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USE OF POLYMERS IN HIGH SPEED DEWATERING OF FINE GRAINED SEDIMENTS TO REPLACE CONFINED DISPOSAL FACILITIES - A CASE STUDY

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ABSTRACT

Hydraulically dredging waterways with a high percentage of fine grained sediments generally involve additional considerations and costs. These are often the same waterways that need to be dredged for environmental restoration or recreational navigation and are located in some of the most environmentally regulated areas. Land prices and population densities have made the use of traditional "confined disposal facilities" too expensive or impractical.

The use of polymers to remove fined grained sediments from water has been growing. Polymers are a class of chemicals that cause very small slow settling particles to clump together into much larger, fast settling agglomerates. This can reduce the land area and time needed to meet effluent discharge standards. To be effective, the chemistry and dosage of a polymer must be matched to the site specific requirements of the sediment.

In a recent marine harbor dredging project, polymers were used with a patented high speed sediment dewatering system to address fine grained sediments. Dredge effluent water was returned to the environment by allowing clarified water to fall away from agglomerated sediment. Turbidity readings of the effluent water measured generally less than 75 NTU. Because of environmental concerns, toxicity testing was conducted on the effluent water to access potential impacts to fish and benthic communities, and the dredging process was allowed to proceed.

Belt presses further dewatered the captured sediment so it could be immediately trucked away without the use of a confined disposal facility or dewatering lagoon. The entire dewatering and belt press operations was set up in a portion of a harbor parking lot.

Keywords: Polymers, sediment dewatering, fined grained sediments, dredging silts and clays, rapid dewatering.

INTRODUCTION

When evaluating dredging opportunities, fine grained sediment deposits have special considerations. Because of their chemical and physical make up, fine grained sediments consisting of silts and clay size particles have a number of special concerns, when compared to sands and gravels.

1. They are easy to re-suspend due to their small size and weight, even after deposition, causing continuing water clarity and water quality concerns.
2. Fined grained sediments carry an electrical charge of which the magnitude is directly related to the particle surface area (Lambe 1969). Many pollutants attach to fine grained sediment particles.
3. As part of their natural sediment transport processes, many tributary streams and rivers continue to deliver and deposit fine grained sediment particles to ports, marinas and lakes
4. When dredging, they are very time consuming and space intensive to dewater.
5. The ability to find beneficial reuse options for fine grained sediments is often more problematic for many if not all of the above reasons.

A continuing emphasis on water quality concerns and contaminated sediments, in addition to the waterfront commercial, recreational and residential development markets, has created a significant market in fine grained sedi-

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ment dredging in areas subject to fine grained sediment deposition. However, the areas in which fine grained sediment needs to be removed are often commercial or residential areas with little room for the large dewatering lagoons or confined disposal facilities required for removing the smaller than sand size particles. Water quality regulations which differ from state to state and sometimes within a state, may require that the dredge return water meet total suspended solids requirements which may be well below what was originally envisioned as design limits for lagoons. Therefore, alternatives to traditional dewatering lagoons or confined disposal facilities have been developed to facilitate dredging of these locations. Many of these alternatives include the use of polymers to help more quickly settle fine grained particles.

USING POLYMERS

Polymers, which are defined as "… numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule" (NASA 2008) have been used for many years in the water treatment industry to help remove fine grained particles. By causing smaller particles to clump together, polymers can reduce the settling time of fine grained particles in water. The resulting clumped sediment particles created through the flocculation or aggregation process resemble cottage cheese and are referred to as floccules. The addition of polymers to fine grained sediment in water can help meet the often very low total suspended solids (TSS) requirements for dredge return water. Because most other pollutants of concern are attached to fined grained sediments, removing the fined grained sediments will often remove many of the other pollutants that may also be regulated and monitored in a dredge carriage water discharge permit.

Processes that are most effective for fine grained sediment removal generally rely on physical processes that first remove debris and sand and gravels from the dredge flows. Polymer is then added to the remaining fine grained slurry. The flocculated sediment is then allowed to settle in clarifiers or other settling devices including geotextile fabric tubes. Fine grained particles that may naturally take days to settle, will settle within minutes or hours after the addition of polymer depending on the depth of the settling basin or sediment collection process. Depending on the proposed deposition or use of the dewatered sediment or area limitations, the sediment may be furthered dewatered with mechanical processes, including belt presses or plate presses.

The use of polymers in dredging requires that a number of different issues be considered.

1. The polymer must be matched to the specific sediment that is being removed. If the sediment changes significantly from one location to another in a water body, the polymer or polymers used may need to change.
2. Often more than one polymer will be used to maximize the polymer effectiveness and the durability of the resulting floccules.
3. The amount of polymer required to cause the sediment to clump together is very specific to the sediment concentration. Too much or too little polymer can result in poor water quality results. Therefore, the polymer dosage process must take into account and react to the constantly changing fine grained sediment concentration of the dredge flow.
4. The resulting floccules may be physically broken down if excessively agitated.
5. The quantity of polymer used in dredging is generally significantly greater than the quantity used in traditional municipal wastewater treatment; therefore the impact on aquatic life of any polymer remaining in the discharge or return water must be considered.
6. Polymers can be cationic, having a positive ionic charge, or anionic, having a negative charge. The use of some polymers, especially cationic polymers, may raise special concern for aquatic species.
7. Some fine grained sediment particles are so light that even when flocculated, they tend to stay in suspension.
8. The use of polymers in saltwater applications may result in additional challenges, due to water chemistry.

USE OF POLYMERS IN A RAPID DEWATERING SYSTEM

Areas that often need fine grained sediment dredging are often in developed or industrial areas where land values are at a premium. The land required for construction of a traditional, multiple acre, confined disposal lagoon is generally not available. Often, the land available for the entire sediment removal operation, including temporary stockpiling of dewatered sediments and truck loading, may be limited to a water front park or parking lot.

To meet the need for handling sediments in such a small foot print, Genesis Fluid Solutions developed a rapid dewatering system. Figure 1 is a photo of the rapid dewatering system. After removing the coarse materials and sands from the dredge flow, the system uses polymers to flocculate the remaining fine grained sediment. The dredge carriage water is almost instantaneously removed from the sediment by passing the flocculated dredge slurry over a screen system. The resulting flocculated sediment captured on the angled screen is then moved to a system that allows it to either be used as is or be further dewatered by physical means for immediate removal or daily removal by truck. The dredge carriage water is collected from the process and sent to a small traditional clarifier to capture any remaining small broken floccules that pass through the screen dewatering system before being discharged to the receiving waterway

Figure 1. Rapid Dewatering System Developed by Genesis Fluid Solutions

SANTA CRUZ HARBOR – A CASE STUDY

In August of 2007, Genesis Fluid Solutions was chosen by Santa Cruz Port District in Santa Cruz, California, in the United States, to provide sediment dewatering for a 19115 cm (25,000 cy) harbor dredging project. The Santa Cruz Port District, which operates the harbor, had its own 202 millimeter (8 inch) dredge and dredge crew. Because of endangered species issues, the dredging window was very limited.

The space available for the dewatering operation was approximately half of an acre, which consisted of two rows of parking with a through lane at the end of the harbor and a narrow strip of land between the harbor and the public road. Pedestrian, bike and car traffic was routed around and immediately adjacent to the dewatering operations. The very visible and narrow work area meant the public was generally within 7.6 meters (25 feet) of the dewatering operation requiring strict attention to the cleanliness of the operation and intolerance for any inadvertent material sprays or spills off site. The site layout plan is shown as Figure 3.

Figure 2. Rapid dewatering facility at Santa Cruz Harbor

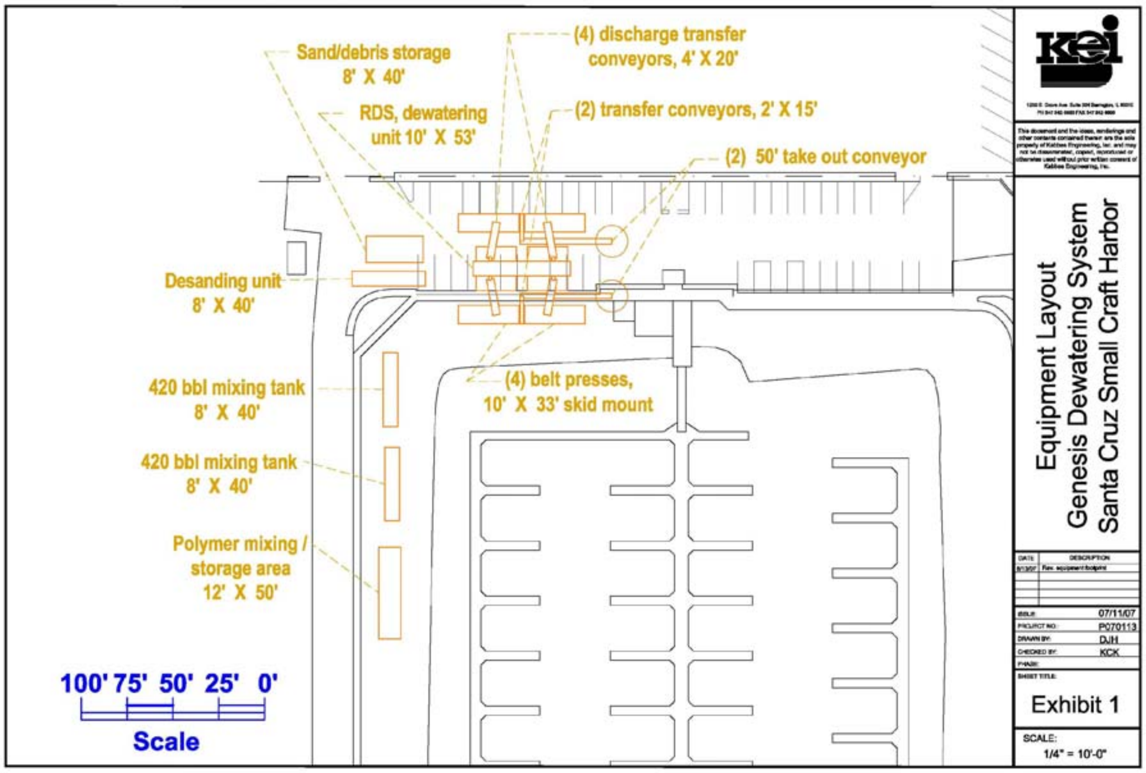

Figure 3. Equipment Layout at Santa Cruz Harbor

During sediment testing, a combination of anionic and cationic polymers for a total of three polymers were chosen for use, to achieve the best flocculation and create durable floccules. The polymers were delivered to the dredge slurry using a polymer pump control system created by NALCO, the polymer supplier. The NALCO control module continuously calculated the polymer demand and varied the polymer dosage based on the changing fined grained sediment slurry concentrations supplied by the dredge. Figure 2 shows the dewatering equipment facility at Santa Cruz Harbor dewatering facility during operation.

Toxicity Testing

Prior to beginning full scale dredging, toxicity tests were conducted on the expected return water after sediment dewatering through the application of the proposed polymers. The effluent water needed to meet acute and chronic toxicity requirements of the California Environmental Protection Agency regional water board. A 145 page report was prepared by an outside independent laboratory outlining the results of the testing (Kinnetic Laboratories, Inc, 2007). The toxicity testing was conducted on water that would be expected to be released as effluent water from the dredging operation, with and without the addition of polymer to access the impact of the polymer. This water was referred to in the testing as process water. Table 1 depicts a summary of the results of the toxicity tests on the discharge water from the sediment treated with and without the sodium based polymer. The results provide the concentration of total ammonia, NH_3, tested in the water. It also provides the NOEC or “No Observed Effect Concentration”, the TU or calculated Toxicity Units, and the EC50 and EC25. The bivalve mussel larvae, known as Bay Mussel or Mytilus (edulis) galloprovincialis, were used to access chronic toxicity. To access acute toxicity, the fish, Inland Silversides (*Menidia beryllina*) was used.

The results showed no significant decreases in survival or normal development in any process water concentration for chronic toxicity. There was no significant fish mortality in any test concentration of process water for acute toxicity. There was a single fish mortality (5% mortality rate) in an undiluted sample of the process water with polymer; however, there was a higher mortality rate (10% mortality rate) in the undiluted process water that was not

Table 1. Summary of Toxicity Testing Results

Lab ID	Process Sample T10001-01 w/ Polymer Result	TU	Process Sample T10001-02 w/o Polymer Result	TU
T-NH3 (Mg/l)				
Process Water Sample	0.3	-	3.8	-
Site Water	0.18	-	0.18	-
Bivalve Development				
NOEC	>100.0	1.0	100.0	1.0
EC50	>100.0	na	na	na
EC25	>100.0	<1.0	na	na
Bivalve Survival				
NOEC	100.0	1.0	100.0	1.0
EC50	>100.0	na	na	na
EC25	>100.0	<1.0	na	na
Fish Survival				
NOEC	>100.0	1.0	>100.0	1.0
EC50	>100.0	na	>100.0	na
EC25	>100.0	<1.0	>100.0	<1.0

na = Not Applicable

treated with polymer. By formulating a sodium based polymer as compared to an ammonium based polymer, NALCO was instrumental in finding a polymer formulation that met the regulatory needs. A document describing how the polymers were to be used and the measures employed to safeguard against accidental upsets in the system was prepared by Kabbes Engineering and approved by the regulating authorities before proceeding. A series of toxicity tests at various times during the project operations were conducted to assure the standards were meet.

Additional Mechanical Dewatering

Prior dredging operations conducted by the Port District had experienced problems trucking and disposing of fine grained sediments when the sediment was too wet. Therefore, the Port District required that the sediment leave the site in a condition that met or exceeded 50% solids. The flocculated sediment discharged from the Rapid Dewatering System averaged 25% solids. The tight working space did not allow for even a temporary partial-day storage area for additional gravity bed dewatering of the flocculated sediments. Therefore, belt presses were used to achieve the 50% minimum solids content.

The belt presses proved problematic to the operation for several reasons. The rental belt presses delivered to the job site were not the belt presses ordered, but because of the client's need to start immediately due to an endangered species deadline for dredging the delivered belt presses were used. Secondly, the belt presses provided additional waste water with broken floccules to be treated before discharge. While the effluent from the rapid dewatering system easily met and exceeded the required 75 NTU effluent limit, the water from the belt presses needed additional treatment though the system to meet the 75 NTU standard. Lastly, the belt presses were operated by the belt press owner who showed a significant reluctance to operate the belt presses at an acceptable speed. As a result, the belt presses dictated the production of the entire job site. Limited space did not allow additional belt presses to be added. Towards the end of the job, the operator did increase belt speed to some extent and production rates increased directly as a function of the belt press speed.

Production rates by the end of the project reached 382 cm per day (500 cy per day) of truckable sediment with a solids content of 50% or greater, using the Port District operated small 202 mm (8 inch) dredge. To increase productivity in future projects requiring drier sediments, Genesis prefers to use small temporary dewatering beds. The small temporary beds take advantage of the greatly enhanced free water drainage capacity of flocculated sediment to create drier material in less than 24 hours. Genesis has successfully used small dewatering bed technology underlined with a pumped underdrain system to achieve additional dewatering of the flocculated sediment.

CONCLUSIONS

Fined grained sediment removal will continue to be an important part of dredging as we continue to deal with water quality and polluted sediment issues. The attraction of clean water for both recreational needs and residential development will also continue to require dredging of fine grained sediments, especially in non-coastal areas. The areas demanding dredging are usually the very same areas that have no land to construct traditional sediment dewatering lagoons, except for an occasional park or parking lot. Polymers offer one of the few methods to quickly dewater fine grained sediments in areas with limited spaces. The rapid dewatering systems, such as the one used by Genesis Fluid Solutions in Santa Cruz, can offer a very fast and effective method to use polymers to dewater dredge slurries and provide truckable sediments in a very space-limited location.

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