budgeting. 3.3 Describe equity for vulnerable groups (Persons with disability (PWD), elderly). 3.4 Explain urban-rural equity.	• Discuss equity principles. • Describe gender-responsive water budgeting. • Describe equity for vulnerable groups (Persons with disability (PWD), elderly). • Describe urban-rural equity.	Textbooks, Projector, Whiteboard, Computer, Internet	• Apply equity criteria to a water plant of a nearby community. • Build a gender-responsive budget. • Audit water infrastructure for PWD. • Compare urban-rural access. • Record and report findings	Guide students to: • Apply equity criteria to the water plant of a nearby community. • Build a gender-responsive budget. • Audit water infrastructure for PWD. • Compare urban-rural access.	Equity Rubrics, Budget Templates, Journals,

					• Record and report findings	
GENERAL OBJECTIVE 4.0: Understand gender-inclusive water governance						
10-12	4.1 Describe women in Water Users Association (WUA). 4.2 Explain women's leadership in water. 4.3 Explain community-based gender-inclusive Water Resources management (WRM). 4.4 Explain gender-sensitive grievance redress	• Describe women in Water Users Association (WUA). • Discuss women's leadership in water. • Discuss community-based gender-inclusive Water Resources management (WRM). • Discuss gender-sensitive grievance redress	Textbooks, Projector, Whiteboard, Computer, Internet	• Profile women in 3 Nigerian WUAs. • Plan women-leadership training. • Design community-based plan. • Design grievance mechanisms. • Record and report findings	Guide students to: • Profile women in 3 Nigerian WUAs. • Plan women-leadership training. • Design community-based plan. • Design grievance mechanisms. • Record and report findings	Case Studies, Training Templates, Journals, Video Recordings,
GENERAL OBJECTIVE 5.0: Understand gender mainstreaming in infrastructure						
13-15	5.1 Explain gender-responsive design. 5.2 Explain menstrual hygiene management (MHM) in WASH. 5.3 Explain social safeguards. 5.4 Describe monitoring and	• Describe gender-responsive design. • Discuss menstrual hygiene management (MHM) in WASH. • Describe social safeguards. • Discuss monitoring and evaluation	Textbooks, Projector, Whiteboard, Computer, Internet	• Demonstrate MHM in your Institution • Design a gender-responsive water point. • Apply MHM-friendly design to school WASH. • Apply safeguards checklist.	Guide students to: • Demonstrate MHM in your Institution. • Design a gender-responsive water point. • Apply MHM-friendly design to school WASH. • Apply safeguards	Design Templates, MHM Guides, M&E Templates, Case Studies, Training Templates, Journals, Video

	evaluation (M&E) with gender indicators.	(M&E) with gender indicators.		• Build M&E with 10 gender indicators in your institution. • Record and report findings	checklist. • Build M&E with 10 gender indicators in your institution. • Record and report findings	Recordings,
--	--	-------------------------------	--	--	---	-------------

COURSE ASSESSMENT:

Tests:	10%
Course work:	10%
Practical:	40%
Examination:	40%
Total:	100%



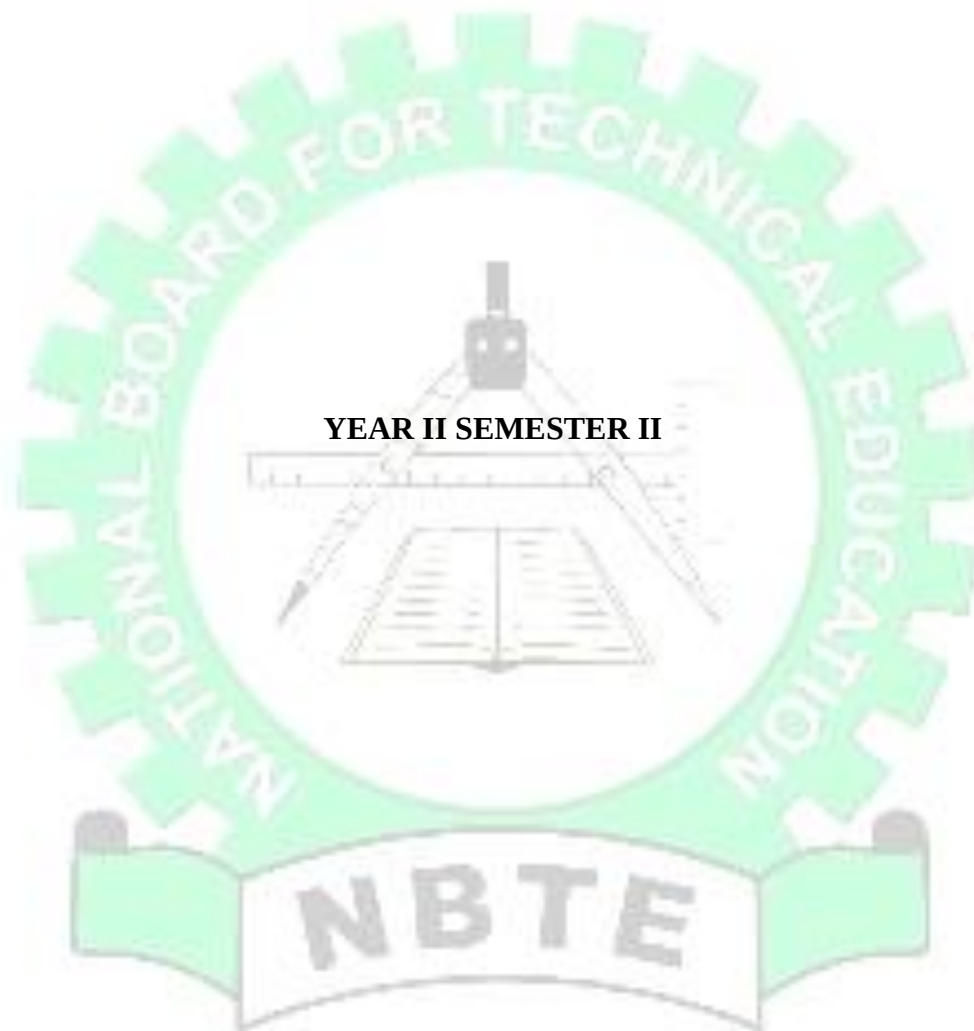
NETWORKING AND REAL-TIME WATER SYSTEM

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: NETWORKING AND REAL-TIME WATER SYSTEMS	COURSE CODE: HWR 416	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: I	PRE-REQUISITE:	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills of Internet of Things (IoT), sensor networks and real-time water systems.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand IoT architecture for water systems; 2.0 Understand sensor network design; 3.0 Understand real-time data acquisition; 4.0 Know real-time analytics and alerting; 5.0 Know production deployment for water systems.		

PROGRAMME: HND HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: NETWORKING AND REAL-TIME WATER SYSTEMS			COURSE CODE: HWR 416		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: I			PRE-REQUISITE:		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in Internet of Things (IoT), sensor networks, and real-time water systems.						
GENERAL OBJECTIVE 1.0: Understand Internet of Things (IoT) architecture for water systems						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain 4-layer IoT architecture. 1.2 Explain edge/fog/cloud computing. 1.3 Describe IoT protocols (MQTT, CoAP, HTTP, etc). 1.4 Explain IoT security and privacy.	• Discuss 4-layer IoT architecture. • Describe edge/fog/cloud computing. • Explain IoT protocols (MQTT, CoAP, HTTP, etc.) • Describe IoT security and privacy.	Textbook, Projector, Whiteboard, Internet, Computer internet	• Design 4-layer architecture of IoT. • Implement edge processing on ESP32 • Compare MQTT vs HTTP. • Carry out a security checklist.	Guide Students to: • Design 4-layer architecture of IoT. • Implement edge processing on ESP32. • Compare MQTT vs HTTP. • Carry out a security checklist.	ESP32, MQTT broker, HTTP broker, Computer, Internet, Checklists
GENERAL OBJECTIVE 2.0: Understand sensor network design.						
4-6	2.1 Explain sensor placement optimization.	• Discuss sensor placement optimization.	Textbook, Projector, Whiteboard,	• Carry out studies on optimization of sensor	Guide Students to: • Carry out studies on optimization of sensor	Sensors, Mapping tools, Computer,

	2.2 Explain network topology (star, mesh, etc.). 2.3 Describe Long Range Wide Area Network (LoRaWAN) deployment. 2.4 Explain coverage planning.	• Describe network topology (star, mesh, etc.). • Discuss Long Range Wide Area Network (LoRaWAN). • Discuss coverage planning.	Internet, Computer Etc.	placement. • Deploy 3 topologies. • Deploy 5-node LoRaWAN. • Conduct coverage testing.	placement. • Deploy 3 topologies. • Deploy 5-node LoRaWAN. • Conduct coverage testing.	Internet, Projector Etc.
GENERAL OBJECTIVE 3.0: Understand real-time data acquisition.						
7-9	3.1 Explain real-time data pipelines. 3.2 Explain data ingestion and preprocessing. 3.3 Describe time-series databases (Influx dB). 3.4 Explain real-time validation.	• Discuss real-time data pipelines. • Describe data ingestion and preprocessing. • Describe time-series databases (InfluxDB). • Discuss real-time validation.	Textbook, Projector, Whiteboard, Internet, Computer	• Build a pipeline from sensor to Decibel (dB). • Preprocess data in-flight. • Set up Influx dB and visualize. • Demonstrate real-time validation rules.	Guide Students to: • Build pipeline from sensor to Decibel (dB). • Preprocess data in-flight. • Set up Influx dB and visualize. • Demonstrate real-time validation rules.	Influx dB, Grafana, Sensor nodes, Computer, Internet, Projector
GENERAL OBJECTIVE 4.0: Know real-time analytics and alerting.						
10-12	4.1 Explain rule-based alerting. 4.2 Explain anomaly detection. 4.3 Describe Machine Learning (ML) intro for water. 4.4 Explain multi-	• Discuss rule-based alerting. • Discuss anomaly detection. • Discuss Machine Learning (ML) intro for water.	Analytics textbooks, Projector, Whiteboard, Internet, Computer	• Carry out how to build 5 rule-based alerts. • Carry out how to implement z-score anomaly detection.	Guide Students to: • Carry out how to build 5 rule-based alerts. • Carry out how to implement z-score anomaly detection.	Software Machine Learning Language, Libraries, Gateways, Computer, Internet

	channel alerts.	• Discuss multi-channel alerts.		• Demonstrate how to use Machine Learning for flood prediction. • Carry out how to configure multi-channel alerts.	• Demonstrate how to use Machine Learning for flood prediction. • Carry out how to configure multi-channel alerts.	
GENERAL OBJECTIVE 5.0: Know production deployment for water systems.						
13-15	5.1 Explain reliability and redundancy. 5.2 Explain scaling and load handling 5.3 Explain maintenance and field ops. 5.4 Describe documentation and handover.	• Discuss reliability and redundancy. • Describe scaling and load handling. • Discuss maintenance and field ops. • Discuss documentation and handover.	Textbooks, Projector, Whiteboard, Computer, Internet	• Carry out reliability checklist for deployment. • Carry out Plan scaling for 4x growth. • Conduct field maintenance run. • Produce 10-page deployment document for water system.	Guide Students to: • Checklist to deployment. • Carry out Plan scaling for 4x growth. • Conduct field maintenance run. • Produce 10-page deployment document for water system.	Reliability checklists, Redundancy Checklist, Scaling plans, Document Template Computer, Internet
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



INTEGRATED WATER RESOURCES MANAGEMENT

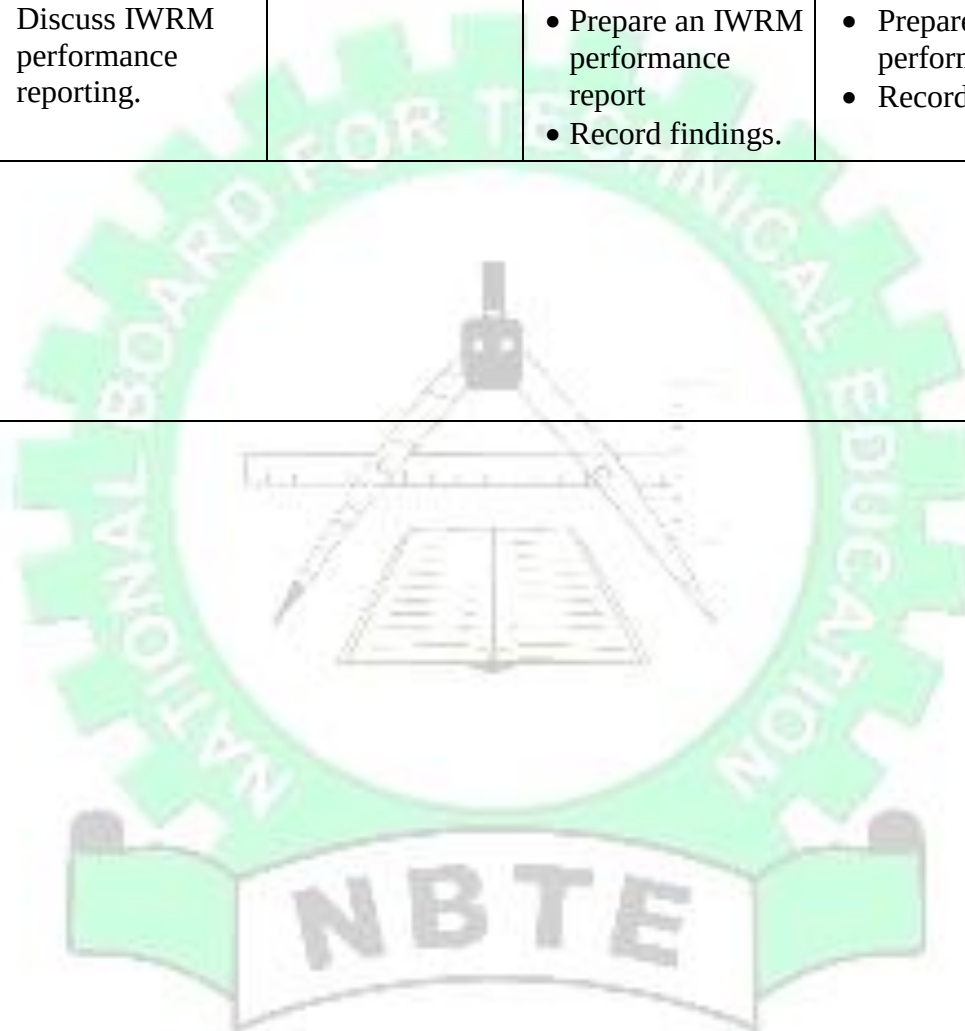
PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: INTEGRATED WATER RESOURCES MANAGEMENT	COURSE CODE: HWR 421	CONTACT HOURS: 4 HOURS/WEEK
	CREDIT UNIT: 4	THEORETICAL: 2HOUR/WEEK
YEAR: II SEMESTER: II	PRE-REQUISITE: HWR 411	PRACTICAL: 2 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills of operational Integrated Water Resources Management implementation.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand Integrated Water Resources Management (IWRM) implementation arrangements; 2.0 Understand stakeholder engagement and participation; 3.0 Know IWRM financing and economics; 4.0 Understand gender-mainstreamed IWRM; 5.0 Understand IWRM monitoring and adaptive management.		

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)			COURSE CODE: HWR 421		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 2 HOUR/WEEK	
YEAR: II SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 2 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills of operational Integrated Water Resources Management implementation						
GENERAL OBJECTIVE 1.0: Understand Integrated Water Resources Management implementation arrangements						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the concept of IWRM. 1.2 Describe the institutional design for IWRM 1.3 Explain basin organization models. 1.4 Outline legal frameworks for IWRM. 1.5 Explain IWRM at multiple scales.	- Describe the concept of IWRM. - Explain the institutional design for IWRM. - Discuss basin organization models. - Discuss legal frameworks for IWRM. - Describe IWRM at multiple scales.	IWRM Textbooks, Projector, Computer, Internet, Journals,	- Source data from one basin. - Map institutional design for one basin. - Profile at least 1 basin organisation model. - Map legal frameworks. - Apply IWRM at 3 scales.	Guide students to: - Source data from one basin. - Map institutional design for one basin. - Profile at least 1 basin organisation model. - Map legal frameworks. - Apply IWRM at 3 scales. - Record and report	Basin Documents, Legal Framework, Scale Templates,

				Record and report findings.	findings.	
GENERAL OBJECTIVE 2.0: Understand stakeholder engagement and participation						
4-6	2.1 Explain stakeholder analysis (advanced). 2.2 Describe participatory methods. 2.3 Explain community engagement. 2.4 Describe conflict resolution in water.	- Describe stakeholder analysis (advanced). - Explain participatory methods. - Describe community engagement. - Discuss conflict resolution in water.	Textbooks, Projector, Whiteboard, Computer, Internet	- Conduct power-interest mapping in a community. - Apply 3 participatory methods. - Plan community engagement. - Simulate conflict resolution. - Record and report findings.	Guide students to: - Conduct power-interest mapping in a community. - Apply 3 participatory methods. - Plan community engagement. - Simulate conflict resolution. - Record and report findings.	Templates, Simulation Scripts, Video Recordings, Simulation software etc.
GENERAL OBJECTIVE 3.0: Understand IWRM financing and economics						
7-9	3.1 Explain IWRM financing mechanisms. 3.2 Describe cost-recovery and tariffs. 3.3 Explain payment for ecosystem services (PES). 3.4 Describe climate finance for IWRM.	- Describe IWRM financing mechanisms. - Discuss cost-recovery and tariffs. - Describe payment for ecosystem services (PES). - Discuss climate finance for	Textbooks, Projector, Computer, Internet, Lesson Notes Journals, Etc.	- Source data from a water utility/corporation - Identify the financing mechanisms. - Design cost-recovery for a water utility. - Design PES for one watershed. - Map climate	Guide students to: - Source data from a water utility/corporation. - Identify the financing mechanisms. - Design cost-recovery for a water utility. - Design PES for one watershed. - Map climate finance for IWRM.	Mechanism Guides, Design Templates, Water utility Financial Reports, Computer, Internet, Simulation software etc.

		IWRM.		finance for IWRM. • Record and report findings.	• Record and report findings.	
GENERAL OBJECTIVE 4.0: Understand gender-mainstreamed IWRM						
10-12	4.1 Describe gender mainstreaming principles. 4.2 Explain gender-responsive IWRM planning. 4.3 Describe women in basin governance. 4.4 Describe M&E with gender indicators.	• Discuss gender mainstreaming principles. • Describe Gender-responsive IWRM planning. • Discuss women in basin governance. • Explain M&E with gender indicators.	Textbooks, Projector, Whiteboard, Computer, Internet	• Apply the mainstreaming checklist to the IWRM plan for a water-sector stakeholder/organisation. • Design gender-responsive IWRM plan. • Profile women in 3 water sector stakeholder/organisation. • Build M&E with gender indicators. • Record and report findings	Guide students to: • Apply the mainstreaming checklist to the IWRM plan for a water-sector stakeholder/organisation • Design gender-responsive IWRM plan. • Profile women in 3 water sector stakeholder/organisation • Build M&E with gender indicators. • Record and report findings	Checklists, Design Templates, M&E Framework Mechanism Guides, Design Templates, Water Utility Financial Reports, Computer, Internet,
GENERAL OBJECTIVE 5.0: Understand IWRM monitoring and adaptive management						
13-15	5.1 Describe M&E framework design. 5.2 Explain the indicator selection (sustainability,	• Describe M&E framework design. • Describe the indicator selection	Textbooks, Projector, Whiteboard, Computer, Internet	• Build M&E framework for a water sector stakeholder/organisation.	Guide students to: • Build M&E framework for a water sector stakeholder/organisation	M&E Templates, Indicator Guides, Stakeholder/organisation Reports, Scenarios

	equity, efficiency). 5.3 Explain adaptive management. 5.4 Describe IWRM performance reporting.	(sustainability, equity, efficiency). • Discuss adaptive management. • Discuss IWRM performance reporting.		• Select 20 indicators. • Apply adaptive management to one scenario. • Prepare an IWRM performance report • Record findings.	ion. • Select 20 indicators. • Apply adaptive management to one scenario • Prepare an IWRM performance report. • Record findings.	
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



HYDROLOGICAL FORECASTING AND EARLY WARNING SYSTEMS

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: HYDROLOGICAL FORECASTING AND EARLY WARNING SYSTEMS	COURSE CODE: HWR 422	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills in hydrologic forecasting and early warning systems for effective water-related disaster preparedness and management.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1. Understand the principles and components of hydrological forecasting and early warning systems; 2. Know hydrometeorological data for forecasting applications; 3. Apply hydrologic forecasting methods and models; 4. Utilize digital technologies and communication systems for real-time forecasting and warning dissemination; 5. Know hydrological hazards and develop early warning products; 6. Develop preparedness and response strategies using hydrologic forecasts and warnings.		

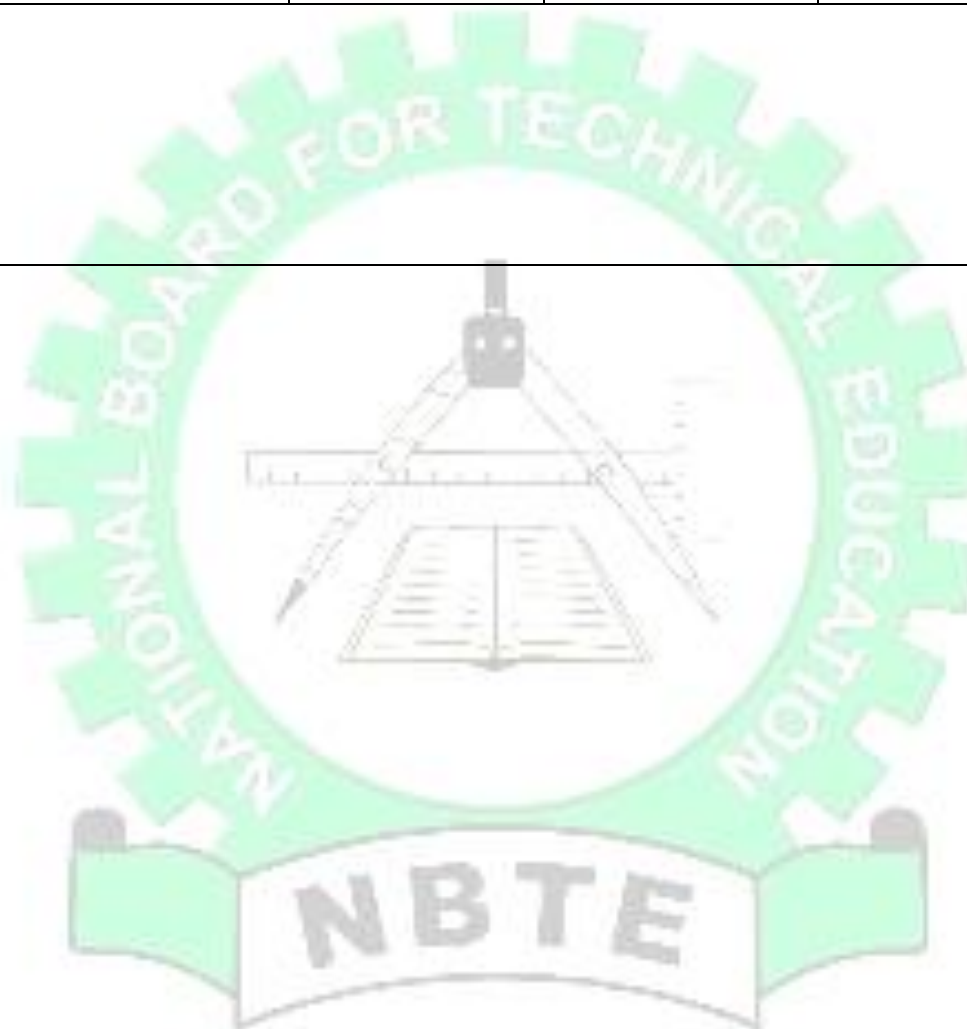
PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: HYDROLOGICAL FORECASTING AND EARLY WARNING SYSTEMS			COURSE CODE: HWR 422		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in hydrologic forecasting and early warning systems for effective water-related disaster preparedness and management.						
GENERAL OBJECTIVE 1.0: Understand the principles and components of hydrologic forecasting and early warning systems.						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the concepts and importance of hydrologic forecasting. 1.2 Describe the components of hydrological forecasting systems. 1.3 Explain the principles of early warning systems. 1.4 Describe applications of	- Discuss the concepts and importance of hydrologic forecasting. - Describe the components of hydrologic forecasting systems. - Discuss the principles of early warning systems. - Discuss	Textbooks, Projector, Forecasting manuals, Technical reports, Multimedia presentations, Computer Etc.	- Identify components of operational forecasting systems. - Examine existing warning system networks. - Interpret forecasting system layouts. - Prepare	Guide students to: - Identify components of operational forecasting systems. - Examine existing warning system networks. - Interpret forecasting system layouts. - Prepare system component inventories.	Forecasting stations, Demonstration equipment, Early warning system case studies, Field visits, Watershed maps, Monitoring network diagrams, Monitoring equipment

	forecasting in Water Resources management.	applications of forecasting in Water Resources management.		system component inventories.		catalogues, Reporting templates
GENERAL OBJECTIVE 2.0: Know hydrometeorological data for forecasting applications						
4-6	2.1 Explain hydrometeorological data requirements for forecasting. 2.2 Explain rainfall, streamflow, and weather monitoring techniques 2.3 Explain data quality control procedures. 2.4 Describe data transmission and storage systems.	- Describe hydrometeorological data requirements for forecasting. - Describe rainfall, streamflow, and weather monitoring techniques - Describe data quality control procedures - Discuss data transmission and storage systems.	Textbooks, Projector, Whiteboard, Computer, Internet	- Collect hydrological and meteorological data. - Perform data quality checks and validation. - Download and organize monitoring data. - Prepare datasets for forecasting models.	Guide students to: - Collect hydrological and meteorological data. - Perform data quality checks and validation. - Organize monitoring data. - Prepare datasets for forecasting models.	Rain gauges, Weather stations, Stream gauges, Computers, Databases, Hydrological software, Monitoring records
GENERAL OBJECTIVE 3.0: Apply hydrologic forecasting methods and models.						
7-9	3.1 Explain short-term and long-term forecasting methods. 3.2 Explain rainfall–runoff forecasting principles.	- Describe short-term and long-term forecasting methods. - Describe rainfall–runoff	Textbooks, Projector, Whiteboard, Computer, Internet	- Develop simple hydrological forecasting models. - Generate streamflow	Guide students to: - Develop simple hydrologic forecasting models. - Generate streamflow forecasts.	Computer, Modelling software, Forecasting software, Rainfall records,

	3.3 Explain flood forecasting techniques. 3.4 Describe uncertainties in hydrologic forecasts.	forecasting principles. - Describe flood forecasting techniques. - Discuss uncertainties in hydrologic forecasts.		forecasts. - Carryout rainfall–runoff forecasting procedures. - Evaluate forecast accuracy.	- Apply rainfall–runoff forecasting procedures. - Evaluate forecast accuracy.	Climate data, forecast portals, Statistical software, Observed data records
GENERAL OBJECTIVE 4.0: Utilize digital technologies and communication systems for real-time forecasting and warning dissemination.						
10-11	4.1 Explain telemetry and real-time monitoring systems. 4.2 Explain communication technologies used in warning systems. 4.3 Explain data integration and information management systems. 4.4 Describe warning dissemination strategies.	- Discuss telemetry and real-time monitoring systems. - Describe communication technologies used in warning systems. - Describe Explain data integration and information management systems. - Discuss warning dissemination strategies.	Textbooks, Projector, Whiteboard, Computer, Internet	- Configure telemetry devices. - Monitor real-time hydrological data streams. - Test warning communication channels. - Develop warning dissemination workflows.	Guide students to: - Configure telemetry devices. - Monitor real-time hydrological data streams. - Test warning communication channels. - Develop warning dissemination workflows.	Telemetry units, Communication modules, Monitoring stations, Online dashboards, GSM devices, Radios, Internet platforms, Emergency communication templates
GENERAL OBJECTIVE 5.0: Know hydrological hazards and develop early warning products.						

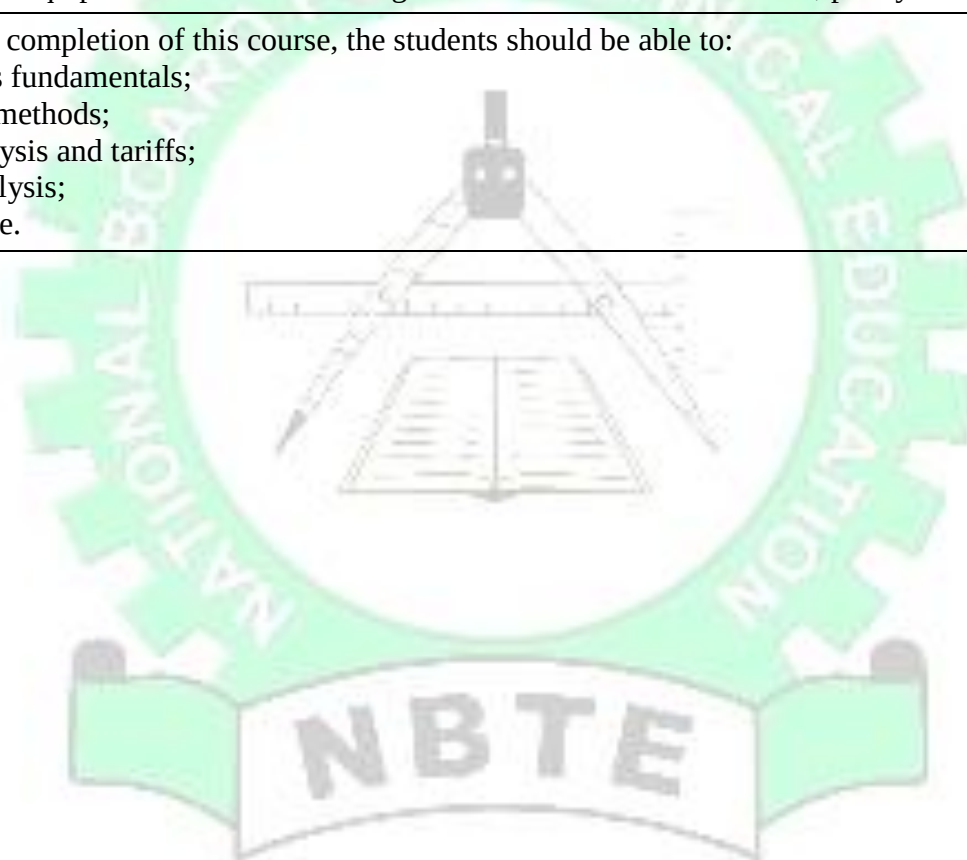
12-13	5.1 Explain hazard, exposure, vulnerability, and risk concepts. 5.2 Describe warning thresholds and trigger levels. 5.3 Explain hazard mapping principles. 5.4 Describe forecast-based decision-making.	• Discuss hazard, exposure, vulnerability, and risk concepts. • Describe warning thresholds and trigger levels. • Discuss hazard mapping principles. • Discuss forecast-based decision-making.	Warning system guidelines, GIS and hazard mapping manuals, Technical reports and case studies, Textbooks, Projector	• Develop flood and drought warning thresholds. • Produce hazard and warning maps. • Generate warning bulletins and advisories. • Interpret forecast outputs for decision support.	Guide students to: • Develop flood and drought warning thresholds. • Produce hazard and warning maps. • Generate warning bulletins and advisories. • Interpret forecast outputs for decision support.	Historical hydrological records, GIS software, DEMs, Satellite imagery, Reporting template, Computers, Forecast datasets, Case studies
GENERAL OBJECTIVE 6.0: Develop preparedness and response strategies using hydrological forecasts and warnings.						
14-15	6.1 Explain emergency preparedness planning. 6.2 Describe community-based early warning systems. 6.3 Explain response coordination mechanisms. 6.4 Describe climate-related hydrologic risks and adaptation.	• Discuss emergency preparedness planning. • Describe community-based early warning systems. • Describe response coordination mechanisms.	Textbooks, Projector, Whiteboard, Computer, Internet	• Prepare hydrologic emergency response plans. • Conduct forecasting and warning simulation exercises. • Develop community awareness materials.	Guide students to: • Prepare hydrologic emergency response plans. • Conduct forecasting and warning simulation exercises. • Develop community awareness materials. • Evaluate effectiveness of warning systems.	Planning templates, Case studies, Simulation Scenarios, Training materials, Communication tools, Educational materials, Assessment checklists, Performance

		Discuss climate-related hydrologic risks and adaptation.		Evaluate effectiveness of warning systems.		indicator.
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						



WATER ECONOMICS, POLICY AND GOVERNANCE

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: WATER ECONOMICS, POLICY AND GOVERNANCE	COURSE CODE: HWR 423	CONTACT HOURS: 3 HOURS/WEEKS
	CREDIT UNIT: 3	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: II	PRE-REQUISITE: Nil	PRACTICAL: 2 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills on water economics, policy and governance.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand water economics fundamentals; 2.0 Understand water valuation methods; 3.0 Understand cost-benefit analysis and tariffs; 4.0 Understand water policy analysis; 5.0 Understand water governance.		



PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: WATER ECONOMICS, POLICY AND GOVERNANCE			COURSE CODE: HWR 423		CONTACT HOURS: 3 HOURS/WEEKS	
			CREDIT UNIT: 3		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: II			PRE-REQUISITE: Nil		PRACTICAL: 2 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills on water economics, policy and governance.						
GENERAL OBJECTIVE 1.0: Understand water economics fundamentals						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain water as an economic good. 1.2 Describe demand and supply economics. 1.3 Explain opportunity cost and pricing. 1.4 Describe externalities and public goods.	- Describe water as an economic good. - Discuss demand and supply economics. - Describe opportunity cost and pricing. - Discuss externalities and public goods.	Textbooks, Projector, Whiteboard, Computer, Internet	- Source data from water utility/ corporation. - Tabulate water as different goods. - Plot demand and supply curves. - Compute opportunity cost. - Identify externalities for one project. - Record findings.	Guide students to: - Source data from water utility/ corporation. - Tabulate water as different goods. - Plot demand and supply curves. - Compute opportunity cost. - Identify externalities for one project.	Water utility/corporation reports, Tables, Plotting paper, Calculators, Computers,
GENERAL OBJECTIVE 2.0: Understand water valuation methods						

4-6	2.1 Describe production-based valuation. 2.2 Explain travel-cost and hedonic methods. 2.3 Explain contingent valuation method (CVM). 2.4 Describe ecosystem-services valuation.	• Discuss production-based valuation. • Describe travel cost and hedonic methods. • Describe contingent valuation method (CVM). • Discuss ecosystem-services valuation	Textbooks, Projector, Whiteboard, Computer, Internet	• Source for data from a nearby farm. • Compute production-based value for one farm. • Design travel-cost survey. • Design CVM survey. • Value ecosystem services of one wetland. • Record and report findings.	Guide students to: • Source for data from a nearby farm. • Compute production-based value for one farm. • Design travel-cost survey. • Design CVM survey. • Value ecosystem services of one wetland. • Record and report findings.	Farm reports, Survey instruments, Valuation templates, Computer, Internet,
GENERAL OBJECTIVE 3.0: Understand cost-benefit analysis and tariffs						
7-9	3.1 Explain cost-benefit analysis (CBA) 3.2 Explain discount rates and sensitivity. 3.3 Describe tariff design (flat, block, increasing block). 3.4 Explain pro-poor tariff design.	• Discuss CBA (NPV, BCR, IRR). • Describe discount rates and sensitivity. • Describe tariff design (flat, block, increasing block). • Discuss pro-poor tariff	Textbooks, Projector, Whiteboard, Computer, Internet	• Source data from water utility/corporation. • Compute NPV, BCR, IRR for one project. • Run sensitivity analysis • Compare 3 tariff structures. • Design pro-poor lifeline tariff.	Guide students to: • Source data from water utility/corporation. • Compute NPV, BCR, IRR for one project. • Run sensitivity analysis • Compare 3 tariff structures. • Design pro-poor lifeline tariff.	Project data, Tariff templates, Water utility/corporation reports, Computer, Internet,

		design.		Record findings	Record and report findings	
GENERAL OBJECTIVE 4.0: Understand water policy analysis						
10-12	4.1 Explain policy cycle (advanced). 4.2 Explain policy analysis methods. 4.3 Outline Nigerian water policies (NWRP, NIPRD). 4.4 Explain policy reform processes.	- Discuss policy cycle (advanced). - Describe policy analysis methods. - Describe Nigerian water policies (NWRP, NIPRD). - Describe policy reform processes.	Textbooks, Projector, Whiteboard, Computer, Internet	- Source data from water utility/ corporation. - Trace one policy cycle. - Apply policy-analysis framework. - Compare NWRP and NIPRD. - Plan policy-reform process. - Record and report findings.	Guide students to: - Source data from water utility/ corporation. - Trace one policy cycle. - Apply policy-analysis framework. - Compare NWRP and NIPRD. - Plan policy-reform process. - Record and report findings.	Policy document, Templates, Water utility/ corporation reports, Computer, Internet,
GENERAL OBJECTIVE 5.0: Understand water governance						
13-15	5.1 Explain governance frameworks 5.2 Explain institutional analysis. 5.3 Describe public-private partnerships (PPP). 5.4 Describe	- Discuss governance frameworks (OECD water governance). - Describe institutional analysis. - Describe public-private partnerships.	Textbooks, Projector, Whiteboard, Computer, Internet	- Source data from public or private water agency. - Apply OECD principles to one institution. - Conduct institutional analysis. - Profile one	Guide students to: - Source data from public or private water agency. - Apply OECD principles to one institution. - Conduct institutional analysis. - Profile one Nigerian water PPP.	OECD documents, Analysis frameworks, PPP cases, Computer, Internet,

	transparency and accountability.	• Discuss transparency and accountability.		Nigerian water PPP. • Audit transparency of one utility. • Record findings.	• Audit transparency of one utility. • Record findings.	
--	----------------------------------	--	--	--	--	--

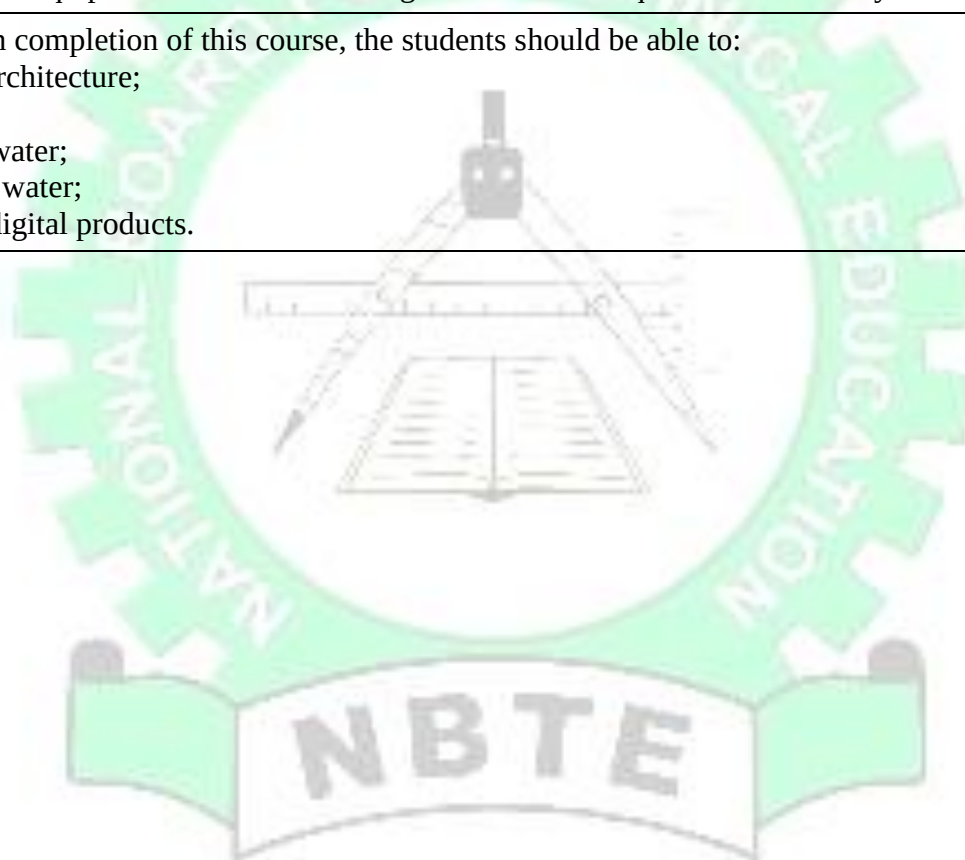
COURSE ASSESSMENT:

Tests:	10%
Course work:	10%
Practical:	40%
Examination:	40%
Total:	100%



SMART WATER SYSTEMS AND DATA ANALYSIS

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: SMART WATER SYSTEMS AND DATA ANALYSIS	COURSE CODE: HWR 424	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEKS
GOAL: This course is designed to equip students with knowledge and skills to acquire smart water systems and data analytics.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know smart water systems architecture; 2.0 Know water data analytics; 3.0 Know machine learning for water; 4.0 Know big data and cloud for water; 5.0 Know decision support and digital products.		



PROGRAMME: HND HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: SMART WATER SYSTEMS AND DATA ANALYSIS			COURSE CODE: HWR 424		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip student with knowledge and skills smart water systems and data analytics						
GENERAL OBJECTIVE 1.0: Know smart water systems architecture						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1Explain the concept the digital-twin for water. 1.2 Describe the principle of SCADA for water systems. 1.3Explain integration of operational systems. 1.4 Describe Nigerian smart-water case studies.	• Discuss the meaning and relevance of digital-twin for water system • Describe the full meaning of SCADA and its application for water systems. • Discuss integration operational systems. • Discuss Nigerian smart-water case studies.	Textbooks, Projector, Whiteboard, Computer, Internet	• Sketch digital-twin for one water system. • Analyse using SCADA for water systems. • Design integrated operational system.	Guide students on: • Conduct spatial analysis. • Analyse and interpret SCADA. • Design integrated operational systems.	Digital-twin guides, SCADA demos, Computer, Internet, Software

GENERAL OBJECTIVE 2.0: Know water data analytics						
4-6	2.1 Explain exploratory data analysis (EDA). 2.2 Describe time-series analysis (advanced). 2.3 Describe statistical computing in R/Python. 2.4 Explain data visualization	- Describe in details the EDA. - Discuss time-series analysis. Describe statistical computing in R/Python. - Describe data visualization.	Textbooks, Projector, Whiteboard, Computer, Internet	- Conduct EDA on water dataset. - Apply time-series decomposition and ARIMA. - Apply analytics in R/Python. - Run analytics in R/Python. - Apply and Build Grafana dashboards.	Guide students on: - Analysis and interpretation of EDA - Analysis and interpretation of time-series. - Apply statistical computing in R/Python. - Apply and Build Grafana dashboards.	Laboratory computers, R/Python, Grafana dashboards, Internet, Software
GENERAL OBJECTIVE 3.0: Know machine learning for water						
7-9	3.1 Explain supervised learning (regression, classification). 3.2 Describe random forest and gradient boosting. 3.3 Describe neural networks (intro). 3.4 Explain unsupervised learning (clustering).	- Describe supervised learning (regression, classification). - Discuss random forest and gradient boosting. - Discuss neural networks. - Discuss unsupervised learning (clustering).	Textbooks, Projector, Whiteboard, Computer, Internet	- Build regression for rainfall-runoff. - Apply random forest for flood prediction. - Apply simple neural networks. - Apply k-means clustering to water-quality.	Guide students on how to: - Build regression for rainfall-runoff. - Analyse random forest for flood prediction. - Apply simple neural networks. - Analyse k-means clustering.	Laboratory computers, Scikit-learn, TensorFlow Keras, Internet, Software
GENERAL OBJECTIVE 4.0: Know big data and cloud for water						

10-12	4.1 Explain the meaning of big-data (volume, velocity, variety). 4.2 Describe cloud platforms (AWS, Azure, GCP intro). 4.3 Explain Google Earth Engine (GEE) for water. 4.4 Explain data lakes and warehouses.	- Describe the concept of big-data. - Discuss cloud platforms. - Describe Google Earth engine (GEE). - Describe data lakes and warehouses.	Textbooks, Projector, Whiteboard, Computer, Internet	- Apply big-data characteristics for water. - Apply AWS/Azure for water services. Build GEE script for catchment analysis - Design data-lake architecture.	Guide students on how to: - Apply and build big-data characteristics for water - Apply AWS/Azure water services - Design and apply GEE script for catchment analysis - Design and apply data-lake architecture	Laboratory computers, GEE accounts, cloud documentation Laboratory computers, AWS/Azure, GCP Internet, Software
GENERAL OBJECTIVE 5.0: Know decision support and digital products						
13-15	5.1 Explain the concept of decision-support systems (DSS). 5.2 Describe web and mobile water-apps. 5.3 Explain API design for water data. 5.4 Describes data ethics and governance	- Describe DSS. - Discuss web and mobile water-apps. - Explain API design for water data -Discuss data ethics and governance	Textbooks, Computer, Projector, White board marker, Lesson notes	- Design DSS for one water decision. - Build simple water-data web. - Apply an API for water data. - Apply data ethics and governance checklist.	Guide students on: - Design DSS for one water decision. - Build simple water-data web. - Apply an API for water data. - Apply data ethics and governance checklist.	Laboratory computers, Scikit-learn, API, (DSS). Internet, Software

COURSE ASSESSMENT:

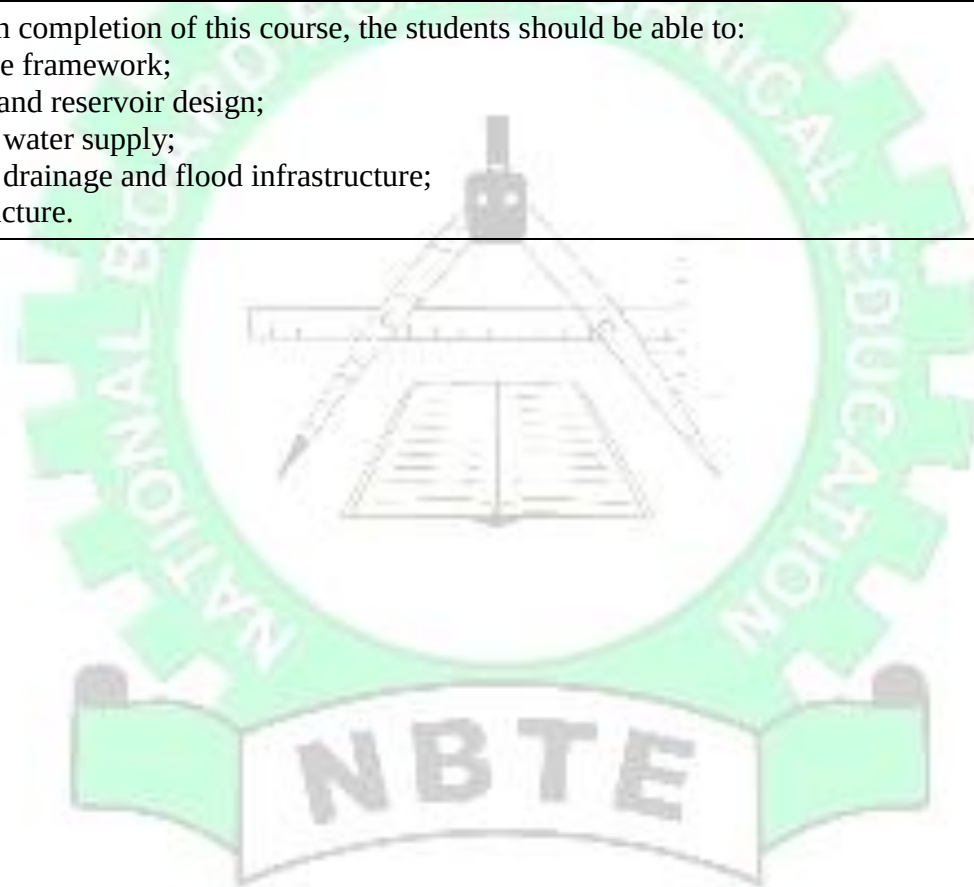
Tests:	10%
Course work:	10%
Practical:	40%
Examination:	40%
Total:	100%





CLIMATE-RESILIENT WATER INFRASTRUCTURE TECHNOLOGY

HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: CLIMATE-RESILIENT WATER INFRASTRUCTURE TECHNOLOGY	COURSE CODE: HWR 425	CONTACT HOURS: 4 HOURS/WEEKS
	CREDIT UNIT: 4	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 3 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skill of climate-resilient design of water infrastructure.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand climate-resilience framework; 2.0 Know climate-resilient dam and reservoir design; 3.0 Understand climate-resilient water supply; 4.0 Understand climate-resilient drainage and flood infrastructure; 5.0 Know coastal water infrastructure.		



PROGRAMME: HND HYDROLOGY AND WATER RESOURCES MANAGEMENT						
COURSE TITLE: CLIMATE-RESILIENT WATER INFRASTRUCTURE TECHNOLOGY			COURSE CODE: HWR 425		CONTACT HOURS: 4 HOURS/WEEKS	
			CREDIT UNIT: 4		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 3 HOURS/WEEKS	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skill of climate-resilient design of water infrastructure.						
GENERAL OBJECTIVE 1.0: Understand climate-resilience framework						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain the concepts of climate resilience water infrastructure. 1.2 Describe climate-risk and vulnerability in water sector. 1.3 Describe adaptation and mitigation in water sector. 1.4 Explain mainstreaming climate and its rationale in projects.	• Discuss the concepts of climate resilience water infrastructure. • Discuss climate-risk and vulnerability in water sector. • Discuss adaptation and mitigation in water sector. • Discuss mainstreaming climate and its rationale in projects. • Describe principles and policies of climate resilience	Textbooks, Projector, Whiteboard, Computer, Internet	• Conduct resilience checklist to one infrastructure. • Conduct climate-risk screening. • Identify 5 adaptation and mitigation measures. • Construct mainstream climate in one project. • Create the visual content to state	Guide students to: • Design a climate checklist. • Carryout a climate risk screening. • Identify principles and policies of climate resilience. • Identify rationale for mainstreaming climate. • Report and record findings.	Climate risk screening checklists, Screening tools, WEAP, R-ClimDex for rainfall trend, Projector, Internet

	1.5 State principles and policies of climate resilience planning.	planning.		the rationale for mainstreaming climate.		
GENERAL OBJECTIVE 2.0: Know climate-resilient dam and reservoir design						
4-6	2.1 Explain the concept of climate resilient dam and reservoir design. 2.2 Explain the principles and policies of climate dam and reservoir design. 2.3 Describe climate-resilient spillway design. 2.4 Explain sedimentation and dead storage. 2.5 Describe dam safety and risk implementation 2.6 Explain estimation of adjusted flood design using climate factor.	• Discuss the concept of climate dam and reservoir design. • Describe the principles and policies of climate dam and reservoir design. • Discuss climate-resilient spillway design. • Describe sedimentation and dead storage. • Discuss dam safety and risk. • Discuss estimation of adjusted flood design using climate factor.	Textbooks, projector Manuals Journals Climate data Whiteboard Internet Computer	• Identify dam safety and risk component. • Compute adjusted flood design using climate factor. • Input 3 climate scenario into WEAP. • Plot rule curve on excel.	Guides students to: • Use NIHSA checklist to check spillway crack, seepage control etc. • Plot graph showing normal rule curve vs climate rule curve from January to December. • Calculate climate flood. • Calculate spillway size and length. • Prepare report and record findings.	Design templates WEAP Tape Cameras GPS Excel AutoCAD Graph sheets

GENERAL OBJECTIVE 3.0: Understand climate-resilient water supply						
7-9	3.1 Explain climate resilient water supply and diversification sources. 3.2 Explain resilient treatment design. 3.3 Explain emergency water supply. 3.4 Explain threats to climate resilient water supply.	● Explain climate resilient water supply and diversification sources. ● Discuss resilient treatment design. ● Discuss emergency water supply. ● Explain threats to climate resilient water supply.	Textbooks, Projector Manuals Journals Climate data Whiteboard Internet Computer	● Design diversified-source water supply ● Carryout resilient treatment design. ● Plan emergency-water-supply protocol. ● Identify threat to climate resilient water supply.	Guides the students to: ● Design diversified-source water supply. ● Carryout resilient treatment design. ● Plan emergency-water-supply protocol. ● Identify threat to climate resilient water supply. ● Record and report findings.	Design templates, protocol templates Excel Census data Rainfall data Stream flow data
GENERAL OBJECTIVE 4.0: Understand climate-resilient drainage and flood infrastructure						
10-12	4.1 Explain urban drainage under climate change. 4.2 Explain nature-based solutions (NBS). 4.3 Describe flood-resilient infrastructure design. 4.4 Describe integrated stormwater	● Discuss urban drainage under climate change. ● Discuss nature-based solutions (NBS). ● Explain flood-resilient infrastructure design. ● Explain integrated stormwater management.	Textbooks, Projector Manuals Journals Climate data Whiteboard Internet Computer	● Re-size urban drainage under +20% rainfall. ● Design NBS (swale, rain garden, wetland etc). ● Carry out flood-resilient design for project(s). ● Design integrated stormwater system.	Guides students to ● Re-size urban drainage under +20% rainfall. ● Design NBS. ● Carry out flood-resilient design for project(s). ● Design integrated stormwater system.	Drainage tools, NBS guides SWMM model Internet Climate data

	management					
GENERAL OBJECTIVE 5.0: Know coastal water infrastructure						
13-15	5.1 Explain sea-level-rise considerations. 5.2 Explain coastal flood protection. 5.3 Describe emerging coastal resilience.	• Discuss sea-level-rise considerations. • Discuss coastal flood protection. • Discuss emerging coastal resilience.	Textbooks, Projector Case studies Manuals Journals Climate data Whiteboard Internet Computer	• Compute SLR impacts for coastal. • Design coastal flood-protection structure. • Profile Lagos/Niger Delta cases. • Identify emerging resilience principles.	Guides students to • Compute SLR impacts for one coastal. • Design coastal flood-protection structure. • Profile Lagos/Niger Delta cases. • identify emerging resilience principles.	Coastal data, design templates, case studies Climate data Hydrographic data Internet
COURSE ASSESSMENT: Tests: 10% Course work: 10% Practical: 40% Examination: 40% Total: 100%						

FOOD-ENERGY-WATER NEXUS AND AGRICULTURAL WATER MANAGEMENT TECHNOLOGY

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY		
COURSE TITLE: FOOD-ENERGY-WATER NEXUS AND AGRICULTURAL WATER MANAGEMENT	COURSE CODE: HWR 426	CONTACT HOURS: 3 HOURS/WEEK
	CREDIT UNIT: 3	THEORETICAL: 1 HOUR/WEEK
YEAR: II SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 2 HOURS/WEEK
GOAL: This course is designed to equip students with knowledge and skills to address the Agri-water nexus and the broader food-energy-water nexus.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand nexus concepts and frameworks; 2.0 Understand Agri-water demand and productivity; 3.0 Understand food-energy-water (FEW) nexus modelling; 4.0 Understand Agri-water governance; 5.0 Understand nexus interventions and innovation.		

PROGRAMME: HIGHER NATIONAL DIPLOMA IN HYDROLOGY AND WATER RESOURCES MANAGEMENT TECHNOLOGY						
COURSE TITLE: FOOD-ENERGY-WATER NEXUS AND AGRICULTURAL WATER MANAGEMENT			COURSE CODE: HWR 426		CONTACT HOURS: 3 HOURS/WEEKS	
			CREDIT UNIT: 3		THEORETICAL: 1 HOUR/WEEK	
YEAR: II SEMESTER: II			PRE-REQUISITE: NIL		PRACTICAL: 2 HOURS/WEEK	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills to address the Agri-water nexus and the broader food-energy-water nexus.						
GENERAL OBJECTIVE 1.0: Understand nexus concepts and frameworks						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain food-energy-water (FEW) nexus. 1.2 Explain Agri-water nexus. 1.3 Explain nexus thinking and trade-offs. 1.4 Explain nexus in Nigerian/African context.	• Discuss food-energy-water (FEW) nexus. • Discuss agri-water nexus. • Describe nexus thinking and trade-offs. • Discuss nexus in Nigerian/African context.	Textbooks, Projector, Case study, Journals, Multimedia, Policy document,	• Sketch an Agri-water nexus diagram. • Build FEW diagrams for one region. • Identify 5 trade-offs. • Profile one Nigerian nexus case. • Record and report findings	Guide students to: • Sketch an Agri-water nexus diagram. • Build FEW diagrams for one region. • Identify 5 trade-offs. • Profile one Nigerian nexus case. • Record and report findings	Nexus diagrams, Region data, Case studies, Computer, Internet, Drawing kits,

GENERAL OBJECTIVE 2.0: Understand Agri-water demand and productivity						
4-6	2.1 Describe agricultural water-demand quantification. 2.2 Explain water-productivity analysis. 2.3 Explain efficiency gains and water savings. 2.4 Explain sustainable intensification.	• Discuss agricultural water-demand quantification. • Describe water-productivity analysis. • Discuss efficiency gains and water savings. • Describe sustainable intensification.	Textbooks, Projector, Case study, Journals, Multimedia, Policy document,	• Quantify demand for one farm area. • Compute water productivity for 3 crops. • Estimate water savings from efficiency. • Plan sustainable-intensification programme. • Record findings	Guide students to: • Quantify demand for one farm area. • Compute water productivity for 3 crops. • Estimate water savings from efficiency. • Plan sustainable-intensification programme. • Record and report findings	Demand data, Productivity templates, Case studies, Computer, Internet, Drawing kits,
GENERAL OBJECTIVE 3.0: Understand FEW Nexus modelling						
7-9	3.1 Explain nexus indicators. 3.2 Explain nexus accounting methods. 3.3 Explain scenario modelling (FEW). 3.4 Explain nexus decision support system (DSS).	• Discuss nexus indicators. • Describe nexus accounting methods. • Discuss scenario modelling (FEW). • Discuss nexus decision support.	Textbooks, Projector, Case study, Journals, Multimedia, Policy document,	• Profile one Nigerian case. • Compute 5 nexus indicators. • Apply nexus accounting framework. • Run FEW scenarios. • Build nexus DSS. • Report findings.	Guide students to: • Profile one Nigerian case. • Compute 5 nexus indicators. • Apply nexus accounting framework. • Run FEW scenarios. • Build nexus DSS. • Record and report findings.	Demand data, Productivity templates, Case studies, Computer, Internet, Drawing kits,

GENERAL OBJECTIVE 4.0: Understand Agri-water governance						
10-12	4.1 Explain policy coherence (water-Agri-energy) 4.2 Explain institutional coordination. 4.3 Describe farmer-pastoralist conflicts over water. 4.4 Explain how to apply gender in Agri-water.	• Discuss policy coherence (water-Agri-energy). • Describe institutional coordination. • Explain farmer-pastoralist conflicts over water. • Describe gender in Agri-water.	Textbooks, Projector, Case study, Journals, Multimedia, Policy document, Etc.	• Profile one Nigerian case. • Apply coherence framework. • Map institutional coordination. • Profile one farmer-pastoralist conflict. • Apply gender inclusion to Agri-water. • Record findings.	Guide students to: • Profile one Nigerian case • Apply coherence framework • Map institutional coordination • Profile one farmer-pastoralist conflict • Apply gender inclusion to agri-water • Record and report findings	Coherence frameworks, Conflict cases, Case studies, Computer, Internet, Drawing kits, Etc.
GENERAL OBJECTIVE 5.0: Understand nexus interventions and innovation						
13-15	5.1 Explain nexus-smart interventions. 5.2 Explain digital Agri-water innovation. 5.3 Describe climate-smart Agri-water. 5.4 Describe policy recommendations.	• Discuss nexus-smart interventions. • Explain digital Agri-water innovation. • Describe climate-smart Agri-water. • Discuss policy recommendations.	Textbooks, Projector, Journals, Multimedia, Policy document,	• Profile one Nigerian case. • Design 5 Nexus-smart interventions. • Apply digital tools to agri-water. • Apply climate-smart practices. • Draft policy recommendations. • Report findings.	Guide students to: • Profile one Nigerian case. • Design 5 Nexus-smart interventions. • Apply digital tools to agri-water. • Apply climate-smart practices. • Draft policy recommendations. • Record and report findings.	Intervention templates, Digital tools, policy, Templates, Case study,

COURSE ASSESSMENT:

Tests:	10%
Course work:	10%
Practical:	40%
Examination:	40%
Total:	100%



Abbreviation

S/No.	Abbreviation	Full Meaning
1.	IWRM	Integrated Water Resources Management
2.	RS	Remote Sensing
3.	GPS	Global Positioning System
4.	ADCP	Acoustic Doppler Current Profiler
5.	SWAT	Soil and Water Assessment Tool
6.	HEC-HMS	Hydrologic Engineering Center – Hydrologic Modelling System

LIST OF MINIMUM RESOURCES/ PHYSICAL FACILITIES

Programme	Laboratories	Workshop(s)	Studio/Drawing Room and Others
Hydrology and Water Resources Management Technology (HND)	1. Hydrogeology And Groundwater Laboratory 2. Water Resources Modelling Laboratory 3. Advanced Water Quality and Environmental Monitoring Laboratory 4. Remote Sensing and GIS Laboratory 5. Hydrographic Survey and Bathymetry Laboratory 6. Advanced Hydrology and Climate Change Laboratory 7. Hydrological Modelling Laboratory 8. Advanced Hydraulics Laboratory 9. Digital Water Monitoring and IoT Laboratory 10. Programming, Data Analytics and Smart Water Systems Laboratory 11. Flood Forecasting and Early Warning Laboratory 12. Water Supply and Wastewater Engineering Demonstration Laboratory.	1. Borehole Drilling and Well Construction Workshop	1. Drawing Room 2. Computer/ Geo-informatics Studio 3. Safety Equipment (for each Workshop) 4. Advanced Computer and Geospatial Analysis Studio

1. HYDROGEOLOGY AND GROUNDWATER LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Terrameter	3
2	Groundwater Modelling Software Suite	5
3	Borehole Camera	2
4	Water Level Indicator	5
5	Pumping Test Equipment	3 Sets
6	Data Loggers	5
7	Observation Well Equipment	3 Sets
8	Groundwater Sampling Pumps	5
9	Resistivity Meter	3
10	Aquifer Test Analysis Software	5

2. WATER RESOURCES MODELLING LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	High Performance Computers	20
2	HEC-RAS Software	5
3	SWAT Software	5

4	MIKE HYDRO Software	3
6	Projector	2
7	Plotter	1
8	UPS Units	20
9	Network Server	1
10	Data Storage System	1
11	WEAP	5
12	WaterCAD	5
13	SewerGEMS	5
14	EPANET	5

3. WATER QUALITY AND ENVIRONMENTAL MONITORING LABORATORY

S/NO	DESCRIPTION OF ITEMS	QUANTITY
1	Spectrophotometer	2
2	Atomic Absorption Spectrophotometer	1
3	Multiparameter Water Quality Meter	5
4	Turbidity Meter	5
5	BOD Incubator	2
6	COD Digester	2

7	pH Meter	5
8	Conductivity Meter	5
9	Dissolved Oxygen Meter	5

4. REMOTE SENSING AND GIS LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	GIS Workstations	20
2	ArcGIS Software	10
3	ERDAS Imagine Software	5
4	ENVI Software	5
5	Large Format Plotter	1
6	A0 Scanner	1
7	Differential GPS	5
8	UAV/Drone	2
9	Image Processing Server	1
10	Projector	2
11	Global Mapper	10

5. HYDROGRAPHIC SURVEY AND BATHYMETRY LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Echo Sounder	2
2	Bathymetric Survey Boat	1
3	DGPS Receiver	3
4	Acoustic Doppler Current Profiler (ADCP)	
5	Hydrographic Survey Software	5
6	Depth Sounder	3
7	Life Jackets	40
8	Safety Boat Equipment	2 Sets
9	Portable Sonar Equipment	2
10	Data Acquisition System	2

6. HYDROLOGY AND CLIMATE CHANGE LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Automatic Weather Station (AWS)	2
2	Automatic Rain Gauge with Telemetry	5
3	Water Level Data Logger	10
4	Pressure Transducer Water Level Sensors	10

5	Acoustic Doppler Current Profiler (ADCP)	1
6	Automatic Sediment Sampler	2
7	Hydrological Telemetry System	2
8	Flood Early Warning Demonstration System	1
9	Solar Powered Monitoring Stations	4
10	Climate Data Acquisition Server	1
11	Soil Moisture Monitoring Network	20
12	River Stage Recorder	5

7. HYDROLOGICAL MODELLING LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	High Performance Modelling Workstations	20
2	Dedicated Hydrological Modelling Server	1
3	Large Format Display Screen	2
4	Network Storage System (NAS)	1
5	High-Speed Internet Facility	1

8. HYDRAULICS LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Hydraulic Bench	5
2	Bernoulli Apparatus	2
3	Reynolds Apparatus	2
4	Venturi Meter Apparatus	2
5	Pipe Friction Apparatus	2
6	Open Channel Flow Flume	2
7	Tilting Flume	1
8	Hydraulic Jump Apparatus	2
9	Sediment Transport Flume	1
10	Scour Tank	1
11	Pipe Network Demonstration Unit	2
12	Parshall Flume	2
13	Cutthroat Flume	2

9. DIGITAL WATER MONITORING AND IoT LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Arduino Development Kits	20
2	Raspberry Pi Kits	20
3	ESP32 IoT Boards	40
4	Water Level Sensors	20
5	Flow Sensors	20
6	Pressure Sensors	20
7	Water Quality Sensors	20
8	GSM Communication Modules	20
9	LoRa Communication Modules	20
10	Data Acquisition Systems	10
11	IoT Gateway Devices	5
12	Smart Water Meter Demonstrators	10
13	Solar Power Supply Kits	10

10. PROGRAMMING, DATA ANALYTICS AND SMART WATER SYSTEMS LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	High Specification Desktop Computers	40
2	Central Data Analytics Server	1
3	Smart Board	1
4	Multimedia Projector	2
5	UPS Systems	40
6	Network Attached Storage System	1
7	Python	5
8	R Studio MATLAB	5
9	SPSS	5
10	Power BI	5
11	Tableau	5
12	PostgreSQL/PostGIS	5

11. FLOOD FORECASTING AND EARLY WARNING LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Flood Forecasting Workstations	10

2	Forecasting Server	1
3	Real-Time Monitoring Dashboard	1
4	Large Display Screens	2
5	Early Warning Communication System	1
6	Telemetry Demonstration Platform	1
7	Delft-FEWS	1
8	FEWS NET Tools	1
9	Flood Forecasting Workstations	10

12.0 WATER SUPPLY AND WASTEWATER ENGINEERING DEMONSTRATION LABORATORY

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Pilot Water Treatment Plant	1
2	Rapid Sand Filter Unit	1
3	Slow Sand Filter Unit	1
4	Coagulation-Flocculation Unit	1
5	Sedimentation Tank Model	1
6	Chlorination Unit	1

7	Activated Sludge Demonstration Unit	1
8	Trickling Filter Demonstration Unit	1
9	Membrane Filtration Unit	1
10	Wastewater Recycling Unit	1
11	Anaerobic Digester	1

13.0 BOREHOLE DRILLING AND WELL CONSTRUCTION WORKSHOP

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Drilling Rig	1
2	Air Compressor	1
3	Borehole Development Equipment	2
4	Borehole Logging Equipment	1
5	Well Completion Equipment	3
6	Borehole Casing Installation Kit	3

14.0 STUDIO/DRAWING ROOM AND OTHERS

S/N	DESCRIPTION OF ITEMS	QUANTITY
1	Computer Workstations	40
2	Multimedia Projector	2

3	Smart Interactive Board	1
4	Colour Printer	2
5	Plotter	1
6	Scanner	2
7	GIS Software Packages	10
8	Internet Router	2
9	Server System	1
10	UPS Units	40

15.0 SAFETY EQUIPMENT (FOR HND LABORATORY)

S/NO	EQUIPMENT	NO. REQUIRED
1	First Aid Box	1
2	Safety Goggles	32
3	Safety Helmets	32
4	Rubber Boots	40 Pairs
5	Reflective Jackets	32
6	Fire Extinguishers	4
7	Hand Gloves	40 Pairs
8	Eye Wash Station	1
9	Emergency Shower	1
10	Safety Signage Set	1 Set

LIST OF PARTICIPANTS

S/N	FULL NAMES	ADDRESS	EMAIL ADDRESS
1.	Prof. Idris M. Bugaje	Executive Secretary, National Board for Technical Education, Kaduna.	es@nbte.gov.ng
2.	Prof. Abubakar Ismail	Dept. of Water Resources & Environmental Engineering, ABU Zaria	aismail@abu.edu.ng
3.	Dr. Maria Yohanna	SSC4A Zaria	Mariayohanna23@gmail.com
4.	Dr. Mustapha Yaqub	Samaru College of Agriculture, ABU Zaria	mustaphayahqub@gmail.com
5.	Halilu Aminu	623 Kundilar Gando, Kano	Aminuhalilu.nbte@gmail.com
6.	Salami Adedotun	NWRI, Kaduna	Adedotun.salami@gmail.com
7.	Engr. Farida Ujudud Shariff	NWRI, Kaduna	Fareedah456@gmail.com
8.	Engr. Dr. O. O. Bello	Director (Curriculum Development) National Board for Technical Education, Kaduna.	engroobello@gmail.com
9.	Mr Ayo Aroge	Director (Polytechnic and Allied Programme) National Board for Technical Education, Kaduna.	ayoaroge2@gmail.com
10.	Dr. Kubura Jauro D.	Director Deputy (Agricultural Technology Dept.) NBTE Kaduna	kuburagombe@yahoo.com
11.	Engr. Bashir Datti Amin	National Board for Technical Education, Kaduna.	
12.	Muhammad Aliyu Maiwada	National Board for Technical Education, Kaduna.	
13.	Muhammad Umar Auna	National Board for Technical Education, Kaduna.	Muhammadauna.mu@gmail.com

14.	Abdulrahman Idris	National Board for Technical Education, Kaduna.	
15.	Ahmad Rufa'u Mahmoud	National Board for Technical Education, Kaduna.	Rufahm98@gmail.com
16.	Rukayya Uthman	National Board for Technical Education, Kaduna.	Rukayyahuthman87@gmail.com

