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Contaminated Sediment Transport During Floods[1]

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Thomas A. Fontaine[2]

Abstract

Over the past 48 years, operations and waste disposal activities at Oak Ridge National Laboratory have resulted in the contamination of parts of the White Oak Creek catchment. The contaminants presenting the highest risk to human health and the environment are particle reactive and are associated with the soils and sediments in the White Oak Creek drainage system. The erosion of these sediments during floods can result in the transport of contaminants both within the catchment and off-site into the Clinch River. A data collection program and a modeling investigation are being used to evaluate the probability of contaminated sediment transport during floods and to develop strategies for controlling off-site transport under present and future conditions.

Introduction

White Oak Creek (WOC) drains a 16 km^2 catchment that includes the main plant facilities and waste disposal areas of Oak Ridge National Laboratory (ORNL) near Oak Ridge, Tennessee. The drainage system of WOC has become contaminated over the 48 year history of plant operations and waste disposal activities at ORNL. During floods the erosion of sediment results in the transport of particle reactive contaminants (e.g., ^{137}Cs, Hg, PCBs) both within WOC and out of the catchment into the Clinch River. A long term strategy is being

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developed to monitor and model the release of contaminated sediments from WOC under existing conditions as well as to predict the transport of contaminated sediment that could be expected during extreme floods or future land use changes.

In order to monitor contaminant transport and to collect data for the modeling investigation, streamflow and sediment are monitored at seven locations (Figure 1). Suspended sediment samples are collected using both automatic and manual sampling methods. At each station, one or two pumping samplers are used to collect one L samples of stream water every 15 minutes during floods. The samplers are automatically activated when streamflow exceeds a preset stage (e.g., 30 cm below bank-full stage). Stream water samples are also collected manually using the US DH-48 and US DH-76 samplers in order to verify the data collected by automatic samplers at each station.

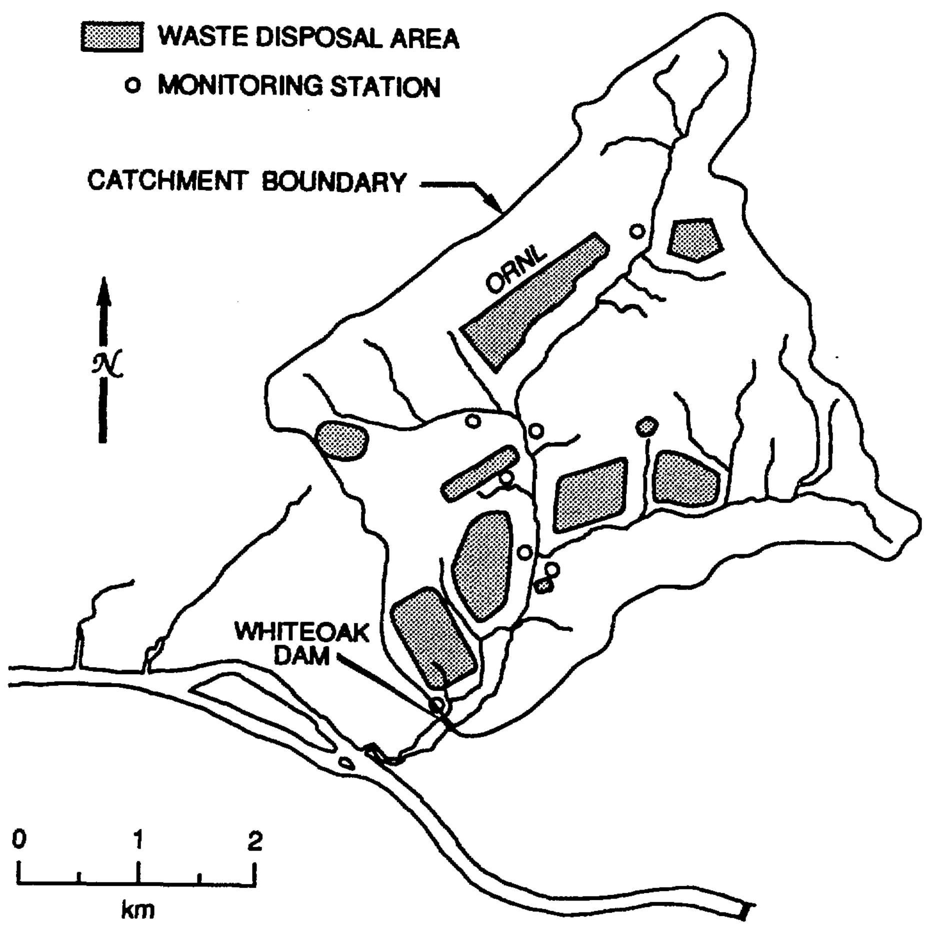

Figure 1. Location of Monitoring Stations

The particulate matter in the water samples is analyzed for suspended sediment concentration, particle size distribution, and concentration of contaminants. Because of the variety of contaminants that exist in the waste areas and channel system and because the transport mechanisms have not yet been completely determined, samples are primarily evaluated for contamination based on screening for gamma emitters (e.g., ^{137}Cs and ^{60}Co). Additional contaminant analyses for beta emitters (e.g., ^{90}Sr) and for metallic and organic contaminants are used when the additional expense is justified.

Results

Based on the analysis of several floods in the winter of 1991-1992, the following observations have been made: (1) comparisons of suspended sediment concentration, particle size distribution, and contaminant load from samples collected with pumping samplers and manual sampling equipment indicate that automatic pumping samplers are adequate for collecting data on sediment and contaminants. However, the location of the point intake for the pumping sampler is a critical variable for all three types of data; (2) contaminant concentrations are inversely proportional to particle size; (3) concentrations of ^{137}Cs (pCi/dry-gm of sediment) are inversely proportional to streamflow; (4) suspended sediment concentrations increase exponentially with increasing discharge; (5) off-site discharge of particle reactive contaminants can be predicted for baseflow and small magnitude floods based on field measurements, but predictions of contaminant transport during larger floods require a computer model capable of simulating the nonlinear relationships between streamflow, suspended sediment concentration, particle size distribution, contaminant concentration, and active contaminant sources. A transport model is currently being constructed for this purpose.