Integrated Approach to Dewatering and Stabilization of Ash Basins for Closure

Christopher D. Hardin[1] and Paul C. Schmall[2]

[1]The UNC Charlotte, Energy Production Infrastructure Center, 9201 University City Boulevard, Charlotte, NC 28223-0001; [2]Moretrench, 100 Stickle Ave, Rockaway, NJ 07866

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ABSRACT

In its Final Coal Combustion Residual Rule, the U.S. Environmental Protection Agency (EPA) indicates dewatering of CCR ash basins is an important component of the ash basin closure and stabilization process. As power utility owners, design engineers and contractors attempt to arrive at the most appropriate method for remediating coal ash basins, dewatering and stabilization of wet ash is a primary technical issue. This presentation provides an explanation of the integrated approach to dewatering that has been safely and effectively used on over 12 ash basin closure projects.

This technical paper and presentation will provide the following:

- Practical guidelines for using in situ tests to assess the permeability of the fly ash, typical yield per device, and radius of influence that can be achieved by pumping from within the ash basins,
- An understanding of the technical principles that govern the increase in shear strength when pre-drainage techniques are used in different types of ash basins;
- An explanation of the different types of dewatering wells/wellpoints, installation methods, and their applicability in different types of ash basin conditions and closures,
- Guidelines on how near surface dewatering, wellpoint dewatering and deep well dewatering can be used as part of an systematic closure plan, and
- How to implement pre-drainage methods and periodic vane shear tests as part of an integrated dewatering and ash basin remediation program.

This paper will provide attendees with an understanding of the importance of dewatering as the first step required for coal ash basin remediation.

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INTRODUCTION

Dewatering of ash basins to increase stability and facilitate construction is an essential part of the ash basin closure process. Since the promulgation of the Final Coal Combustion Residual Rule (Final CCR Rule)[1] by the U.S. Environmental Protection Agency (EPA), the types of ash basin closure designs and the complexity of the surface and subsurface conditions that are being encountered has increased. To address the wide variety of layered coal ash materials and changing pore water conditions, ash basin owners, contractors and design engineers are looking more and more to construction dewatering.

For the purposes of ash pond pre-drainage, construction dewatering is defined as follows:

> ***Construction dewatering*** *is the removal and/or control of groundwater or pore water within the soils or industrial waste material located beneath or adjacent to a construction project. This type of dewatering is required to increase stability of slopes or excavation areas, or to allow construction of a structure or final cover system and can be accomplished by a combination of wellpoints, deep wells, pumping from sumps, surface ditches, evaporation and surface drying or by installing geosynthetic drains or vacuum dewatering systems.*

The primary purpose of this paper is to provide an explanation of the different types of dewatering methods that can be used to dewater ash basins. This explanation is offered to assist design engineers, ash basin owners and contractors with an increased understanding of the principles that govern the increase in stability that occurs when interstitial water is removed from partially saturated ash basins. A secondary, but equally important reason is to offer ideas and practical suggestions for controlling costs for ash basin construction by a proactive and integrated use of different dewatering methods. This is important because the experience of industry professionals for the past four to five years is that the impact of excavating poorly dewatered ash during ash basin closure is the primary reason for cost overruns and unexpected project delays. Third, this paper attempts to “de-mystify” the relationship between dewatering, and the increase in strength of coal ash as it transitions from wet to partially saturated to dry.

One of the most important things that this paper will offer ash basin owners, contractors and design engineers is a tool box of dewatering methods that can be used to enhance safety, control costs, and improve constructability on saturated and partially saturated ash basin closure sites. Construction dewatering, properly applied, increases safety by stabilizing the coal ash in basins so that it can be safely excavated, graded, and covered with a synthetic liner system using conventional construction equipment. Recent technical evaluations and surveys of coal ash basin closures from confidential client information and industry databases indicates that dewatering and movement of wet or partially saturated ash accounts for 40 to 50 percent of the ash basin closure construction costs (CALM Office Meeting, December 2016[2]). The significance of this finding cannot be underestimated. Similar studies by respected electric power utilities indicate that a slight increase in the upfront bench scale and geotechnical field tests provides a substantial decrease in the overall cost of ash basin closure design and closure. If facility owners expand their approach to ash pond remediation to include construction dewatering methods, the safety of excavation and placement of ash material substantially increases. The result is reduced cost and a better quality end product for ash basin closure.

Finally, this paper addresses recent developments with an “integrated approach to dewatering and stabilization” where contractors, ash basin owners and design engineers have started using similar technical terms, and are looking for ways to optimize the process and approach for wet and partially saturated ash basin closure dewatering and construction. The Integrated Approach explained in this paper and presentation provides basic guidelines on how to use a “tool box” of dewatering methods. These common terms and a common set of dewatering methods allow ash basin owners to develop specifications that acknowledges the value of early dewatering and site preparation. Recognizing that the effective use of dewatering for ash basin construction is both a matter of skill and practical execution, this paper identifies the key items that owner and general contractor need to look for when considering different dewatering methods in an effort to help “demystify” the use of dewatering methods.

PRACTICAL GUIDELINES AND CONSIDERATIONS

When considering the type of dewatering method that is most applicable to a specific ash basin in-place closure, excavation, or hybrid closure project one should always begin with the end in mind.

From the perspective of dewatering tool selection, the following items are typically considered during the design phase or at the beginning of an ash basin closure construction project:

- What geotechnical information is available about the ash basin, and/or what are the permeability characteristics coal ash in the basin? If little or no geotechnical or permeability information is available how could it be obtained and/or how could the properties be estimate during the design or pre-bid phase?

- What are the end goals of the ash basin closure – complete excavation, closure in place, or hybrid closure?

- How strict are the discharge requirements for the discharge of decant water or discharge from the dewatering system? Could the dewatering wells be used as a pre-treatment mechanism or device to minimize the cost of wastewater or decant water treatment?

- What type of construction equipment is being used to move the partially saturated or dry ash materials? If conventional construction equipment, non-amphibious or pecialty devices are used how can dewatering assist and enhance the construction operation?

- How can the project closure grading and stormwater management design be developed to enhance the excavation of saturated ash materials, improve the materials management from a dewatering perspective and stabilization perspective to reduce the overall cost of construction?

Early Involvement in the Constructability and Design Decision Process

Typically, dewatering and stabilization of the partially saturated ash basin materials is considered a “sideline” or “support” activity of the ash basin closure process. Many times, the dewatering contractor is consulted by the owner for general information during the design and pre-construction evaluation of closure alternatives. Other projects consider dewatering and stabilization after the closure construction and site stabilization process has started. This does not take into consideration that dewatering and treatment of pore water from ash basin closure projects can be a significant cost associated with closure construction and is almost certainly on the project’s critical path.

A basic consideration of construction risk and potential cost impacts on over 50 projects indicates that excavation, dewatering and decant/pore water treatment accounts for 40 to 60 percent of the overall project cost**.** This high percentage suggests that dewatering and wet ash stabilization may need to be considered at the front end of the ash basin closure process**.**

To accomplish this important project objective, recent experience on ash basin closure projects in several states suggests the following:

1. **Utilize Upfront Geotechnical Testing and Dewatering Pump Tests:** Projects where cone penetrometer (CPT) and pump tests are available provide valuable information that assist with developing an optimized approach to ash pond dewatering and stabilization. about how to dewater and stabilize an ash basin. If CPT and pump test information is not available, then testing can be instituted at a relatively low cost.

2. **Consideration of Dewatering in the Design and Construction of Ash Basin Closures:** Commencement of dewatering during the removal of the decant water and initial ash basin stabilization process can reduce the time and cost required for ash basin closure. Key considerations include: a) comparing the cost of dewatering to the probable cost of wet ash processing during construction; b) reducing the risk, uncertainty, and cost of ash basin construction under partially saturated or saturated conditions; and c) the potential of reducing wastewater treatment cost by the use of dewatering wells as pre-treatment devices.
3. **Develop Integrated Surface and Subsurface Dewatering Systems:** By considering dewatering systems (i.e. deep wells, wellpoints, and surface trenches) early in the design and construction of ash basin closures, the risk, uncertainty and costs can be managed and controlled better. Dewatering systems designed to efficiently remove water and achieve minimum strength requirements for ash materials are essential for the ash basin closure construction.

ASH BASIN CHARACTERISTICS AND DEWATERING

To understand the importance of ash basin characteristics and pore water chemistry on ash basin closure and dewatering, a basic understanding and appreciation of the heterogeneous nature of fly ash in ash basins is necessary. Recent presentations by respected contractors and geotechnical engineers (Hardin, 2016[3]; Hebeler, 2016[4]) and academic researchers (Jewell, 2016[5]) indicate that a few of the main defining characteristics are: a) that each ash basin is different, b) ash basins typically have complex deposition and placement of sluiced materials, and c) heterogeneity of ash basin materials, both horizontally and vertically, in most ash basins. Simply put, most ash basins are consistently inconsistent.

Another important characteristic and defining geotechnical principle that must be considered for effective ash basin design and construction is that the water, pore water and changing water levels in ash basins can contribute significantly to the instability and inconsistent strength characteristics of coal ash. These field conditions can often be accounted for or mitigated during construction by the specialized skills of experienced ash basin closure contractors and field geotechnical engineers. Arriving at how best to address these conditions is matter of experience, skill and practical science.

There are several key items that are typically considered in order to effectively address the heterogeneity in most ash basins, and account for these characteristics in the closure design and construction:

- **Ash Material Permeability and Layering:** The horizontal and vertical permeability at specific locations and across the overall ash basin, and low permeability layers or "perched water" lenses, can be observed and evaluated from the information obtained from the results of CPT probes, lab tests and pre-construction pump tests.

- **Radius of Influence and Drawdown with Distance for Dewatering Wells:** Pump tests that are conducted in representative areas of ash basins can be useful to develop the probable radius of influence and the distance of drawdown of wellpoint systems and deep dewatering wells.

- **Connection with Horizontal Drains and Rim Ditches and Interior Ditches:** As the grading/excavation design and dewatering systems for ash basin closure are developed it is important that surface stormwater channels and subsurface dewatering systems are developed. This type of integrated approach to dewatering has been demonstrated on ash basin closure sites in the Midwest, Virginia and the Southeast to reduce cost and increase productivity.

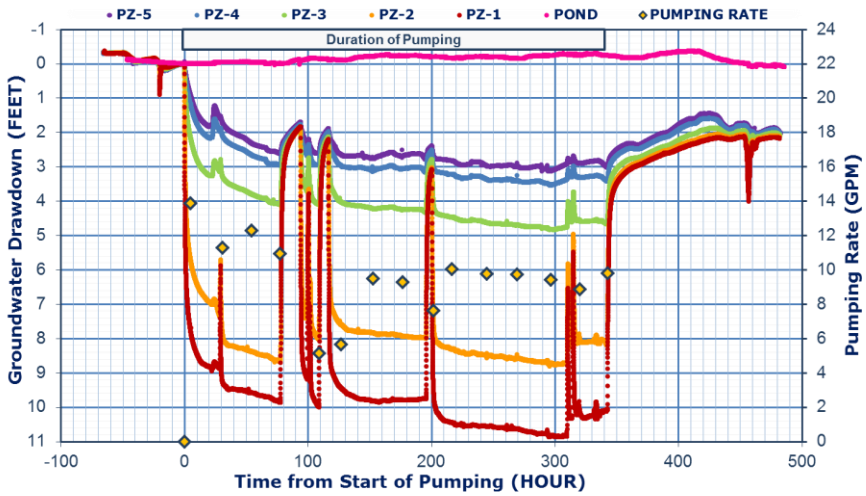

Figure 1: Typical Pump Test Curve

ASH BASIN DEWATERING AND STRENGTH GAIN

In general, the removal of water from predominantly silt-sized soil-like materials like fly ash has been demonstrated to increase the strength of materials from a construction perspective. Even though fly ash is a silt-sized particle, increase in strength and performance under surcharge loads and construction vibrations tend to be site specific and best quantified by experienced field engineers and contractors during the construction process. The challenges presented by the thixotropic nature of partially saturated fly ash materials in ash basin is well documented (Johnson and Nilsson, 2014[8]; Landry, 2015[6]; Jewell, 2016[5]), but at this time has not been quantified from a geotechnical or construction equipment performance perspective. For purposes of this technical discussion and for developing a practical understanding, the thixotropic characteristics of fly ash are defined as follows:

> ***Thixotropy*** *is a time-dependent shear thinning property. Certain gels or fluids that are thick, or viscous, under static conditions will flow (become thin, less viscous) over time when shaken, agitated, sheared or otherwise stressed.*

The fact that the dewatering of fine grained soils improves strength is generally understood and appreciated by most geotechnical engineers and contractors working with fly ash materials. Quantifying the amount of strength gain caused by dewatering, and/or accounting for subsequent loss of strength when partially saturated fly ash materials are subjected to surcharge loads or equipment vibration, is much more difficult.

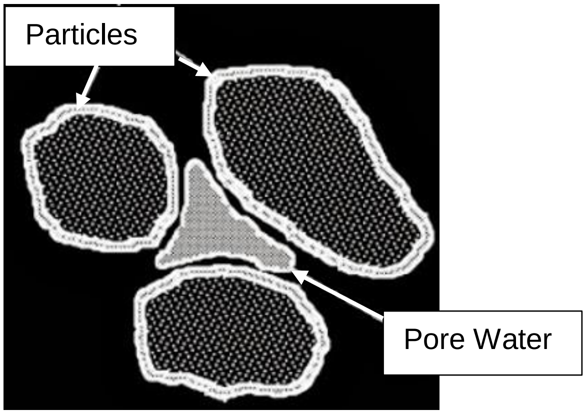

Figure 2: Soil Moisture Diagram

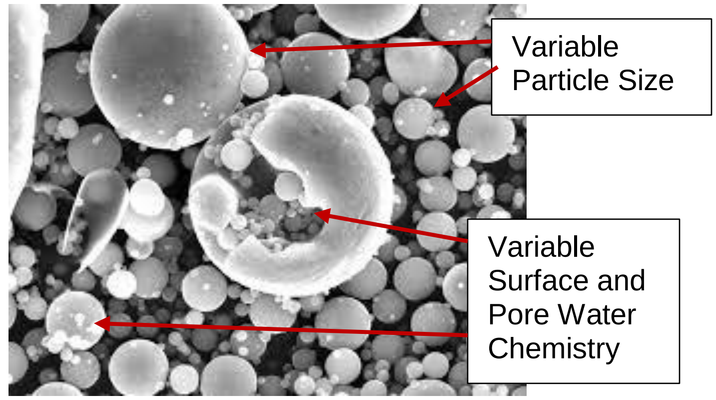

Figure 3: Typical Fly Ash in Ash Basins

Fly ash particles are unique in that they tend to be round, silt-sized particles that have both glass-like properties and some reactivity as a pozzolanic material. Conventional geotechnical laboratory testing generally indicates that fly ash is a material with very low or no plasticity, and therefore should have performance properties of a low plasticity silt-sized particles. Construction experience with wet fly ash indicates much more inconsistency than typical silt soils when fly ash is handled with conventional construction equipment. Recent field experience indicates that fly ash in ash ponds frequently has intermittent layers of fine particle ash with lower permeability and increased difficulty with dewatering and construction.

Strength Gain and Verification of Changing Site Conditions

Construction dewatering for ash basins is utilized to increase soil strength by removing pore water from the saturated fly ash so that interparticle suction occurs, thereby increasing the internal friction angle and the apparent cohesion of fine grained silt, sand and clay mixtures. In general, this approach works well, but field verification of changing conditions in partially saturated ash is essential. Previous journal articles and recent field studies indicate that even when fly ash appears to be dry and the moisture content is measure below the liquid limit it can become unstable again when subjected to construction vibrations and surcharge loading (Hardin, 2016[7], Nilsson and Johnson, 2012[8]).

Methods for Verifying Strength Gain of Fly Ash

One of the challenges presented by partially saturated fly ash materials in the construction of ash basin closures is how much lowering of the phreatic surface or "water table" is required to provide adequate stability for excavation and access by construction equipment. Three basic, but important questions that need to be asked by owners, design engineers and contractors working over ash basins:

> *How much pore water and/or interstitial water needs to be removed to provide adequate strength for excavation and mass grading of a partially saturated ash basin? How much must the phreatic surface be lowered?*
>
> *How much should the moisture content be reduced for safe construction?*

Field Approximation of Moisture Content

One of the most effective ways to make a field approximation of the acceptable moisture content for construction is to evaluate the in-place moisture content versus the Optimum Moisture Content (OMC) for the Standard Proctor (ASTM D-698), as compared to the Plastic Limit, and Liquid Limit as determined by the Atterberg Limit test (ASTM 4318). Typically finer ash will exhibit some plasticity. Experienced geotechnical engineers and contractors know that soils and fly ash materials will start to "pump and rut" and flow above the Plastic Limit, and when approaching the Liquid Limit moisture content. The in-place moisture content of an ash basin area that is improved by dewatering should be less than the Liquid Limit, and approach the Plastic Limit to provide an increase in strength.

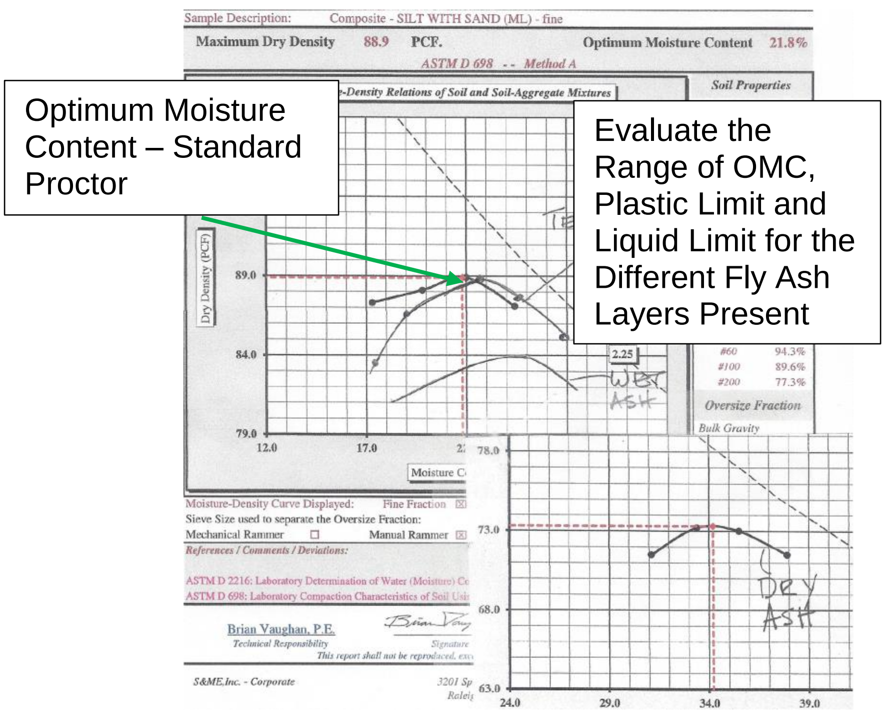

Figure 4: Typical Field Curve for Moisture Content Evaluation

Another important item that needs to be considered is the site-specific benefits from the strength gain of dewatered fly ash. This involves answering the following question:

> *What is the safest and most effective way to measure and/or approximate the strength of the fly ash, and the influence of the in-place moisture content in a construction environment and/or on a site with changing site conditions?*

Vane Shear Testing and Undrained Shear Strength Analysis

Previous studies and respected technical papers on this subject indicate that an undrained shear strength analysis (USA) and periodic vane shear testing are some of the best methods for measuring the strength gain provided by dewatering, soil improvement methods and/or surcharge loading. Even though lab testing is helpful for developing the design guidelines for dewatering and strength gain this information must still be “translated” into a practical field application method that can be used by contractors and field engineers. The following technical papers provide useful information on how to evaluate, measure and increase the strength of ponded fly ash materials with dewatering and in-place stabilization:

- Stability Evaluation During Staged Construction, C. Ladd, 1991, 22nd Terzaghi Lecture[9]
- Practical Considerations for the Management and Closure of Wet Coal Ash Pond Systems, Babcock, Hardin and Perotta, WOCA 2011[10]
- Evaluation of the Settlement Behavior of Fly ash for Ash Basin Closure Projects, Hardin, et al., WOCA 2011[11]
- Dewatering Fly Ash for Remediation: Two Approaches, G. Landry, WOCA 2015[6]

Since the purpose of this paper is not to “prove” the benefits of ash basin dewatering or debate the application of different geotechnical engineering design methods, the following practical guidelines are provided for evaluating the strength gain from dewatering in wet fly ash basin construction:

1. **Measure and evaluate the undrained shear strength of the ash basin:** Using the CPT and vane shear test devices, determine the undrained shear strength prior to the start of dewatering and at periodic intervals during the dewatering process.

2. **Develop correlation tables for moisture content, undrained shear strength and target values of strength gain:** Obtain regular information between dewatering wells and drainage layers to document how the partially saturated ash basin improves with removal of interstitial water. There should be a noticeable increase in strength with progressive dewatering.

3. **Account for perched water layers and localized instability by field observations:** Even with the best dewatering systems and a robust field verification testing program, there will be localized areas where soft/wet ash will remain trapped in the subsurface of the ash basin. These are best accounted for by regular observations of experienced project superintendents and equipment operators.

4. **Use in-place pore water pressure devices for deeper or more challenging ash basins:** Most ash basins, and even layered ash basins can be effectively dewatered and stabilized using a combination of dewatering wells, wellpoints and drainage layers, but deeper fills or cut areas present challenges with rotational

slope stability and build-up of excess pore water pressures.   These can be accounted for with “real-time” reading of pore water pressure devices that are strategically located in potential problem areas.

Figure 5: Typical “real-time” pore water pressure reading device

Figure 6: Hand held vane shear test readings safely obtained over geogrid

DIFFERENT TYPES OF DEWATERING WELLS AND DRAINAGE SYSTEMS

As the state of the practice has advanced for wet ash basin closure construction since the implementation of the Final CCR Rule, the application of different type of dewatering systems has also advanced.   The five main types of dewatering methods or systems that are being used to dewater ash basins are:

1. **Dewatering Wellpoints – Jetted Wellpoints and Fabric Drains:**   Jetted wellpoints are probably recognized as the most universally recognized dewatering tool. Special installation and construction measures must be implemented in ash because of the unique behavior of ash. The most significant modification is in the filter design. The typical Terzhaghi filter design does not apply to the highly spherical ash particles and a finer filter sand must be used. For high capacity wellpoints a proprietary fabric screen is used. The use of some fabrics in lieu of a sand filter has been a somewhat frequent misapplication.   Fabrics with apparent opening size not designed for fly ash will either pass excessive material or plug. Conventional non-woven wick drain fabric, which has been used repeatedly, is a significant restriction to water yield and will plug.

   KEY POINTS: a) Properly sized screen or geotextile fabric materials are essential for long term performance; b) the installation method is important to maximize yield in a layered ash; c) pumping is typically by vacuum or low volume pumps; and d) a pre-construction pump test is effective in optimizing the dewatering system design.

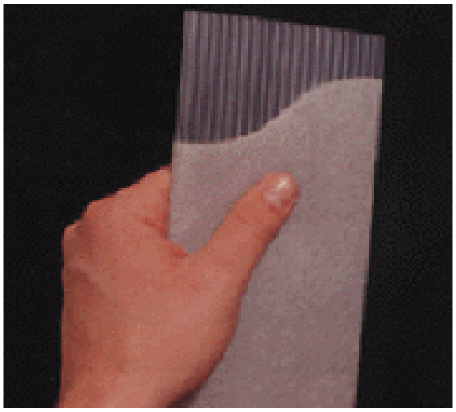

Figure 7: A non-woven wellpoint geotextile fabric will restrict the flow of water

Figure 8: Typical jetted wellpoint materials – geotextile screen and a properly graded sand maximizes yield

2. **Surface Drainage – Rim Ditches and Interior Ditches:** The rim ditch and interior ditch method are used on many ash basin closure sites, and works best when applied by experienced contractors. This can be used in conjunction with wellpoint and deep well dewatering systems. A rim or interior ditch system is effective except when low strength or flowing ash is encountered in the ditches and excavation stability is an issue. Typically this means that the phreatic surface is not lowered too far beneath the working surface.

   KEY POINTS: a) Maintenance can be an item that need to be considered with rim ditch systems that need to remain in operation in high precipitation areas, and for long term drainage/drying operations, and b) Use of rim ditches in soft/wet ash materials requires a substantial amount of contractor skill. Frequently, the companies who have the best reputation with use of rim ditches and interior ditches in ash materials have highly experienced field personnel for installation and maintenance of these systems.

Figure 9: Typical interior for rim ditch excavation

Figure 10: Typical rim ditch with sump pump for drainage

3. **Deep Well System – Conventional or Jetted Wells with Graded Filters:** Deep wells are typically used for dewatering deeper ash basins. Typically, when the ash is thicker and deeper it permits the installation of dewatering devices on wider spacing. Deep wells are usually intended to tap deeper, more permeable strata. The wells should be designed with a screen and filter sand combination to accommodate as much water as the ash will yield at any particular depth. Usually this means a well should have the screen capacity to dewater coarse clean bottom ash strata where it may be encountered. Deep well installation typically requires access for a drilling rig and other construction equipment.

Figure 11: Typical deep well installation. Photo courtesy of Moretrench.

Figure 12: Deep well at surface, prior to piping.

KEY POINTS: a) Deep wells are usually relied on to be a versatile dewatering tool. They may yield significant amounts of water or they may pump very little;
b) low yielding systems are actually more difficult to operate and maintain;
c) the wells are typically constructed with the same screen and filter materials as wellpoints and if designed and installed properly can be an effective first step in the treatment process- pumping crystal clear water.

4. **Constructed Drains – Perimeter Drains and Interior Drains:** One method that is being utilized more frequently is the construction of shallow drains at key points beneath the ash basin final cover system, stormwater channels or perimeter drains. This approach requires the involvement of the dewatering contractor and ash basin closure contractor early in the construction process to size drains and select materials.

   KEY POINTS: a) The use of constructed drains to promote dewatering is an effective way to control uncertainty and cost; b) contractors typically require some assistance from the design engineer and partial compensation from the ash basin owner to take the risk required for installation; and c) constructed drains in conjunction with rim ditches and dewatering wells have been demonstrated to work effectively on challenging ash basin projects.

Figure 13: Constructed drain with bottom ash and geogrid, Photo courtesy of R.B. Jergens

Figure 14: Interior drain with geogrid, Coal Drain geonet, prior to bottom ash placement. Photo courtesy of R.B. Jergens.

5. **Hybrid Dewatering Systems:** This type of dewatering system or method typically incorporates several of the methods described above in Items 1 to 4. A hybrid dewatering system utilizes the best tool for the local conditions and site specific application. It typically requires close coordination between the ash basin owner, design engineer and contractor.

   KEY POINT: a) The ability to use a variety of dewatering tools is an essential part of the flexibility that is required to close ash basins with somewhat unpredictable and heterogeneous fly ash layers; b) early planning and involvement of an experienced ash basin closure contractor and dewatering contractor allows the best dewatering tool to be selected at different locations; and c) a pre-planned approach that allows hybrid dewatering systems and methods to be used as part of a planned, yet flexible design approach typically increases safety and reduces cost.

UTILIZATION OF DEWATERING AS PART OF AN INTEGRATED CLOSURE DESIGN

To effectively dewater a challenging ash basin site requires consideration of the dewatering as an integral part of the overall design, instead of a “sideline” or “support” activity for construction. This requires making a paradigm shift in the ash basin closure planning process to include dewatering as an essential part of the constructability review that is conducted prior to developing the final project specifications. Recent cost evaluation and practical experience on several large ash basin closure projects indicates that consideration of dewatering during the pre-construction period will reduce uncertainty, increase safety, and result in a more cost effective ash basin closure project. Recent project experience indicates that the following needs should be considered to have the dewatering utilized as part of an integrated closure design:

1. **Determine the End Goals of the Project:** Early consideration of what is needed to dewater and stabilize a deep excavation, in-place closure or hybrid closure project can allow the owner and design engineer to reduce uncertainty and control

construction costs. This typically requires meeting with experienced ash basin closure contractors and dewatering specialty contractors after the closure plan is almost complete, but prior to a constructability review or development of specifications. Including dewatering as an integral part of the initial and final design process has been shown to reduce the overall cost of the project.

2. **Consider What Type of Dewatering Methods are Needed:** Knowing how dewatering is completed on ash basin projects provides the owner, design engineer and contractor useful information for scheduling and cost estimation. Knowledge of the different types of dewatering methods and their advantages and disadvantages for different types of fly ash and for wastewater treatment allows development of scenarios for construction. Understanding how dewatering can influence different types of ash basin closure can allow owners and design engineers to incorporate flexibility in the project specifications that helps control cost, while increasing safety when working over soft/wet ash.

3. **Obtain the Geotechnical Information and In Situ Tests for Dewatering:** If the ash basin owner and/or design engineer obtains useful geotechnical information and/or pump tests to approximate the spacing of wellpoints or drainage systems, then the contractors can develop a variety of innovative and cost effective solutions for ash basin closure. This information can also be used to develop wastewater treatment and ash basin stabilization plans. In general a lack information increases the potential risk for ash basin closure contractors and can result in an unexpected increase in the overall cost of the project.

4. **Make Information About Subsurface Conditions Available to Contractors:** One of the biggest struggles and complaints offered by experienced ash basin closure contractors and field engineers is the lack of information about the subsurface conditions on most ash basin projects. Recent developments in physical access, sampling and testing of ash basins has substantially reduced the cost of gathering this information in the design and pre-construction phases. If more information about subsurface conditions on wet ash basin is provided to contractors it almost always results in better dewatering and ash stabilization plans and reduced overall cost.

5. **Value Engineered Alternative – Start Dewatering Ahead of Construction:** It should be noted that no amount of geotechnical investigation will tell you exactly what the necessary dewatering effort will be. The work must be done in phases or “observationally”. This takes time for the review of system performance with each increment of system installation. This process, however, can be performed while final closure design is underway and the pond is sitting idle. When the time is available, the time dependent process could be underway. In such a manner, with the dewatering implemented early on, there is the opportunity to provide a pre-drained pond to the site work contractor, thus reducing the contractor’s risk and improving safety, cost and schedule.

SUMMARY AND CONCLUSIONS

The dewatering and handling of saturated fly ash on a closure construction project typically provides the highest degree of uncertainty, and the largest portion of the overall construction cost associated with ash basin closure projects. Recent experience on several large, and challenging ash basin closure projects indicates that early involvement of an experienced dewatering contractor, and practical closure construction engineers is one of the best ways to reduce risk and control cost. There are a wide range of options for dewatering the ash. Early involvement by dewatering specialists, and/or a constructability review by an experienced dewatering contractor allows for the optimal approach to be implemented in a phased or observational approach. This takes advantage of valuable time before the ash basin construction starts. The practical guidelines presented in this technical paper are offered to provide ash basin owners, design engineers and closure contractors a "tool box" of methods that can be used in a wide variety of ash basin closure and beneficial use projects.

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