A SunCam online continuing education course

An Introduction to Pond and Lake Dredging

by

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Introduction

This course is designed to be an introduction into the planning, assessment, design and execution of dredge projects in inland waterways of Ponds and Lakes (coastal waterbodies that are tidally influenced will need to be approached differently). These bodies of water are an incredible resource in our country, they are sources of our drinking water, they provide flood storage and recreational opportunities, and are an integral part of our landscape.

There are numerous influences that affect the quality of our Ponds and Lakes, from development within the watershed, changes in environment and water levels (floods and droughts), and aging infrastructure (both on the inputs and the outlet/ control structures). All of these influences may result in diminished water quality, invasive aquatic species, and sedimentation and infill of the waterbody. Dredging is an effective approach to counteract these negative effects on the waterbodies and that's what we will discuss in this course. It is important to note that dredging may help reduce the negative impacts of the past, but it should also be paired with compatible projects to reduce those impacts from the future, including stormwater management treatment strategies, invasive species monitoring, and other strategies, which will not be covered in this course.

Desired Outcomes

Most Pond and Lake restoration and dredging projects come from a desire to restore the waterbody to a previous state. Most project goals for these types of projects end up with a combination of some of the following desired outcomes:

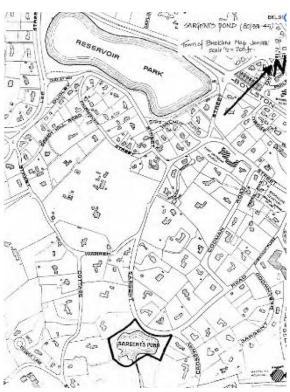
- Improved Water Quality
- Improved Water Circulation
- Increased Water Depths

- Better control of Aquatic Invasive Species
- Diminish/reduce erosion in the watershed
- Improved fish habitat
- Bank Stabilization
- Better access for recreational activities

Whichever combination of desired outcomes is applicable for your project will determine your approach on investigations and the design as the project moves into further stages.

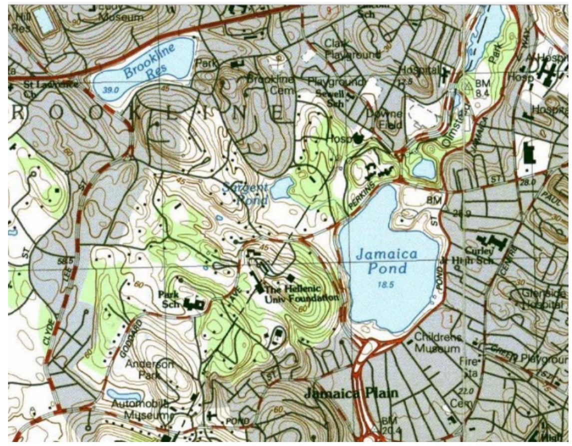
Initial Assessments

In order for a project to become viable and the construction estimates and methodologies refined, engineering studies and design efforts will be needed. A lot of this work can be performed concurrently and much of the initial assessments can be done from your desktop.



The first step, as with any project, is to see what information on the site is readily available. Your client or the local municipality may have copies of plans, reports, studies, and permits for work previously done on a Site. This information is infinitely valuable to give a historical perspective on what has been done at the Site, what are the issues they have attempted to address and what were the strategies. Historical documentation review is very important because it can provide plenty of background on a Site and keep you from repeating work that has already been completed, particularly if they were strategies that didn't work or meet the desired goals.

Following the review of the historical documentation, checking publicly available information is another great planning tool. GIS programs and databases can provide a wealth of data and information on a project Site that can help to mold the path forward for the project. Some valuable information you may be able to gain from GIS analysis can include:

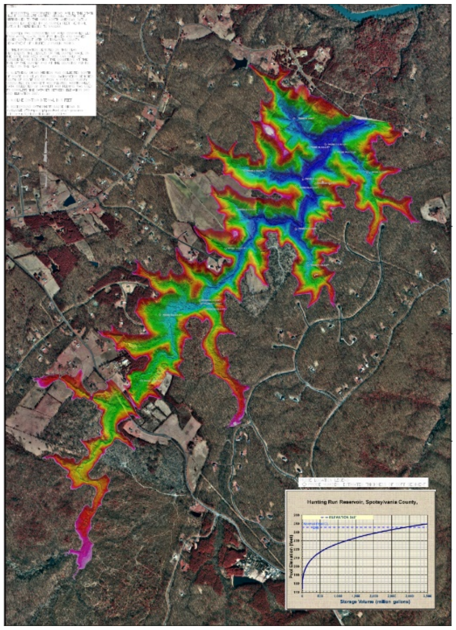


- Property lines and parcel sizes
- Land use within the surrounding watershed
- Presence of Endangered Species and/or Habitat
- Wetlands and natural resources in the area
- Dams and Impoundments
- Drinking water supplies
- Surrounding topography

Once the desktop study is completed, then you'll need to move into the more detailed engineering study and design phase.

Topographic and Hydrographic Surveys

Before any study and design can really move forward, an accurate existing conditions plan set is needed. This would include a current bathymetry set, local topography, particularly along the areas of access to the water that the equipment will use, and a delineation of wetland areas and resources along the banks of the waterbody. You'll also need the surveyor to identify right-of-way (ROW) issues and property lines that may affect the design and implementation. Therefore, a typical land survey is usually conducted for all landward areas that may be used to implement the design.



To get an accurate bathymetric existing condition plan, there are several types of hydrographic survey tools that can be used. The first, and by far the least accurate, is a lead line survey. These surveys occur if you have a normal or fixed pool elevation, where you can use a graduated line with a heavy weight on the end and record water depths that way. This was an early form of hydrographic survey, but really shouldn't be used anymore, unless you are looking for relative project goals rather fixed project goals (i.e. more depth versus an additional four feet of depth).

The other bathymetric survey techniques will depend on the site, access, and water depths. In locations with shallow water depths, where the pond or lake is seasonally drawn down, or where a steady platform is available, the traditional land survey can be extended over water and can provide accurate soundings.

Another survey technique for shallow water areas or places with limited access for boat launching is to conduct a single beam survey. A single beam precision acoustic fathometer which has a 3-degree range is typically accurate to approximately one-tenth of a foot. The fathometer samples many times per second, translating to a data point sample every 1-2 foot along the vessel's track. A GPS (either DGPS or RTK) unit will provide accurate lateral (X, Y) positions. The hydrographic data is typically collected with lines running along the long axis of the water body, and occasional cross-tie lines to ensure data accuracy. The exact spacing of the hydrographic data collection lines may vary in the field due to field conditions and/or the data needs as determined by the field crew. Single beam surveys provide an accurate depiction of bottom conditions, however because they don't provide complete bottom coverage, there is the risk of variations in topography or obstructions that could exist between the survey lines.

The most accurate survey technique, but which requires a deeper water pool and solid vessel access is a multibeam survey. The multibeam transducer typically has a 45-60-degree range, with the data collected up to 45 degrees in most depths being the most reliable. The data is usually collected at sufficient density to provide 200% bottom coverage in water depths greater than 10 feet and up to 150% bottom coverage in minimum water depths of 4 feet. The survey crews typically space their lines to ensure sufficient overlap so the survey data is the most accurate available and "flyers" or bad points are worked out in the processing of the data, something that isn't always an option in single beam data.

Depending on the type of waterbody and the associated concerns and risks, there are other geophysical tools that may need to be deployed, such as side scan sonar, sub bottom profiling and magnetometry. These geophysical tools can be used to identify archaeological resources, obstructions, changes in strata, and other items that could affect the execution of the dredging that typically would not be picked up in a bathymetric survey.

Whichever survey method is chosen, you as the designer need to be comfortable with the level of accuracy and density of coverage provided so you can begin to create your design.

Sediment Sampling for Physical and Chemical Characteristics

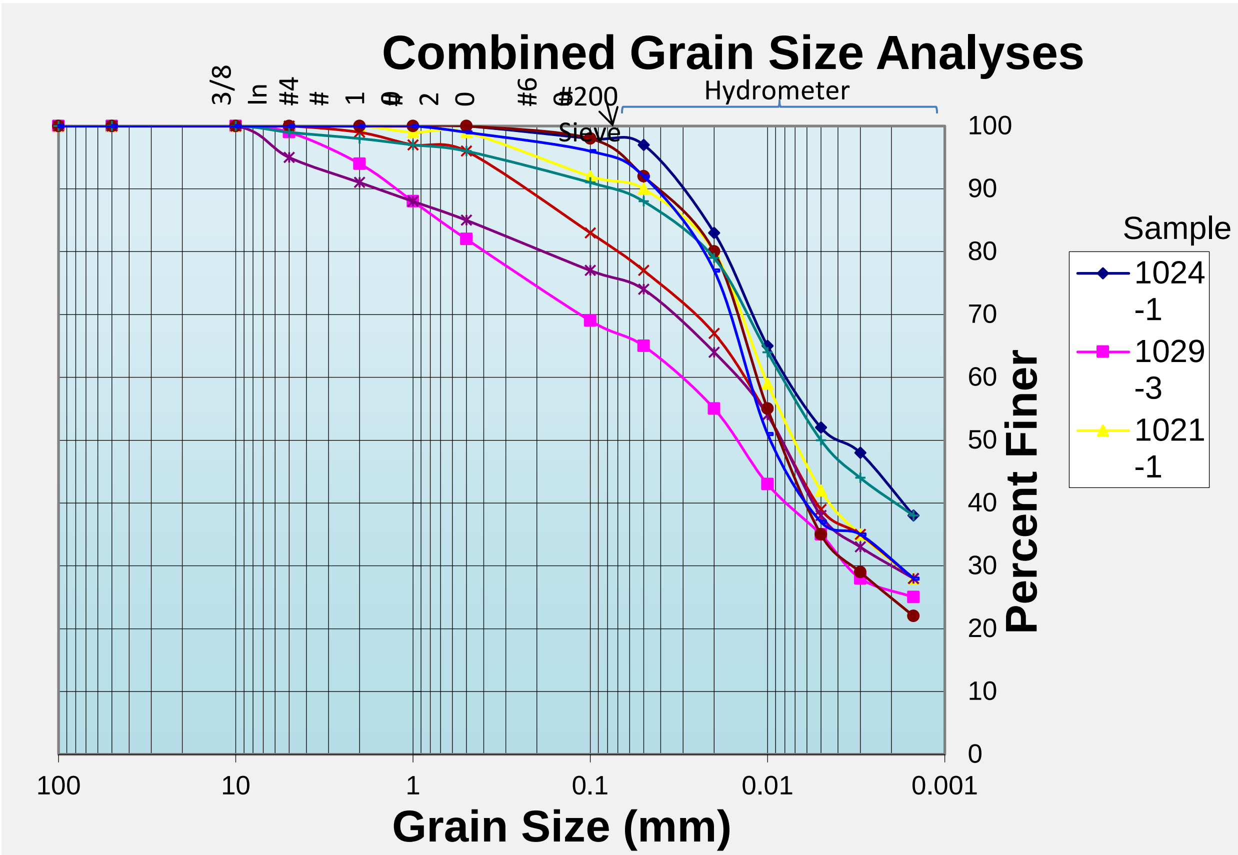
The next step in the design process is to conduct a sampling program in order to gain a better understanding of its physical and chemical characteristics. If there is any historical data, that can be very valuable to study, but you'll still want to conduct your own sampling program.

The goal of the sampling program is to determine how the material can be removed and what can be done with it once it has been removed. The physical data will tell you grain size, organic and water content, and identify the different strata and layers. The chemical characteristics will tell you if there is a potential for re-use of the sediments and if not, identify potential disposal options for the sediment.

There are several options available for sampling sediment and its most often dictated by the types of sediment and access to the waterbody available. A russian peat corer is a great tool for sampling soft, mucky organic sediments. A ponar or clamshell sediment sampler is an effective tool for sampling surficial sediments but won't provide accurate depth data. Vibracores generate a good profile of the sediments, but typically require vessel access and can be more expensive than the other sampling methodologies.

Russian Peat Core Sample

The sampling program will need to be designed to provide sufficient density, both laterally and horizontally to accurately portray the changes in characteristics of the sediments and to meet the sampling requirements of the permitting authorities. Typically, one sample per 500 cy or 1000 cy of material to be dredged is sufficient, but its always best to check with the governing regulatory agency prior to executing a program to ensure that the density and laboratory parameters will meet their requirements for the permitting process.



Input and Outputs

Another input factor you'll need to understand for the design and most importantly to implement the design, is the volume of water inputs coming into the waterbody and those going out of the waterbody. This is typically done in a multi-stage process. Usually when doing your GIS work at the beginning of the project you'll gain an understanding of the tributary drainage area of the watershed for your waterbody. With that information, you'll also want to investigate the point-source inputs coming into the waterbody, this will include any streams and stormwater outfalls, and those leaving the pond, be it through a dam, weir, spillway or other outlet structure. Quantifying flow from the stormwater outfalls is much more straightforward, since they are a normal shape and using Manning's Formula, you can determine the pipe flow capacity and how it will hold up during particular storm events. That is very similar with weirs and spillways, as they are typically a fixed shape with known dimensions and therefore can be modeled to better understand the flows. Quantifying flow from streams is more complicated. You'll need a good survey of the streambed bottom so you can have some accurate cross-sections. Then at a few representative cross-section locations, you'll need to collect streamflow data. The USGS has the industry standard for the most accurate way to do this, and a good overview of it can be found in this presentation: https://acwi.gov/monitoring/conference/2016/2_wednesday_may4/E9F9/Hydrology_secure.pdf

That being said, highly accurate streamflow measurements can be a timely and costly process and not all projects and budgets can afford that, nor do they necessarily need it. Some streams dry up seasonally, which may be the optimal time to dredge if that's the case, or they get channelized upstream and that is easier to calculate flow. Each case and each project is different, but as long as you can come up with reliable understanding of the volume water in the system so that you can plan accordingly for the design and the implementation.

Additional Design Considerations

Once you have a more complete understanding of the issues your project faces and how you want to approach the design, there are a couple of other factors you'll want to add into the design process:

- Engineering the details related to the dewatering of sediments for achieving water quality requirements. If the sediment is going to be disposed of at an off-site facility, it can't be loaded directly into the trucks, so the dewatering details will need to be worked out. One approach may be passive dewatering, where if there is enough space and time, the sediments are stockpiled and allowed to dewater, a process that can be accelerated by turning the stockpile from time to time. A more active dewatering strategy would be to amend the sediments with sand or lime to reduce the moisture content of the sediment more quickly. If the project is being hydraulically dredged, then the dewatering strategy for the dredge slurry becomes more integral to the overall project approach. All of the dewatering options may include identifying the optimal management approach for collecting, treating, and delivering the water back to the source. There are often water quality limitations and putting back highly turbid water directly to the source

or downstream will often exceed those limitations, so there will likely needed to some management of the return water. Options may include passing the water through a frac tank, geotube or some other bladder type product, or it may be as simple as discharging to fabric and stone lined detention basin surrounding by silt fence. Turbidity curtains are another option common used during wet work operations.

- The review and analysis of potential quality of life issues associated with the Project including traffic impacts, noise impacts, air quality impacts, odors, and visual aesthetics, and developing appropriate control measures. If your project takes place in a residential setting, you'll want to have strict controls on work hours, where the trucks can and can't pass, and plans for odor controls as high organic content sediment that is passively dewatering does have a displeasing odor. Even when its not in a residential area, truck and vehicle access is always an important factor. Planning how trucks and heavy equipment can get into and out of the waterbody safely and efficiently will save on the implementation costs and can get you thinking ahead about potential issues with neighboring businesses or other operations and traffic in the area.

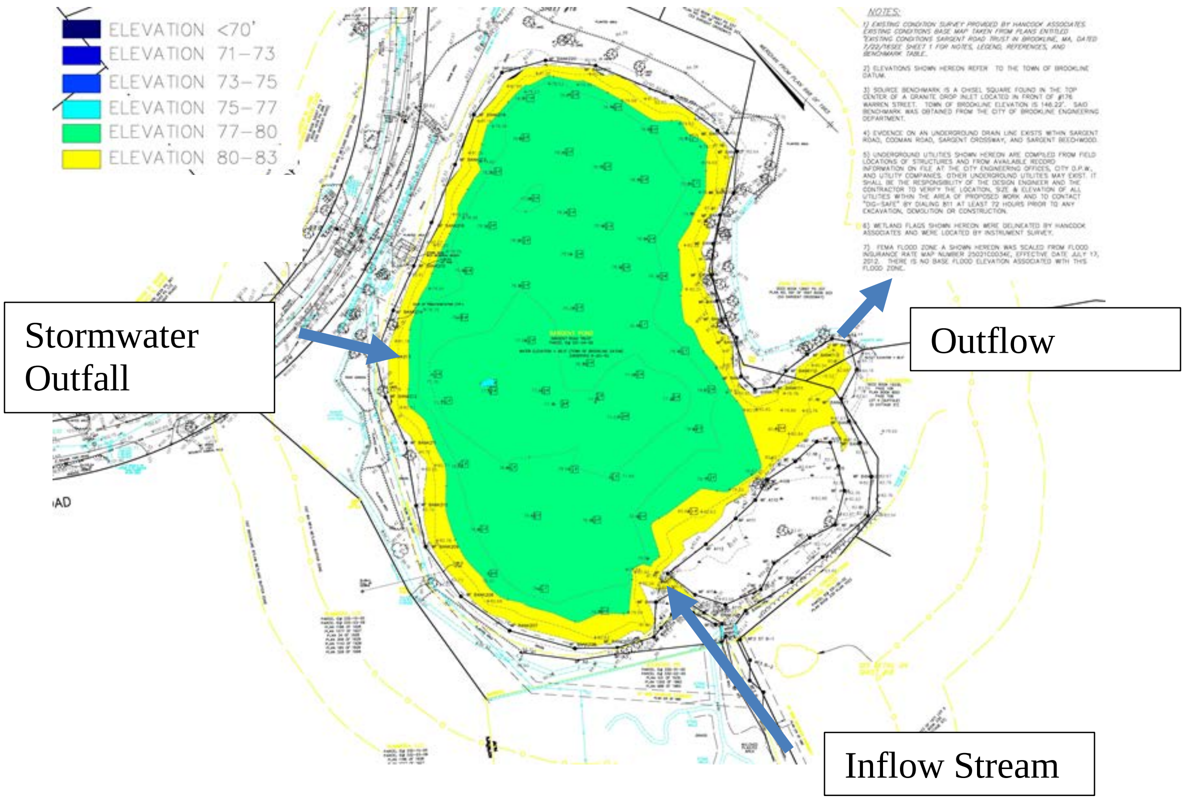
Creating the Design

By this stage, you should have everything you need to move forward with putting together your design and design plans. You should have defined your project goal or goals at the very beginning of this process, so now is the time to take all of the information gathered and start tailoring your design to meet those project goals.

Let's say for example, that you have a pond that has been slowly filling in and has lost a lot of its depth and therefore has poor water quality and poor water circulation. It is fed by an inflow stream and one 16" stormwater outfall from the roadway. The pond initially was bowl shaped with a clay liner at the base that you do not want to disturb. The sediment samples you took throughout the pond show highly organic silts in the top 2 feet, and silty sands below

that down to the clay liner. The chemical analytical results show that the sediment is incompatible for any beneficial re-use and will have to be transported off-site for disposal at a licensed facility.

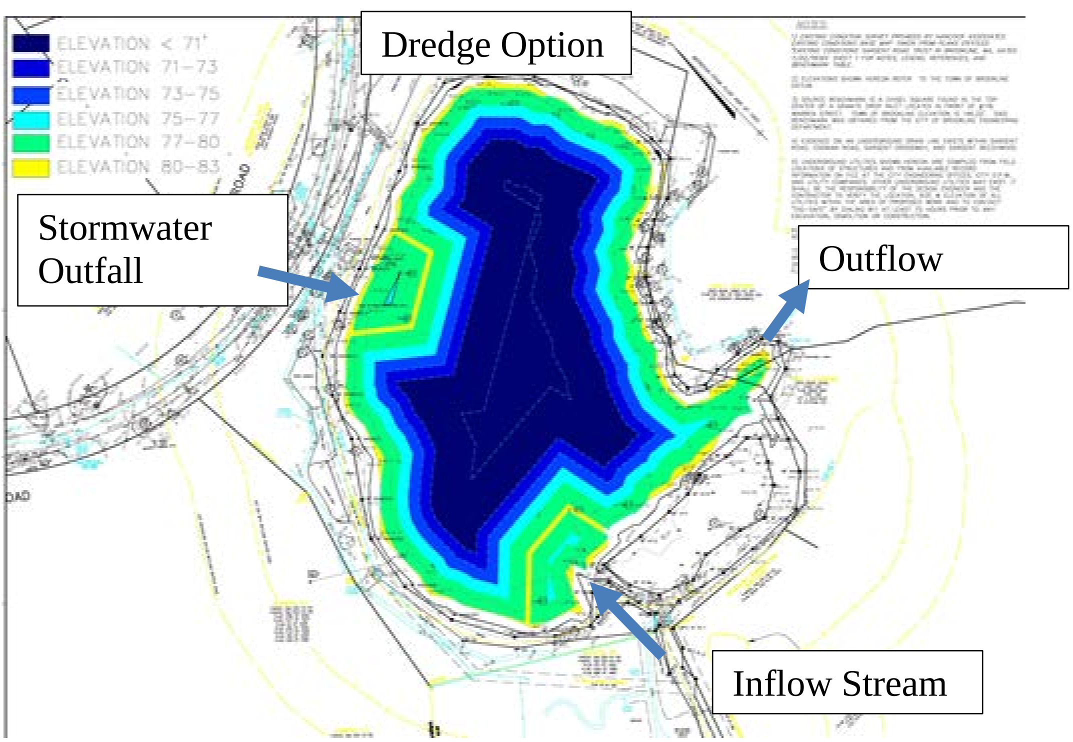
Here is your existing conditions plan, color-coded to show depths, with a normal pool elevation of 82.5. As you can see there is nowhere in the pond that has more than 5 feet of depth.



So now you can begin to layout your dredge design. Its's always best to look at a couple of options.

Option 1 will be dredging to match the bowl shape of the pond liner and do the best effort to restore as much of the original depth as possible. The first thing to do would be to review the physical characteristics of the sediments to see at what slope they would stand up to and use that slope as the base of your design. As stated earlier, the top 2 feet were pretty much muck, so all of that will need to come out, but then there are silty sands with a relatively high water content, as much as 40% in one sample. We typically use a slope stability software to model a dredge footprint and see what a stable slope would be. In general, clay soils stand up at the highest angle, 2H(horizontal):1V(vertical) or even 1.5H:1V, and glacial tills that have mixture of silts and sand stand up at 3H:1V, and very sandy or loose soils need as much as 5H:1V or 10H:1V. Because our soils have such a high water content, they will be very difficult for the dredge to shape the profile, therefore we should plan on a 5H:1V or 10H:1V slope.

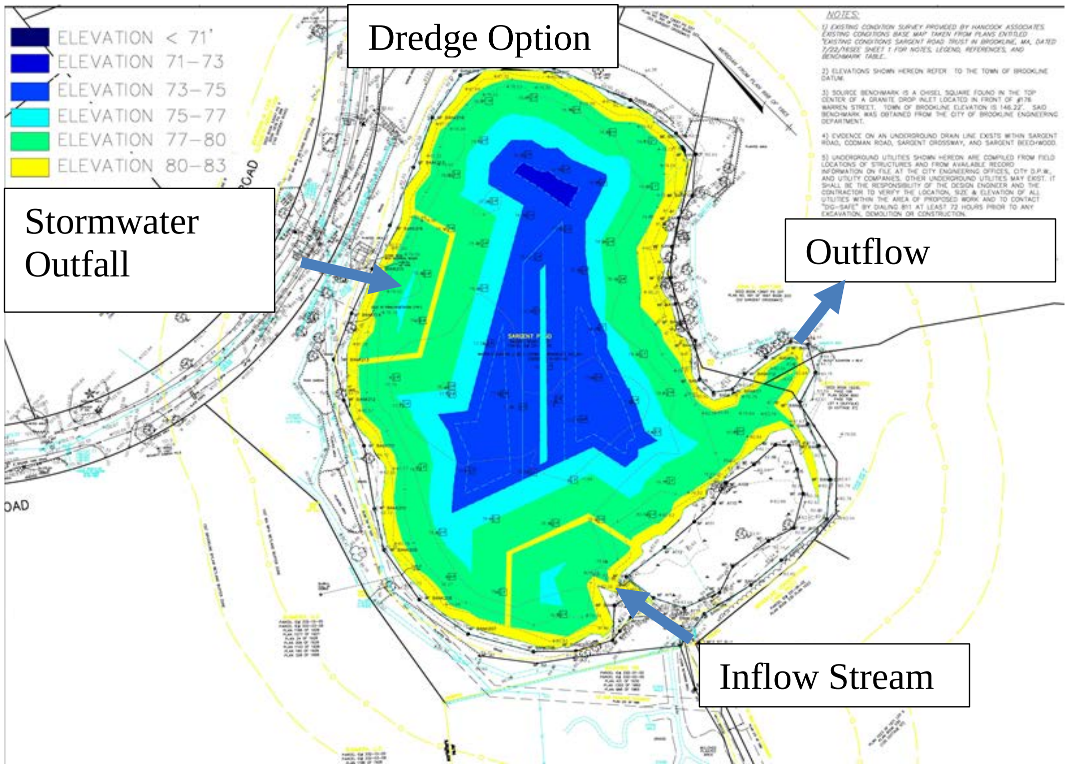
The simplest way to layout out these options in AutoCAD is to create a surface with your existing conditions contours. Then choose your controlling contour where you want your dredge to begin, for our case, let's use elevation 82. On your proposed conditions layer, create an 82 contour that mimics the existing 82 to contour (that will represent the upper bound of your dredge). Then from there, project down your contours at your desired slope until you either reach the depth of the clay liner or your projections can't go any further and you've reached your theoretical bottom. Then you can create a new surface with these proposed conditions contours and subtract the two surfaces to determine your dredge volume.



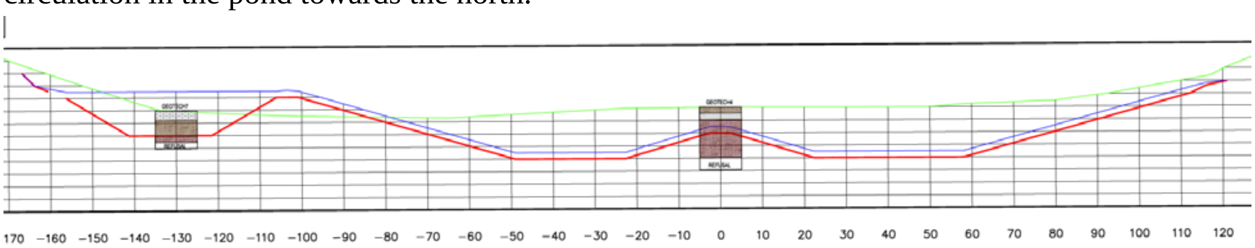
Option 1 significantly increases your depth in the center of the pond, getting 9-10 feet of water depth in the center. This option will likely involve removing the largest volume of sediment. This option doesn't do much to increase the flow and circulation in the pond however, and that was one of the goals of the project, so that's when you can look at another option.

Option 2 would be a more contoured approach to the dredge. Since your inflow and outflow are so close to each other, there is a lot of short circuiting that occurs, and the northern edge of the pond doesn't see much flow and has more stagnant water. For this option, we'll want to try to encourage flow up to the north. You'll see in both options we have set up, that there are plunge pools or sedimentation basins designed around the inflow sources. These are intended to collect sediment brought in by those inflows in a more manageable way. Rather than allowing the sediment to carry through into the pond, particularly in the center where it is deepest but also least accessible, we can put in these plunge pools to allow the sediments to settle out in an area that is more easily accessible and easier to manage in terms of operations and maintenance. From those plunge pools, we can set a berm elevation on the backside that will allow some detention time for settling the solids and will also a controlled overflow elevation from where the water will discharge into the main body of the waterbody.

With that in mind, it would be good to shape the bottom of the pond to encourage flow to the north. This may not be as effective as routing a surface stream, but this is still flow and movement of water at the different depths of the waterbody and paired with the plunge pool berms, the contours can be set to push more flow to the parts of the waterbody that don't receive it. For option 2 we have created a ridge or berm in the center and made the deepest pocket in the north. These two design elements should help push flow in from the stormwater outfall up to the north, allow for more flow and more oxygen in the water.



Option 2 still increases your depth in the center of the pond, getting 9 ft water depth in the north and 7-8 feet towards the middle of the pond, excluding the ridge. This option involves removing less volume of sediment than option 1. This option does however help to increase the flow and circulation in the pond towards the north.



Cross-Section View with Sediment Samples overlain

For this project, we designed 5 options, all a variation on the two main options presented here. Some of the other options including change slopes from 10H:1V to 5H:1V and changing depths. We presented the 5 options, and option 2 was the one that was chosen by the client because it provided increased depth and better flow, which would improve the water quality. It also kept the dredge volume under a particular threshold that option 1 crossed which would have made permitting much more difficult. That's certainly not an insignificant consideration when laying out these designs, is how the design will be reviewed by regulators. If you can save your client time and money while still providing a similar result by decreasing some of the dredge volume, then that's probably the best way to go.

Implementation Considerations

How the dredge design is implemented can have a major impact on the costs of a project and the effectiveness of a solution. For most candidate locations, dredging is generally performed using one of the three classical approaches; mechanical, hydraulic, or excavation-in-the-dry. Each method is discussed in the following sections to provide a comparative overview between the various methods.

Hydraulic versus Conventional, Dry vs. Wet

Mechanical Dredging

Mechanical dredging involves the use of a dredge unit (or bucket excavator) aboard a floating barge platform with the dredged materials being placed into a second barge (or "scow") for transport ashore. Once ashore the dredge materials would need to be handled a second time and offloaded to trucks for off-site disposal or directed to a conveyor system for de-sanding and dewatering. Beyond the cost considerations associated with multiple handling steps for the dredge materials, the real constraint for this approach is whether there is sufficient water to float and maneuver the on-water components.

Mechanical dredge plants typically require a minimum water depth of 5 feet as do the associated barges or scows used in conjunction with the dredge plant. In many situations this restriction on water depth can be overcome by having the dredge plant equipment cut its way in from deeper water that might be present outside the footprint of the dredge area.

Furthermore, mechanical dredging can have a lower level of precision than dry excavation or hydraulic dredging, depending on the equipment and software being used. Sometimes the process can be highly accurate, but the operator is dredging without a line of sight on the bucket as it is typically underwater and is therefore relying on the accuracy of the GPS set up and software installed on the bucket. As a result, an "over-dredge factor" – or the volume removed from the lake bottom beyond the design elevation of the Project, needs to be considered in logistical and budgetary planning. A 1-foot over-dredge is standard in the dredging industry, however depending on the project and the location, there are allowances from 6 inches to 2 feet.

Hydraulic Dredging

Hydraulic dredges work by fluidizing the sediment into a slurry that can be pumped ashore for dewatering and processing. Hydraulic dredges are floating and maneuverable dredge plants that utilize a rotating cutter head operating at the end of the inlet piping to the dredge. Aboard the dredge are large pumps (or a series of pumps) that draw sediment material removed by the cutter head into the 8- to 12-inch transfer piping and discharge the slurry ashore (via a floating pipeline) for dewatering and processing. The floating dredge plant is typically very portable, and well suited for accessing and operating in shallow and otherwise restrictive environments. It is a very unobtrusive method that does not require disturbing the shoreline, except minimally during launching and recovery.

Hydraulic dredging relies on site-water to act as the conduit for transporting dredged sediments ashore for dewatering and processing. The composition of the dredged slurry is primarily water, with approximately 10% to 35% actual dredged solids depending on the pipe diameter, pipeline suction velocity, physical characteristics of the sediment, and operational controls to maintain an effective engagement of the cutter head with the lake bottom.

With that said, hydraulic dredging rates are typically limited by the capacity of the associated dewatering methods used on the project, not by the speed of the dredge. Hydraulic dredging discharges the fluidized slurry directly to upland dewatering processes whereby sediments are separated out and water is returned back to lake. This segregation process can be customized to partition out the sand and coarser fraction from the inlet slurry, thus opening up possibilities for applying the recovered sands in a beneficial reuse option, such as in a beach replenishment application.

In addition to the capabilities of hydraulic dredging equipment to operate in shallow water, the equipment, when properly operated, can remove intended dredge materials to much tighter tolerances and achieve minimal "over-dredge".

The main drawback of hydraulic dredging is the need for sufficient water to create the dredge slurry and the need for a large upland dewatering management area. Water volume is not an issue in deeper lakes and reservoirs that are used for navigable purposes or large water volume storage, but in shallower ponds and lakes, there just isn't sufficient capacity to generate a wet enough slurry. The other issue of a large upland area can be problematic as many inland ponds and lakes are often surrounded by a wooded or heavily vegetated surrounding, limiting the amount of open land available for a dewatering operation and clear cutting will detract from the nature of the project and usually will generate opposition from neighbors or regulators. Another factor to consider with hydraulic dredging is the consistency of the sediment makeup. Softer organics or loose sands work best, but "bonier" material or dense soils interspersed with gravel and cobbles may be problematic and cause damage to the cutter head.

Dry Excavation

The use of dry excavation methods is a very common approach to dredging small lakes, ponds, and riverine systems (under the right circumstances). To effectively implement this approach, the dredge footprint must be exposed by drawing down the water surface elevation in the waterbody. Depending on site conditions, drawing down the water surface elevation may also include the use of dewatering pumps to control the infiltration of groundwater onto the site, and diverting the flow from existing streams that may normally be feeding into the dredge footprint. These control measures maintain the required conditions to facilitate the safe access and the effective operation of heavy machinery. (Note: If the water body you are working on is used for firefighting purposes, you will need to confer with local fire departments to ensure that process of lowering the water elevation in the lake is conducted in a manner than does not limit access to fire pond reserves nor compromise existing firefighting capabilities).

Earlier in the project you should have reviewed the inputs into the waterbody and if using this method, you will need to plan to have the input flows diverted around the dredge footprint and into the main body of the lake.

In addition, the excavation-in-the-dry approach requires suitable access for heavy machinery, including bulldozers, long-reach bucket excavators, and dump trucks. Site work would be required to construct an access road into and out of the dredge footprint to facilitate the effective routing of trucks for removing material off-site for disposal. This site work might involve some alteration of the shoreline to facilitate access, and thus require the restoration of the site to existing conditions or equal upon completion of the dredging effort. The routing of trucks through a residential area would also require the set-up and operation of a truck washing station to prevent tracking of dredge sediments off-site.

Additional measures that may be required by this approach could include the addition of Quicklime or sand to further reduce the water content of the exposed sediment after draw-down to effectively improve the handling properties of the materials, and the potential deployment of swamp mats or stone lined pathways to provide the necessary support under heavy equipment operating in the mud.

Dewatering

The dredging of fluidized sediments for shoreside disposal will require effective and efficient dewatering to facilitate handling, loading, and transport of materials.

The options available are largely dependent on the dredge method utilized, with a wide range of costs for the various options. As an adjunct to dewatering processes, incorporating de-sanding for the segregation of sand and coarse-grained materials should also be considered. Both factors together will lower the weight and volume of materials being discharged from the dewatering process, thus serving to lower the costs and easing the logistics for the disposal of materials. Additionally, sand removed from the dredge material would likely be free of organics and thus potentially reusable with minimal testing.

The two primary approaches for sediment dewatering are classified as either passive or active systems, described as follows:

Passive Dewatering

This method requires little or no mechanical energy and relies primarily on gravitational forces to naturally drain the water out of fluidized dredged material. In the process of lowering the water elevation in the lake, exposed highly fluidized bottom sediments will collapse under their weight, thus dewatering in-situ as the interstitial water is compressed out by gravitational forces. This natural process can be enhanced by broadcasting "Quicklime" over the exposed sediment surface to adsorb residual water.

In hydraulic dredging, a classic approach is to pump dredged slurry directly into a Geo-tube. A Geo-tube is a woven textile bag which generally measures 7-feet in diameter and can be manufactured to any specific length. The dredged material is pumped directly into the Geo-tube, and as the tube fills the flow is diverted to other bags. The dredged material can be treated with a chemical polymer to flocculate fine grained materials thus significantly accelerating the initial settling time for the material, reducing the number of bags that are cycled through during dredging. After the material has completely and passively dewatered, the bags will be cut open at a predetermined time, at which time the sediments will be removed for final disposal.

Active dewatering

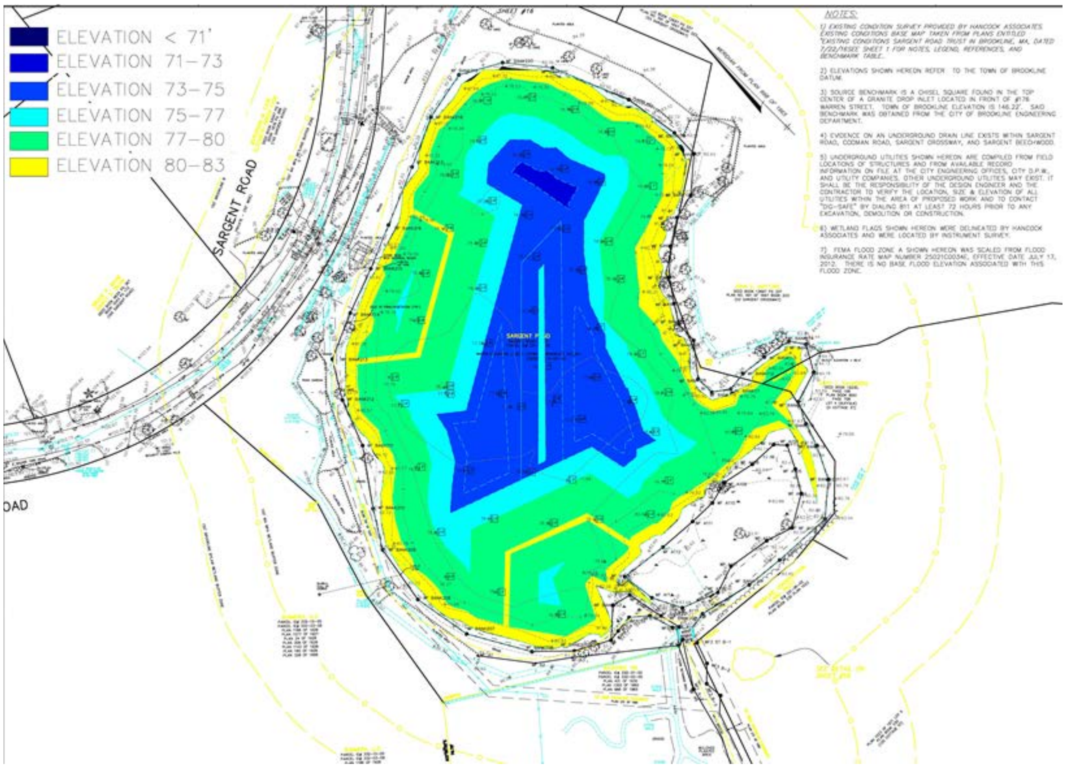
The two primary types of active dewatering (or mechanical dewatering) systems are either a batch-mode filter press or filtration/clarification system. Each system requiring a separate de-sanding module for the removal of sands and the coarse fraction prior to the inlet of the dewatering process if that pre-treatment step resulted in the advantageous acquisition of useable product.

Belt presses simply press the dredged material on screens until the material has been dewatered. The filter press deposits the blocks of dewatered sediment to the side of the press where they can be loaded for disposal. The filter press normally operates as a batch system, meaning a discrete volume of material is loaded and then processed. Polymer addition can be used to flocculate fine particles to facilitate the use of larger screens. A filter press working in a batch–mode approach does slow the production rate of dredging, thus negatively impacting costs.

Filtration / clarifiers have the capability of pre-screening and segregating debris and coarser materials into separate spoils piles for individual handling, testing, and disposal. The primary advantage of this technology is its modular configuration that can be sized to dewater and process sediments in real-time at the full production rate of the dredge.

Design Example

Going back to the design example from above, Option 2, its best to look at how the design can be implemented and which methodology to use, as that will very likely come up during the permitting process. The potential dredge methodologies to review include mechanical, hydraulic, and excavation-in-the-dry.

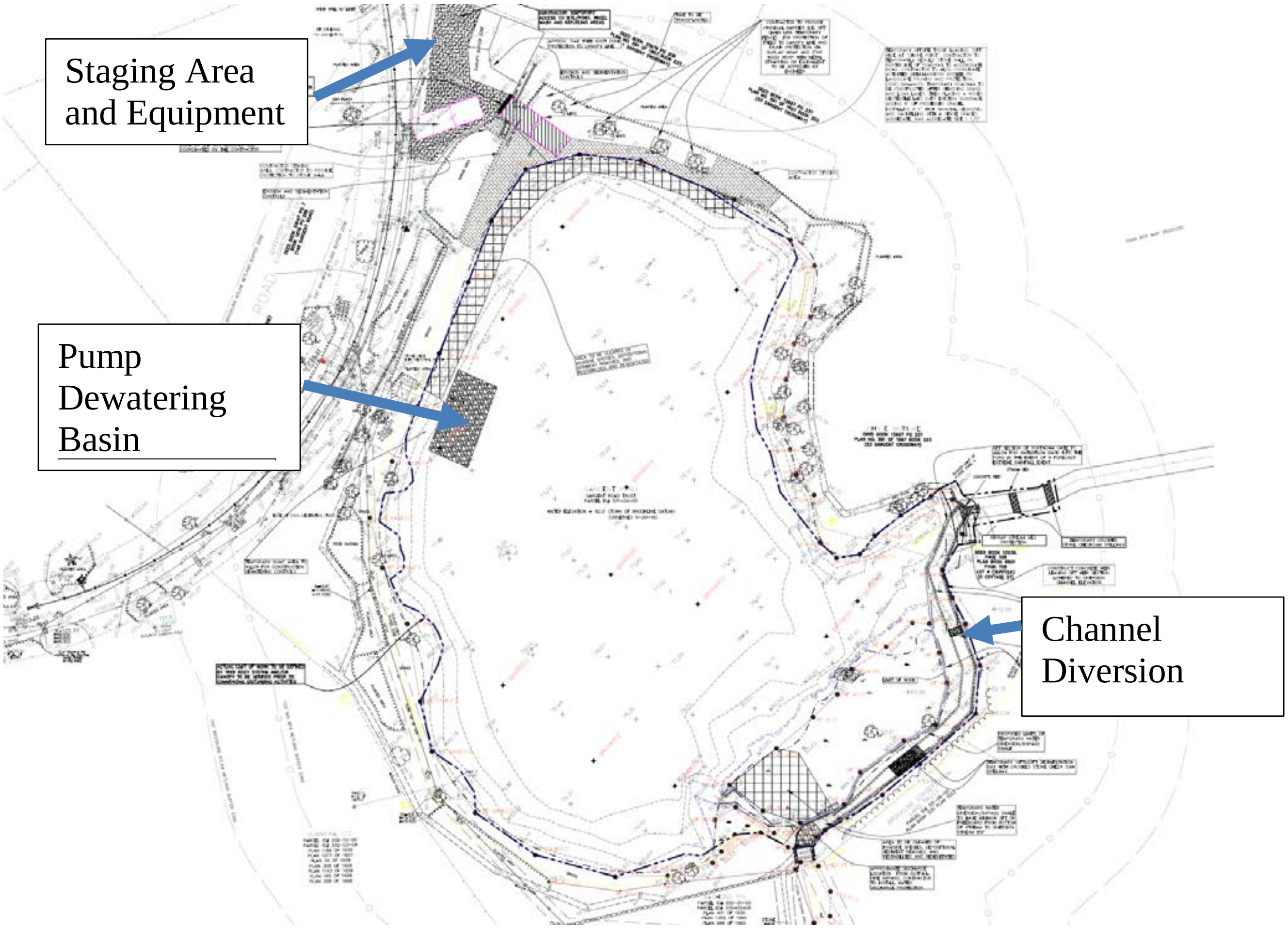


Mechanical dredging is infeasible due to the very limited water depths which would preclude water access for deep draft barge-mounted bucket dredge equipment but is also very costly due to the high mobilization costs and the added costs associated with multiple handling steps needed to get the dredged sediments through the process.

Hydraulic dredging is modular and can be easily assembled on-site, with requires some form of dewatering and capturing of the entrained sediments, and an associated piping system to deliver water back to the pond after the dewatering process. For this process to work, you'll need a lot of water, as a typically dredge slurry is less than 35% solids. For the amount of water available in the pond at the start of the project, there won't be sufficient water volume to economically dredge this pond hydraulically.

Excavating-in-the-dry is a compact and cost-effective approach for dredging. This dredging approach requires a means for lowering the water elevation in the pond to an elevation that facilitates access, the potential diversion of surface water inputs to prevent flooding of the dredge footprint, and the required site modifications to facilitate equipment access, material handling, and vehicular access/egress. For this design example, the pond elevation is controlled by an outflow weir, there is also an elevated mound in the southwestern corner of the pond, that can be used to re-route the inflow stream temporarily away from the pond and downstream. Once the stream diversion is in place, the rest of the pond can be lowered using a series a high capacity pumps, and considerations will need to be made to divert stormwater during rain events.

The next thing to decide is how to dewater the sediments. For our project we know that the top layer of sediment is highly organic and mucky, and will retain a lot of water, but even below that top layer, the sediments have a high water content and will require some form of dewatering. There is a small area in the northwest in between the roadway and the pond, however it is not big enough to allow equipment access and store a stockpile of dredge material to allow for passive dewatering. Therefore, dredge material will likely need to be stockpiled in the pond to allow for some initial passive dewatering. For this project, that won't likely be enough to allow for transport of the material, so some form of amendment, such as sand or lime should be planned on to dry up the sediment more efficiently to allow the trucking operations to commence. The figure below shows how the pond can be set up for dredge operations.



Construction Planning and Sequencing

Once the project is designed and permitted, then the procurement process can move forward to select a contractor. Once the contractor is chosen and the contract worked out, the Contractor can begin mobilizing to the site and get going on the dredge project. Assuming the project will involve an "excavation in the dry" dredge, the following section lays out a typically sequencing procedure for the execution of a design and what to look for to minimize issues.

Upon mobilization to the site, the Contractor will first need install all erosion control and protective structures as indicated on the project plans and required by the project permits. This is typically the best time to meet and review their strategy and discuss whether there will need to be any deviations from the project plans. Prior to any ground disturbance, the erosion controls and protective devices will need be reviewed by the engineer and any governing permit issuing authority.

The erosion and sedimentation controls selected and maintained by the Contractor will need to be such that water quality standards and regulatory requirements are not violated as a result of the Contractor's construction activities. The Contractor should install sufficient erosion control measures to protect existing resource areas, including those above and beyond those listed on the Plans or described in the specifications.

A project laydown area should be designated where the Contractor can set up his operations, perform equipment maintenance and refueling, and stockpile materials away from any resource areas. The Contractor will need to be responsible for any necessary sedimentation controls within that laydown area to ensure no soil or discharge waters will be allowed outside of the proposed laydown area to prevent soil from entering nearby waters or municipal systems.

Anti-tracking pads are useful items to be installed at the Site entrance to prevent track out of the mud and muck from the work area. These areas should be inspected daily and cleaned the area as necessary, which may include street sweeper or wash down procedures.

Once erosion controls and protections are in place, site preparations can commence. Depending on how the current access to the waterbody is, the contractor may need to construct a temporary roadway, to allow equipment access to the shoreline and the waterbody for operations. A common way to construct the roadway, although there are several methods, would be to place filter fabric on the access routes and place a dense graded aggregate material (3” or less) or larger trap rock to establish work areas. Depending on the underlying material, other accommodations, including the use of swamp mats, may be necessary.

Pond Diversion and dewatering

Once the staging and site preparations are in place, the Contractor can begin flow diversion of the inflow sources, which may be stormwater outfalls or streams. A diversion scheme should be worked out in the design process so the contractor will know what volume of water to be prepared for, both on a day to day basis and in the event of a heavy rainfall event, as well any structural or material upgrades to be part of the diversion process. For inflow streams that don't run dry, diversion often requires the implementation of a porta dam or equivalent type structure consisting of impermeable hdpe sheeting and structural reinforcing members (wood or metal). These systems will need to be sized to provide the conveyance volume necessary to keep the dredge footprint dry but work with the geography of project site. Some waterbodies may have a small inflow stream and a larger open field nearby where the flow could be diverted with a diversion trench and small earthen berm. Other projects that have tighter restrictions on available land may need a by-pass channel. The system should be installed downstream -up and graded for positive drainage, a minimum slope of 0.005 ft/ ft. Stone check dams and a sedimentation bay may be needed to limit transport of sediment. It's very important that any diversion strategy, be it berm or by-pass channel, be properly sized to not cause downstream erosion or risk breaching and refilling the dredge area.

Once the flow diversion system is in place, the contractor can then begin pumping down the pond in a controlled manner, typically this should be limited to no more than the typically discharge from 2-year storm from the outfall. The water in the pond should be pumped over the portadam structure or diversion berm and into the bypass channel upstream of sedimentation controls. During the drawdown process, there will be pockets of standing water that will remain, so the pumps will need to be portable and relocated to address the pockets of water.

If the waterbody is fed by stormwater outfalls, there will need to be flow diversion for those inputs as well. Ideally you would be able to tie in the stormwater outfalls diversion in with the inflow stream diversion, but these projects are never set up ideally. So often in order to divert an outfall pipe will entail excavating a detention basin right at the outfall. The basin should be excavated to allow a minimum of 4 feet of freeboard. The basin should be lined with filter fabric pinned into the soil and covered with 6" inch minus trap rock to avoid erosion or stirring up sediments. Then, within this basin, the contractor would set up a pumping basin, something on the order of 2 feet in diameter and have a peastone filter around the pump. A 6" diameter pump or one of suitable size will be set in this basin with enough hose to pump from the basin into the bypass swale upstream of sedimentation controls.

Inflow Management During Construction

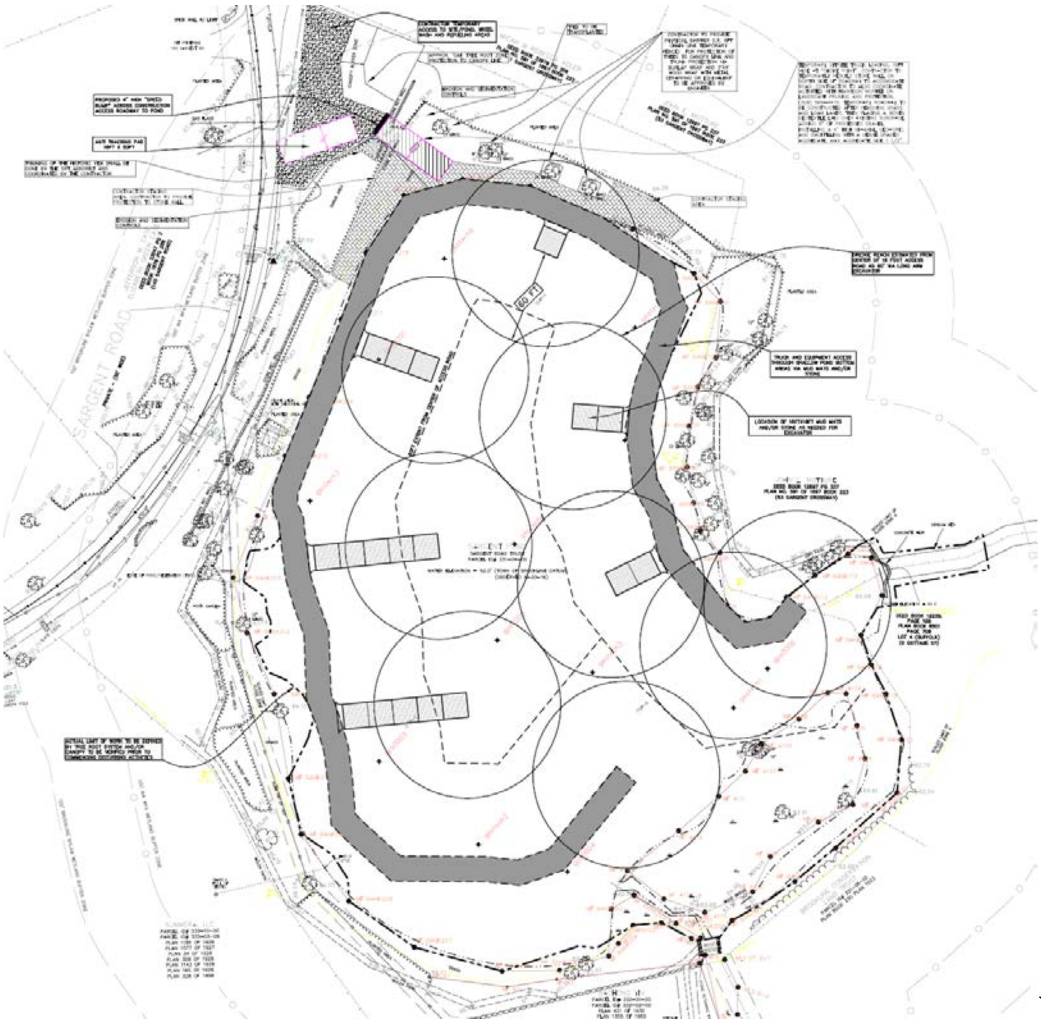
If you anticipate the inflow stream will flow continually during construction, then the contractor will need to inspect the integrity of the diversion structure every morning at the start of operations and immediately repair any deficiencies. When any significant rainfall is anticipated (.5" or greater) the contractor should perform a thorough review of the condition on the diversion structure and ensure that it has adequate supplies and materials on hand to repair or reinforce the structure if needed during the storm event. The contractor will also ensure that it has all the equipment and materials necessary to implement its contingency plans, which may include having an additional bypass pump and hose if that is part of the contingency plan. Another potential contingency plan item would be to construct a secondary berm parallel to the bypass swale if there is enough real estate to allow you to do so. The Contractor should be required to submit a detailed work plan with contingencies as part of its pre-construction submittals so that all parties are aware of and prepared for what should happen in the case of a large storm event being forecasted. Following a large storm, and in the event that water still entered the dredge footprint, the contractor should focus operations on cleaning up the dredge footprint and restoring the diversion structure prior to re-commencing dredge operations.

Dredge Operations

Once the operational and environmental controls are in place the dredging operations will begin. Normally the primary means to access the dredge footprint will be through the use of swamp mats and long stick excavators. If the swamp mats do not provide a stable enough base for operations, the Contractor may have to construct temporary crushed stone roadways into the dredge footprint. The crushed stone, laid down in lifts and densified with the equipment available on the site, will provide a stable base for the dredge operations, but will need to be removed and properly disposed of at the end of the project. Therefore, to prevent migration of materials, the contractor should underlie the temporary roadway with filter fabric.

Design Example

Going back to our pond project, it's important to look at how the dredge will be implemented. We have already settled on the design and decided that it will be an excavation in the dry project. The next thing to figure out is how the equipment will gain access to the dredge footprint. We figure that the contractor will be using a long-stick excavator, but again going back to our soils on-site, we know they aren't conducive to supporting large equipment, and I don't think any contractor is going to want to risk losing a machine or more importantly risking the health and safety of its operator by making a long and deep reach with that excavator on soft mucky soils. Therefore, it's important to look at what's a reasonable way to execute this. Oftentimes, the best way to figure it out is contact a contractor that you have an existing relationship with already and have them walk you through it. Oftentimes they'll point out things they'd like changed or things you hadn't thought of in the design process that won't affect the overall quality of the design but will make a major difference in how the dredge can be implemented (which usually translates into big cost savings to the client). For this project, we reached out to a couple of contractors we had worked with in the past and got a couple of different options, but in general, they discussed having a perimeter access road around the length of the pond for the equipment to travel and most importantly the trucks. That would be the sturdiest "roadway." From there, they would construct "fingers" for the excavators to work off to reach the dredge footprint. Different ideas were suggested, from trap rock to mud mats, but that's more of a means and methods of the contractor than the design detail. The important takeaway from this is that there was a feasible way to approach the dredge that would allow the design to be implemented.



This figure shows the perimeter roadway that traverse the pond and the fingers that provide access for the excavators to dredge. The circles represent the radius of reach for excavators. This figure shows that with some planning, the contractor will be able to dredge the entire footprint without having to crisscross the pond or lay mud mats everywhere.

The Contractor should be required to have precise and accurate horizontal and vertical controls with the dredge equipment. Once they have their excavators in place for the zone they will be working in, they would normally be dredging into an articulated end dump truck that will be traversing the swamp mats or crushed stone roadway. Depending on the layout of the waterbody and land available for the project, a stockpile and laydown area should be established. Most often, the material will need at least some dewatering, so it's best to locate the stockpile area so the material can dewater back into the waterbody or away from sensitive receptors. Oftentimes the contractor will need to work over the dredge stockpile from time to time to increase the material dewatering. The amount of dewatering time required will vary depending on ambient conditions, organic and silt content of the sediment and where from the dredge footprint the material was taken and where in the stockpile it remained.

The Contractor should be responsible for the construction, protection and maintenance of temporary stockpiles through the final disposal. The idea is that the Contractor will place stockpiled soils within the designated stockpile area, graded to shed water, and will cover the stockpiled soils prior to inclement weather and at the end of each work week with an impermeable barrier of a minimum six-mil-thick (0.006") black polyethylene cover overlapped and weighted to form a continuous waterproof barrier over the soil. Protective measures of the stockpile will need to be adjusted depending on the chemical composition of the sediments and the local regulatory environment. The cover should be maintained throughout the stockpile period to prevent water from entering the soils and to prevent blowing dust. The cover should be suitably weighted to prevent the soil from being exposed by wind. Stockpile areas should be graded such that storm water runoff is diverted from stockpiled soils.

Once the stockpile has reached sufficient size to support the transport and disposal of the sediment offsite and after review that the material will not hold too much water, hauling operations can begin. All truck traffic should be given a designated route for entering and exiting the project site, to provide better controls and prevent sediment track out issues. The number of trucks used should be chosen to maximize efficiency of load and transport but also minimize idling and truck standby time. It’s normal that some idling and standby will occur each morning at the beginning of operations as long begins, but as the hauling progresses throughout the day, the staggering of trucks will naturally occur.

The contractor will need to ensure the material in the truck bed is covered and not draining water out of the back. Some water leaking may occur initially as the material first moves, however it should stabilize relatively quickly (prior to leaving the staging area). The Contractor should remove any large chunks of sediment from its tires and undercarriage to minimize track out and will then pass over the anti-tracking pad which will be constructed of large angular stone intended to break up and remove sediment from the tires. As conditions allow (temperatures comfortably above the freezing level), the Contractor may also have a wheel wash station to remove sediment if needed. The wheel wash runoff should be collected downstream of the roadway and returned to the dredge footprint to be managed with the rest of the sediment dewatering.

The Contractor should properly transport and dispose of all items, including solid hazardous and nonhazardous wastes removed from the Site, to appropriate disposal facilities. Depending on how the project responsibility is divided up at the beginning of the project, either the engineer or the contractor will need to characterize all wastes prior to offsite disposal, to determine if they are hazardous or non-hazardous and appropriate for the receiving facility, which may have been selected during the design process or having been nominated by the contractor at the beginning of the project (a lot will depend on how the material is characterized, which will say where an acceptable disposal location is).

The Contractor should be responsible for providing all documentation to track contaminated material from the time of excavation until it is accepted by and disposed of at the disposal facility. Due to the complexity of soil management processes (due to the volume and number of soil stockpiles anticipated on a project), it is imperative that the Contractor is diligent in understanding what is in each pile and where it originated from. Offsite disposal of contaminated material should be in accordance with State, Federal and local regulations at a facility approved by the Engineer.

Re-filling the waterbody

After the Contractor has deemed that they have substantially met the design criteria for the pond and the grading, the Engineer will review with a post-dredge quality control survey. The quality control survey is intended to check that the Contractor has substantially met the design line and grades. Once the design lines and grades have been met, the Contractor can be allowed to begin re-filling the pond. To avoid creating erosion and sediment transport within the pond, the re-filling operations will need to be controlled at first. The initial re-filling should not occur when any large rainfall events (.5” or greater) are forecasted, but rather when smaller events are forecast. A controlled removed of the diversion structure should be implemented to allow the pond to slowly re-fill. Once the pond levels reach a stable elevation, close to their normal pool level, the entire diversion structure can be removed. The last step, once the pond is stabilized at the level of the normal pool the contractor can then remove any remaining sediment collected within the downstream sedimentation controls and remove those controls. Then all the project cleanup can begin, removing the temporary roadways, laydown area, environmental and sedimentation controls and restoring any areas disturbed or damaged during the construction process.

Summary

Pond and Lake dredging projects can be very challenging and difficult projects, and no two projects are the same or have the same solutions, however this course was designed to provide an overview of how to approach, design and execute a dredge project. The most important work is done up front, with the research and investigations, including the hydrographic surveying and the sediment and water sampling. That information will give you the basis for how you want to approach the dredge project, what depths are achievable, what slopes will hold up, how much water does the sediment hold, and where can the sediment be disposed of once removed. Once you have the dredge strategy laid out, designed and permitted, then it becomes critical to work with the contractor to ensure the implementation is successful. Management of dewatering fluids, inflow sources and gaining access to the dredge footprint are all critical steps to be worked out and consistently reviewed during the implementation project. Once the implementation is completed and successful, your waterbody should meet the project goals you laid at the beginning of the project, be it better water quality, better circulation or more depth. While there is not one clear way to manage every dredge project, there are many options and modifications that can be made to successful implement a pond and lake dredge project.

