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Conveyance of Residuals from Water and Wastewater Treatment

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Conveyance of Residuals from Water and Wastewater Treatment

Sludge Treatment, Utilization, Reclamation,
and Disposal Committee of the
Environmental and Water Resources Institute of the
American Society of Civil Engineers



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Abstract: The treatment of water and wastewater results in the production of residual solids that must be handled. These solids typically are concentrated to reduce the water content before their beneficial use or disposal. As these solids are further processed and handled, their intrinsic properties—such as viscosity, rheology, flowability, and texture—change. Although much as been written to describe the chemical characteristics of these residuals, only limited information has been complied describing their handling characteristics and appropriate means of transport. The objective of this manual is to provide a reference document that the practitioner can use to determine the handling characteristics of residuals and to select appropriate conveyance systems.

The monograph has been organized into nine chapters. Chapter 1 provides an overview of the manual and describes a procedure for classifying residuals according to their transport properties. Chapter 2 describes the rheology, the types of water associated with the solids, and transport properties. Chapter 3 discusses the composition and characteristics of residuals as a function of how they are generated. Chapter 4 provides a comprehensive compilation of the types of equipment available for residuals transport, with photographs and illustrations. Chapters 5 through 8 provide guidance on the type of equipment that can be used for each of the major classifications of residuals: non-Newtonian slurries, thickened residuals, dewatered residuals, and granular and compactable residuals. Chapter 9 presents four case studies, highlighting lessons learned from actual operating installations.

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FOREWORD

In 1992, a brief article appeared in the Forum section of the *Journal of Environmental Engineering* that discussed problems related to the transport of dewatered sludge. The comments received on the article were transmitted to the Sludge Treatment, Reclamation, and Disposal Committee. When the committee reviewed them, it was obvious that practicing engineers did not understand the rheology of various treatment plant residuals and transport problems associated with sludge management. The committee members decided to create a state-of-the-art document that could be used by practicing engineers and academicians to ensure an understanding of the complexities in transporting water and wastewater residuals.

Residual management is one of the most critical aspects of wastewater and water treatment. From the first settling tank to final disposal, the process residuals may be transported by a variety of pumps, conveyors, and other material-handling devices. The residuals change in concentration and composition at various times throughout the sludge processing system. This changes the rheology and transport characteristics. If these changes are not recognized, problems can result in the transport of these materials.

This manual is intended to provide information to design and practicing engineers who ensure that the device used to transport the residuals is compatible with the changing characteristics. The manual is composed of nine chapters: Introduction; Rheology and the Distribution of Water in Sludge; Sludge Sources, Composition, and Characteristics; Overview of Residuals Conveyance Devices; Pumping of Non-Newtonian Sludges and Slurries; Transport of Thickened Residuals; Conveyance of Dewatered Residuals; Transport of Granular and Compactable Residuals; and Case Histories.

We hope that everyone who uses this manual will find the information contained in it useful and that we have ensured that engineers will understand the complexities of transport of various types of residuals.

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Chapter 1
INTRODUCTION

PURPOSE

The treatment of water and wastewater produces a significant quantity of residual suspended solids that must be further processed prior to use/disposal. Invariably, the processing stages involve the separation of liquids from the suspended solids and, in doing so, change the characteristics of the residual matter. Furthermore, processing can change a solids/water mixture (sludge/slurry) to cakes of high viscosity and, ultimately, to minimal moisture (dried) at the ultimate solids concentration.

The purpose of this monograph is not to present the means of achieving various levels of solids concentration; rather, it is to define operable and efficient means of conveying the residuals from one point to another in the solids processing system. Another objective is to classify the solids with varying states of moisture content in a manner such that the appropriate equipment can be selected to transport the residuals for additional processing/disposal.

Whereas there is a need to classify the sludge/slurry and solids and define the range of solids concentration, there always will be areas where the classification overlaps. This transitional area is of most concern, and the user must be aware of potential problems when operating in the transitional areas because of significant changes in transport characteristics. Site-specific factors may prevent the level of solids from reaching the next higher classification, where a significant change in product handling characteristics occurs. Furthermore, the material classification may vary from one classification to another at a specific site because the waste materials are processed by different kinds of equipment.

To assist in understanding the complex handling characteristics of many wastewater residuals, a discussion of bound water has been included. The bound water fraction has a significant impact on the physi-

cal characteristics of water and wastewater residuals. The variable quantity of bound water in biological and metal hydroxide sludges often has been the cause of dewatering and solids transport problems. Review of this section is critical to the understanding and use of subsequent portions of this publication.

SCOPE

The residuals addressed in this publication are those derived from the treatment of municipal water and wastewater. Both suspended matter and biological residues, which are very similar to those derived from municipal wastewater, are produced in industrial wastewater treatment. However, solids recovered from primary treatment of industrial wastewater will reflect the constituents used in the industrial facility. The user must determine whether these solids are similar to the residues described herein.

The residuals are classified into levels of concentrations that reflect the points where there are definable changes in the physical properties of the material. The range of solids concentration discussed is from thickened residuals in a solids/liquid mixture to a point where the residuals will emit dust when handled or transported, and the dust could represent a hazardous condition.

The residual concentrations discussed represent the products of concentrating, dewatering, and drying equipment in common practice. These residuals are sorted into five classifications:

Residual	*Classification*
Thickened sludge	A
Thixotropic cake, low range	B_1
Thixotropic cake, high range	B_2
Granular, moist	C_1
Granular, dusty	C_2

The specific equipment that produces the residuals to be conveyed will not be discussed in this manual, except to define any operating factors that could affect the transport characteristics.

This publication provides three levels of recommendations:

1. not recommended
2. recommended for consideration
3. recommended

Wherever possible, the factors that could affect the selection of equipment with a conditional recommendation (consideration) will be explained.

Site-specific factors and detailed knowledge of the residuals will dictate the final selection.

In some cases, transport studies and pilot tests may be deemed advisable. It is not the intent of this publication to supplant the considered need for testing the transport equipment using the anticipated or actual residual material.

This manual does not address the conveyance of unthickened residues. Although a precise definition is lacking, unthickened residuals are characterized by suspended solids in a liquid composition, relatively low viscosity, free flowing, and pumpable using conventional centrifugal pumps. Thickened residues are characterized by a significantly increased viscosity, no free water with a period of long standing, appearance of a solids/liquid mass, and not reliably pumped using centrifugal pumps. Depending on the residue, this dividing line could be 3–7% total solids (TS) for waste-activated sludge (WAS) and metal hydroxides, 5–10% TS for raw primary sludges (PSs), and 15–30% TS for lime sludges, ash, and grit.

There are many references for guidance on the pumping of unthickened residues. The reader is referred to Wilkinson (1960), ASCE (1977, 1992), and Sanks et al. (1989) for additional information about conveyance of unthickened residues.

CONTENTS OF THE MANUAL

This monograph consists of nine chapters directed to the transport of solids at varying levels of moisture. The chapters are as follows:

Chapter 1. Introduction: The section provides the objectives and content, general introduction to the sludge/slurry/solids classification, methodology, and ranking/evaluation procedures.

Chapter 2. Rheology and the Distribution of Water in Sludge: Many of the problems of sludge transport are associated with the viscosity and plasticity of thixotropic and pseudo-plastic materials. This chapter is important to understanding the problems of handling these kinds of sludges. The bound water content of the metal and biological sludges is often the cause of conveyance problems as well as adherence to transported equipment.

Chapter 3. Sludge Sources, Composition, and Characteristics: This is an introduction to physical and chemical attributes of the solids to be processed. It further discusses how these characteristics affect different moisture levels and how other factors (such as temperature) may affect the handling characteristics.

Chapter 4. Overview of Residuals Conveyance Devices: This section provides an introduction to and basic description of the sludge/slurry/solids transport devices generally considered to transport residuals with different moisture contents.