The foundation for food production environmental sciences essay

This report shall describe and identify various soil remediation techniques and evaluate how vital they are in the protection of groundwater and soil as a resource; this shall be achieved through understanding how the human race is impacting and polluting the environment and by recognising the various sources of pollution and how they infiltrate into the soil and water cycle. Groundwater is an essential resource which humanity depends upon; approximately 2 billion people rely on groundwater and aquifers for their main source of drinking water, as a resource groundwater only amounts to 0. 70% of the quantity of water upon the earth without which mankind would not have been unable to develop; water services a range of purposes for example domestic, industrial and agricultureTable 1 highlights the numerous uses that water provides to the human race; approximately 10% of drinking water in Wales and almost a third of England’s drinking water supply comes from groundwater, while in some Arid countries such as the Middle East they are exclusively reliant upon groundwater as their main water resource, There are multiple threats towards groundwater as a resource; pollution occurs easily and can remain undetected for an extended period of time, and even once discovered can be difficult and expensive to remediate, Soils are also a precious resource which can take up to 1, 000 years to form just 1mm soil degradation and pollution is a concern for example; food production may decrease by nearly 20% in agricultural lands particularly in Croplands such as those found in the African pastures if degradation continues at the present rate. To understand why soils are imperative to mankind table 2 highlights some of the services provided by soils. Table 2 emphasises only a few of the vital functions which soil provides and helps support mankind, soil gives an area the ability to grow vegetation therefore providing resources

such as food or timber, it is also vital to the carbon and nitrogen cycle and the absorption of greenhouse gases, acting as a carbon sink These names only a few functions of soil but it through understanding these roles that it is possible to comprehend why soils, are so important and gain appreciation of the reasons why remediation technology is needed. There are numerous threats to both groundwater and soil such as salt water intrusion; however this reports looks specifically at pollutants. Pollutants are substances which are formed either by concentrated human activities or occur naturally Examples of unintentionally pollution events include accidental spills and leakages from surface and underground sources; while an example of pollutants deliberately dumped into the environment includes the case whereby raw sewage was released into private residents properties, gardens and into streams in Bromley, UK over a time frame of ten week in 2003, this illegal act meant the water company was charged approximately £200, 000 for environmental damage in 2011To comprehend how various pollutions impact groundwater and soil an understanding of the hydrological cycle must be had through recognising the way that pollutants are able to enter these resources. The main source of groundwater comes from precipitation in the forms of rainfall, hail, sleet or snow, this precipitation charges the reservoir of groundwater i. e. the aquifer by through flow in the form of infiltration, percolation and groundwater flow, or run off see diagram Appendix A, it is through these processes that pollutants are able to infiltrate or be carried into the soil and groundwater. However these movements in the water cycle are influenced by the texture soil for example water percolates through porous sand more easily than compacted clay soil and natural geology such as permeable Limestone which can contain cracks and fissure compared to

impermeable graniteThere are numerous ways to categories pollutants including degradable pollutants which can easily be broken down or those which are non–degradable which do not The European Commission Water Framework Directives priorities pollutants into two categories the first being " Hazardous Substances" which are toxic and are not permitted to enter the groundwater this includes Cyanide, Hydrocarbon and Mercury, the second category list " Non-Hazardous" pollutants which are less potent and maybe released but only at selected concentrations which will not cause pollution for example Sewage, Table 3 lists ten examples of pollutants found under the Water Framework Directives, 2006 of Hazardous and Non-Hazardous Substances. Table 3 indicates only a few of the various chemicals and substances which are able to pollute and enter both systems, though the substances listed as non-hazardous become hazardous when in large proportions. Hexavalent Chromium contaminated groundwater in Hinkley, California in 1997, polluted by Pacific and Electricty Co which then had to compensate 660 residents in settlements of $333 million was agreed in a lawsuit after it was stated that highly reactive chemical caused serious illness such as intestinal tumors and breast cancer, There is also the concept of point source pollutants whereby the origin of the pollution is known and can be easily identified; an example of this is leachate occurring from landfill. Opposite to this is a diffuse source, (Non-point source) this is a polluting event whereby the source of the pollutant is unidentified and may occur from many small sources which have accumulated over an extended time frame or ranges across a wide parameter, an example of this being run-off from a busy road, Non point sources generally cause more of an environmental impact due to the widespread source of the contaminate and

its ability to impact a larger volume of waterFigure 1 highlights various examples of pollution sources both point and diffused and how they infiltrate into the ground, as shown in the figure the red circles show two examples of point source pollution from landfill and septic tanks and the yellow circles show non-point source from leaking pipes or pesticide and fertiliser application. Table 4 depicts examples of infiltrations from point and diffused sources showing various sources through which pollution events can occur. As a result of the mounting demand to help resolve the issue of both groundwater and soil pollution numerous remediation technologies were created currently remedial technology can be classified into two main categories the first being Civil engineering which either eliminates or encloses the source of the contamination or cordons and impedes the movement of the pollutant by processes such as Soil washing or Soil vapour extraction The second category is a Processes based technique which implements physical, chemical and biological techniques to transform, abstract or eliminate the contaminant this process based method is a more ecological approach of remediation and manipulates the natural processes of the soil to degrade and remediate the soil, an example of this is using organic matter to motivate biological activities, this includes remediation’s such as Biopiles Though the categories are not mutually exclusive and techniques can fall under both designations implementing both sets of mechanismsRemediation can occur in situ through which treatment is utilized without extracting the pollutant or in ex situ where treatment is implemented subsequent to the extraction, with treatment either occurring onsite such as in the situation for all in situ remediation or off sites where contaminants can be treated in offsite facilitiesCivil engineering can be

further assorted into three separate sub-categories; first being extraction of solid materials, second physical containment making use of screening and buried barriers and thirdly hydraulic control used in conjunction with the first two sub-categories as the principal remediation of the polluted groundwater (Harris & Herbert, 1994). The Process based technique of remediation can be segregated into five separate categories; firstly by thermal treatment through utilizing heat to annihilate, abstract or stabilize the pollutant, secondly by physical treatment to segregate the contaminant, thirdly by implementing chemicals to again abstract, destroy or transform the pollutant , fourthly by biological means enabling the natural processes of the soil to remediate the contaminant and lastly by the means of solidification or stabilization where the pollutant are chemically neutralized or immobilizedAn evaluation of all the advantages and disadvantages of each system are shown in Appendix C. Extraction is a simple Ex–situ system whereby the pollutant is excavated before being removed of site either to be then remediated at a treatment facility or simple disposed contaminants that are less harmful can be taken to landfill; it is widely applicable to various contaminantsPermeable Reactive Barriers (PRB) or walls is an in-situ remediation; which involves a wall or barrier being placed in the path of a contaminated groundwater source; this wall is made up of a permeable reactive substance which can be replaceable or permanent in nature and is made up with various chemicals for instance metal oxides, sulphides or granular iron that react in methods such as adsorption, precipitation or transformation (with the contaminated water as it passes through the barrier the methods utilized include changing the contaminant into a less harmful or toxic element A successful PRB system was installed in 1996

North Carolina, to remediate hexavalent chromium illustration of PRB system Appendix D. Pump and Treat technology involves the strategic placement of extraction wells which pumps contaminated water to the surface whereby it is removed and deposited in treatment tanks where chemicals maybe added to remediate or being removed and treated by biological or mechanical means, after treatment and meeting regulated standards the remediated water shall either be pumped back into the ground or released in sewage system There are numerous variations to this technique including collection systems such as Recovery wells and interceptor trenches which the clear the water as it is pumped to the surface or Pump treat Inject (PTI) systems where the treated water is injected back in the groundThermal desorption is the process whereby the contaminated substance is dig out, screened and heated in chambers to temperatures up to 600°C causing all the various chemical components to become more volatile reaching there boiling point become unstable and vaporise, the vaporised substance is then removed by a vacuum and treated, this form of remediation does not destroy the pollutant but merely transforms it into a treatable substance The system is described to have two major components the principal desorber which heats and separates the contaminant and an off-gas treat system which then remediates the pollutant , it is an efficient system in the remediation of petroleum-contaminated soil citied that complete desorption occurred within 30 minutes. Soil washing predominantly occurs in ex situ treatment facilities whereby contaminated soil is scrubbed in a high energy mechanical process where an aqueous based solutions most commonly water The process can be either chemical or physical and forms soil that are segregated with the quantity of hazardous contaminant reduced, This form of remediation is

especially effective at eradicating heavy metal from the soil but overall the effectiveness is dependent upon the type of both soil and pollutantThere are five basic steps in the process first being the removal and excavation of polluted soil; before the second step can occur all coarse grained particles are removed; the remaining soil begins the remedial action entering the scrubbing unit, variation in soil particles influence the ability to absorb contaminants meaning that sand particles which are less cohesive need less rinsing than finer grained particles which attract pollutants more easily such as silt or clay The third steps include separation of solids and liquids where polluted liquids are removed and cleaned; in a traditional wastewater treatment facility and further recycled, now all pollution should have either been destroyed or removed allowing for the finally step the deposition of the cleaned soil in an designated and safe siteAir Sparging is the in-situ remediation commonly used for semi and volatile organic compounds (VOC & SVOC) in groundwater; the technique consists of air being injected into contaminated soils under high pressure, which dislodges the volatilizes as well as filling the soil with oxygen and water which helps make the saturated soil more porous; as the air dislodges the volatilize it forms a zone of semi desaturation water named the radius of influence (ROI) around the source of the injection forcing the volatiles to the unsaturated zone i. e. the Vadose zone in conjunction with Soil Vapour Extraction (SVE) is biodegraded in oxygenation by micro-organism and microbes using the organic chemicals for energyUltraviolet-oxidation Treatment operates to annihilate organic pollution from polluted water; through the means of amalgamating high intensity ultraviolet (UV) light normally in the form of UV bulbs and chemical oxidants either ozone (O3) which reacts synergistically with the UV or

hydrogen peroxide (H2O2) which implements hydroxyl radicals to react and oxides the pollutant both systems oxidise the pollutant altering it into a less toxic form, and if oxidation completes to the maximum the final substances shall be carbon dioxide, salts and clean waterBiopiles are an ex situ bioremediation technique whereby contaminated soils are dug out and situated in extended, thin piles nutrients are added and are aerated at designated intervals the piles can either be stationary with an connected piping system aerating the soil or turned by a mixing machine living or micro-organism in the pile utilise the organic components by consuming them as a carbon source. The high capacity of degrading hydrocarbons means it can be used when contaminants are too volatile for Landfarming remediationThe rate of degradation can be easily controlled by regulating selected parameters such as the pH, temperature, aeration rate or the amount of water present a bulking agent could also be added such as straw, bark or wood chips or other organic composting materials, the process of enhancing these parameters would elevate the biodegradation rate though if these parameters go into excess they may become a limiting factor such as water content which is needed for organism growth but in too high a quantity constrains the advancement of oxygen needed for aerobic bacteria to growAccording to the Environmental Agency (2000) the definition of Natural Attenuation (NA) is the " The effect of naturally occurring physical, chemical and biological processes, or any combination of those processes to reduce the load, concentration, flux or toxicity of polluting substances in groundwater." this means there are no anthropogenic inputs into the process however the site must be thoroughly assessed to ensure the source and all remaining toxic pollutants have been dealt with before NA can occur NA

utilizes natural mechanisms in the soil in a number of methods this includes biological degradation, abiotic oxidation and radioactive decay which are all detrimental to the contaminant or through less damaging processes such as dispersion, stabilisation and absorption and has been classified as the " Do nothing" approach to remediation This form of remediation is mainly applied to Benzene and Hydrocarbon pollution though it could be used for pesticides or inorganic compoundsNA has been acknowledged as an economically worthy option for remediating groundwater with the process being primarily operated for the treatment of polluted aquifers but only after the main source has been removed, this is common practice with NA occurring in conjunction with other forms of treatments due to the extended time frame it undertakes to remediate the pollution Though for the remediation to be truly efficient it must occur at a rate which is faster than the contaminants ability to pollute further into the environment and again this is dependent upon the natural components of the environment such as the geology. Risk of pollutants if not being monitored not degrading or possibly transforming into more toxic pollutants can take place an example of this occurred in Vejen Landfill, Denmark whereby the NA process after ten years had been unable to degrade the Benzene component of the landfill leachate, This form of remediation uses both physical and chemical processes to control and limit the movement of the pollution it is particularly suitable in treatment of heavy metal pollutants The technique implements substances which are pumped into polluted ground binding together with contaminant changing the soil into solid material a chemical such as Cement alone may be used or combined with additional material such as blast furnace slag or crushed fuel ash which are cost effective methods Schifano et al. (2007) cities Quicklime

as an example of solidification/stabilization technique which can significantly decrease in leachate and concentrations of petroleum hydrocarbon after being applied to contaminated soils. Solidification of waste results in contaminants which are insoluble, immobile, less to non-hazardous as well as having elevated strength and durabilityThe need for remediation is particularly clear as these resources are being infected at an alarming rate through anthropogenic actions, in the creation of these harmful substances and for allowing these pollutants to enter into the environment, whether this occurs intentionally or accidentally. The functions and roles that groundwater and soil provide are highlighted in table one and two both illustrating how vital these resources are for human survival, in 2005 the United States where estimated to be extracting 79 billion gallons of groundwater a day; in the use of various servicesPollution is notably concerning in the case of Non-point Source pollution where the origin of the contaminant is unknown, originating from multiple sources examples are highlighted in table three. The Hinkley, California example illustrated the health risks that pollution can cause to the human population, though this case is not alone another example involves pollution nitrate pollution which got into groundwater in Eastern South Dakota back in 1950 this resulted in 144 cases of infant Methemogoglobinemia occurring with a recorded 14 deaths over a period of 30 months, Acute nitrate pollution also caused 200 cattle to die in Ghana, Bostwana in 2000 after seeping into groundwater these examples illustrates why remediation technologies are again so vital. As soil and groundwater are essentially unseen there value too mankind may not be appreciated compared to other environmental functions such as vegetation which are fought for adamantly as they are seen to play a vital role in the environment

especially as a carbon sink, even though soil incorporates a larger store of carbon than that of vegetation and the atmosphere combined, The ten remediation techniques described in the main body of the report; are fundamental in their purpose of remediating polluted soils and groundwater; however after looking at each form it was clear that each technique had tits positive and negative aspects as emphasised in Annex B. It is therefore clear for efficiency of soil remediation to occur at its best capacity, selection of the most suitable technique must be chosen or the use of an amalgamation of processes, however this can be difficult as most technologies are designed for a site specifically, thus for the best remediation of a location to occur the parameters of the varies factors affecting the site need to be taken in to consideration when selecting which type of remediation technology to use, Soil and groundwater are essential to mankind through in the services they provide, it is therefore clear why they are so important to protect, this is especially true due to rate at which mankind is polluting these resources and how easily pollution can infiltrate into the systems from varying sources. Clear understanding of these fact though allow for remediation and control of these pollutants to take place, in there numerous forms whether they are engineered or process based methods or occur in-situ or ex-situ.