

# CAREERS THROUGH MATHS: ENVIRONMENTAL ENGINEER



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## JOB DESCRIPTION

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Environmental Engineers in the UK apply principles of engineering, soil science, biology, and chemistry to develop solutions to environmental problems. They are instrumental in tackling some of the nation's most pressing challenges, including improving recycling rates, managing waste, controlling water and air pollution, and ensuring compliance with stringent regulations from bodies like the Environment Agency and the Scottish Environment Protection Agency (SEPA). A typical day can be highly varied, involving site visits to contaminated land, analysing data in an office, designing remediation systems using computer-aided design (CAD) software, and writing detailed reports for clients or regulatory submissions.

The work environment is split between the office, the laboratory, and the field. An engineer might spend one week modelling the dispersion of a potential pollutant from a new industrial facility in the Humber estuary, and the next overseeing the on-site construction of a groundwater treatment system for a former industrial site in the Midlands. Key duties include conducting environmental impact assessments (EIAs) for major infrastructure projects like HS2 or offshore wind farms, designing systems for water supply and industrial wastewater treatment for companies like Thames Water or Severn Trent, and managing the remediation of land contaminated by historical industrial use, known as brownfield land development.

Mathematics is absolutely central to the role, forming the quantitative backbone of every project. It is used to model complex environmental systems, calculate loads and capacities, optimise designs for cost and efficiency, and provide the robust,

evidence-based analysis required for regulatory approval. Whether calculating the flow rate of a river to determine a safe discharge level or using statistical analysis to monitor air quality around a proposed new road, mathematical proficiency is non-negotiable for a competent Environmental Engineer in the UK.

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## HOW MATHEMATICS IS USED

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- **Calculus (Differential Equations):** This is fundamental for modelling dynamic environmental systems where rates of change are critical. Engineers use differential equations to predict the transport and fate of pollutants in groundwater (a process called contaminant hydrology). For example, when assessing a leak from a fuel storage tank, they model how the contaminant plume will disperse through the aquifer over time, which informs the design of the extraction and treatment system. Similarly, calculus is used to model atmospheric dispersion of emissions from a power station's chimney stack, ensuring that ground-level concentrations comply with UK Air Quality Standards.
- **Fluid Mechanics and Hydraulics:** The principles of fluid dynamics are essential for designing systems that manage water and wastewater. This involves applying Bernoulli's equation and Manning's equation to calculate flow rates, pipe sizes, and pump requirements for everything from municipal water supply networks to surface water drainage systems for new housing developments. For instance, an engineer might calculate the head loss in a pipeline to specify the correct pump for transferring treated wastewater back into a river like the Mersey, ensuring the system is both efficient and resilient.
- **Statistics and Data Analysis:** Environmental Engineers rely heavily on statistics to interpret complex datasets and make informed decisions. They use descriptive statistics to summarise water quality monitoring data from a network of boreholes, and inferential statistics (like hypothesis testing) to determine if there has been a statistically significant change in pollution levels before and after a remediation project. Probability theory is used in risk assessments to evaluate the likelihood of a flood event from a river like the Severn or the potential failure of a landfill liner.
- **Mass Balance and Stoichiometry:** The principle of mass balance (mass in = mass out + accumulation) is applied universally. It is used to track pollutants

through a treatment process, such as calculating the amount of chemical coagulant needed to remove suspended solids from industrial wastewater. In air quality management, a mass balance approach is used to inventory emissions from a factory, ensuring that all sources are accounted for and that the company remains within its permitted limits set by the Environment Agency.

- **Mathematical Modelling and Simulation:** Specialist software packages are used to create sophisticated mathematical models of environmental processes. For example, an engineer might use MODFLOW (a groundwater flow model) to simulate the impact of a new abstraction borehole on nearby wetlands. Or, they might use computational fluid dynamics (CFD) to model the airflow and temperature distribution inside a new energy-from-waste incineration plant to maximise combustion efficiency and minimise the formation of harmful by-products like dioxins.

## KEY SKILLS & TOOLS

Skill/Tool	Application
GIS (Geographic Information Systems) Software (e.g., ArcGIS, QGIS)	Used to analyse spatial data mathematically. An engineer might overlay maps of geology, hydrology, and land use to identify areas at high risk of groundwater contamination from agricultural nitrate runoff, or to site a new landfill facility by calculating buffer zones to residential areas.
Mathematical and Modelling Software (e.g., MATLAB, Python with NumPy/SciPy)	Employed for complex numerical analysis and developing custom models. For instance, using Python to write a script that statistically analyses years of air pollution data from London to identify seasonal trends, or using MATLAB to solve a set of differential equations modelling chemical reactions in a water treatment tank.
Data Analysis and Visualisation Tools (e.g., Microsoft Excel, Power BI, R)	Essential for processing, analysing, and presenting environmental data. This includes using Excel to perform regression analysis on water quality parameters or creating dashboards in Power BI to visually report on a client’s carbon footprint metrics against UK government targets.

Programming Languages (e.g., Python, VBA)	Used to automate repetitive calculations, interface with databases, and enhance the functionality of other software. For example, writing a Python script to automatically process and validate data from remote environmental sensors, or using VBA in Excel to create a custom tool for calculating a site's carbon emissions.
Specialised Equipment (e.g., Water Quality Probes, Air Samplers)	Field equipment collects raw data that is inherently numerical. Engineers must understand the underlying principles, such as calibrating sensors using standard solutions and applying correction factors to ensure the pH, dissolved oxygen, or turbidity readings are mathematically accurate before analysis.
Technical Report Writing and Communication	The ability to translate complex mathematical findings into clear, concise language for non-technical stakeholders, such as presenting the risk assessment for a proposed flood defence scheme to local council members or the public.
Quality Assurance/ Quality Control (QA/QC) Procedures	Applying statistical methods to ensure data integrity. This includes calculating duplicates, blanks, and calibration checks to validate laboratory results, which is crucial for providing defensible evidence in environmental permit applications to the Environment Agency.

**Typical Pathway:** The most common route begins with strong GCSEs (or National 5s in Scotland) in Mathematics and Sciences, followed by A-levels (or Highers) in Mathematics, Physics, and Chemistry. Aspiring engineers then complete a bachelor's degree (BEng) or an integrated master's degree (MEng) in Environmental Engineering or Civil Engineering with an environmental specialism, accredited by the Institution of Civil Engineers (ICE) or the Chartered Institution of Water and Environmental Management (CIWEM). Graduates typically start as a **Graduate Environmental Engineer** in a consultancy (e.g., Arup, Jacobs, WSP), a water company, or a construction firm. To achieve **Chartered Engineer (CEng)** status, they must undertake a period of initial professional development with an employer, submit a technical report, and pass a professional review with an institution like the ICE. Career progression can lead to roles such as **Senior/Principal Engineer**, **Project Manager**, or **Technical Director**.

**Industry Demand:** Demand for Environmental Engineers in the UK is strong and growing, driven by government commitments to net-zero carbon emissions by 2050, major infrastructure projects, and stringent environmental regulations. The UK

government's National Infrastructure Strategy and the push for renewable energy (particularly offshore wind) are creating significant opportunities. Skills in mathematical modelling, data analysis, and sustainable design are particularly sought after by consultancies, utility companies, and local authorities.

**Real-World Impact:** Environmental Engineers have a direct and visible impact on the UK. They were central to the clean-up and legacy planning for the London 2012 Olympic Park, transforming a contaminated industrial site into a sustainable new quarter of the city. They work for companies like the Environment Agency to design and model flood defence systems that protect communities along rivers like the Ouse in Yorkshire. Their mathematical work ensures the UK has clean water to drink, manages waste responsibly, and builds a greener, more resilient infrastructure for the future.