NATURAL RESOURCE TECHNOLOGY

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TECHNICAL MEMORANDUM No. 1

Date: December 21, 2005

Subject: Impoundment Ranking and Replacement Liner Recommendations

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Introduction

This memorandum describes the ranking system that Natural Resource Technology, Inc. (NRT) developed for prioritizing replacement of high-volume byproduct, low-volume waste, and storm water management impoundments and basins at Midwest Generation's Joliet 29, Waukegan, Powerton, Will County, and Fisk generating stations. The ranking system is relative, with a positive score suggesting a low priority for replacement and a negative score suggesting a relatively high priority for replacement. A range of values was initially assigned to each of four criteria based on NRT's collective knowledge of the water quality of materials managed in the impoundments, performance of liner materials, susceptibility of geologic settings to groundwater contamination, and potential issues with sensitive waters, and then calibrated based on observed site conditions at the power stations. Data and descriptive information used in ranking the impoundments are listed on the attached impoundment matrix.

In addition to ranking the existing impoundments, recommendations are provided for replacement liners. Due to the performance standard approach utilized for permitting impoundments in Illinois, specific liner permeability recommendations are necessarily conservative. In most cases, other than fly ash disposal impoundments, an alternative approach based on water chemistry and calculations (possibly using a simple analytical fate and transport model) may enable permitting of less-stringent liner design.

Ranking Criteria

The impoundments were ranked based on four criteria:

1. Existing liner considering type, age, and known condition based on the Pond Characterization document and Midwest's knowledge of the liners. In particular, the Poz-O-Pac liner systems were constructed more than 25 years ago, and are reportedly in poor condition. The scoring system reflects the large differences in performance expected from the existing liner systems:

    10 – HDPE in excellent condition, new
    5 – Formed concrete, aged
    3 – Concrete in unknown condition, aged
    2 – Asphalt in unknown condition, aged
    1 – Poz-O-Pac or earthen/clay in poor condition, aged
    0 – Unknown, gravel, or no liner

2. Impoundment use based on the Pond Characterization document, the NPDES permit applications provided for Powerton ar... , and aerial photographic review of near-by features. For instance, the aerial photograph of Will County indicates that the south run-off basin generally receives parking lot run-off, which was reflected in the scoring as relatively clean stormwater. ... a ... hese features were reflected in the impoundment use scoring. The scoring system is set-up such that negative scores were given to uses most likely to cause exceedances of Illinois groundwater quality standards in the event of a leak:

   5 – General run-off (relatively clean stormwater), limestone run-off
   4 – Yard/area run-off with ASTs near-by or potential for environmental issues
   3 – Yard run-off with oil/water effluent
   0 – Slag settling
   -1 – Coal pile run-off settling
   -2 – Metal cleaning
   -3 – Fly ash settling/disposal

   From the available materials, NRT was unable to determine whether smaller basins listed as "ash settling basins" received fly ash or bottom ash sluice/contact water. This is an important distinction because bottom ash sluice water is usually less concentrated than fly ash sluice water. We have tentatively scored all ash basins as if they receive fly ash sluice/contact water. If any of these basins do not receive fly ash sluice water then the score should be adjusted more similarly to slag settling basins.

3. Geologic setting based on regional geology as depicted in the Illinois State Geological Survey stack unit map (ISGS Circular 542), local geology from the EPRG Geotechnical Analysis of Soil Surrounding the Basins, and the map of Potential for Contamination of Shallow Aquifers (ISGS Circular 532). The ISGS designated areas of high contamination potential as having sand and gravel or transmissive bedrock near the land surface and areas of low contamination potential as having thick sequences of fine-grained silt and clay or less-transmissive bedrock near the land surface. The scoring system was set up to reflect these designations; however, because it is preferable to prevent releases of potentially contaminated water than to rely on geologic conditions to contain releases, the range of values assigned to the geologic setting is narrower than the ranges for the liner type/condition and impoundment use, effectively placing less weight on this criterion:

   0 – Regional fine-grained materials (typically silty/clayey diamicton), confirmed by adjacent soil boring indicating fine-grained soils: relatively low contamination potential.
   -1 – Regional fine-grained materials (typically silty/clayey diamicton), not confirmed by adjacent soil boring, which indicated coarse-grained soils: contamination potential uncertain.
   -2 – Regional conditions indicating bedrock or sand and gravel formation or highly permeable man-made conditions, confirmed by adjacent soil boring indicating generally coarse-grained material: relatively high contamination potential.

4. Adjacency of impoundments to a sensitive water body (Lake Michigan). Only one of the six stations is located adjacent to Lake Michigan, with the remainder located on rivers. The Great Lakes are considered more environmentally sensitive than regional rivers, as reflected by initiatives such as the Great Lakes Water Quality Initiative. Therefore, an additional score was assigned to account for this sensitivity:

   0 – Impoundment/basin located adjacent to river
   -1 – Impoundment/basin located adjacent to Lake Michigan (Waukegan)

Ranking Results

Based on the above criteria, the scores were totaled and the impoundments were grouped for priority of replacement. Three impoundments at two stations had the lowest possible ranking score of -5 indicating highest priority for replacement:

Scores of -5:

Powerton – Secondary Ash Settling Basin, Bypass Basin

Nineteen additional impoundments had negative scores (-1 to -4) that indicate moderate priority for replacement:

Scores of -4: **Joliet 29** – Ash Impoundments 1, 2, and 3

Powerton – Ash Surge Basin

Will County – South Ash Impoundments 1, 2, and 3; North Ash Impoundment

Redwater

The remainder of the impoundments scored between 0 and 7 and have a relatively low priority for replacement.

Other Potential Ranking Criteria

A large group of impoundments had negative ranking scores. Further prioritization of these impoundments could be based on capacity. Higher priority might be given to impoundments with greater capacity, because the large area decreases potential dilution and dispersion, thereby increasing potential for environmental impact. Conversely, permitting for the replacement of large impoundment liners may be more difficult, and Midwest may choose to initially replace liners for smaller basins that have less-intensive permitting requirements.

Another criterion for ranking could be related to known groundwater impacts associated with an individual impoundment. If Midwest desires, NRT could research which impoundments have documented groundwater issues, which would likely result in a more-refined prioritization of the 22 impoundments and basins with scores indicating high to moderate priority.

Recommended Replacement Liner Permeability and Materials

NRT understands that Midwest Generation intends to use the ranking system developed here as the basis for a program to replace impoundment liners. For each type of impoundment, we have recommended a liner permeability and replacement liner material. Recommendations were based on Midwest's desire for cost-effective liner materials, and more importantly, for low maintenance materials. Below is a summary table of our recommendations for each type (category) of impoundment.

Category	Impoundment Use	Liner Permeability and Basis	Recommended Liner Replacement Material
I	Fly Ash Settling/Disposal	$1x10^{-7}$ cm/s max., typically required for basin permitting, may also facilitate eventual closure	-Compacted clay (5 ft thick **) -Geomembrane (60 mil HDPE **) * refer to category I discussion below
II	Metal Cleaning/Settling	$1x10^{-7}$ cm/s approx. or protective of groundwater quality standards	-Geomembrane (40 or 60 mil HDPE) (if liquids are untreated) -4 to 6" asphalt or concrete (if liquids are treated)
III	Coal Pile Run-off/Settling	$1x10^{-7}$ cm/s approx. or protective of groundwater quality standards	-Compacted Clay (typically 2 ft thick) -4 to 6" of asphalt or concrete
IV	Bottom Ash/Slag Settling	$1x10^{-7}$ cm/s approx. or protective of groundwater quality standards	-Compacted Clay (typically 2 ft thick) -4 to 6" asphalt or concrete
V	Yard Run-off/General Run-off	Site specific, relative to expected water quality and site drainage needs	-Earthen; compacted soils and/or gravel

Liner materials that have been proven over the years to have a permeability of less than $1x10^{-7}$ cm/s are compacted clay and geomembranes, when constructed according to material specific quality assurance and testing requirements. For impoundments, the geomembrane material typically selected is HDPE due to its high resistance to breakdown when exposed to sunlight. Although PVC is less expensive then HDPE and easier to install, due to its flexibility, it will break down over time if exposed to sunlight. Therefore, PVC would be highly maintenance intensive on impoundment side slopes where it is exposed if the blanket cover material erodes. Clay can be cost-effective, if a near-by borrow source is available, and is typically a low maintenance liner material. Due to availability concerns, an alternative to clay was also recommended for each type of impoundment. Clay liner installation is straightforward for most contractors if the liner material and quality control testing requirements are specified in the bid documents. If damaged, a clay liner can be easily repaired, unlike geomembranes, which typically require a certified installer to perform repairs.

As indicated in Technical Memorandum No. 2, properly installed asphalt and concrete liners may initially meet the 10^{-7} cm/s permeability value, but they fail to meet this permeability over time due to cracking or other wearing (mechanical equipment or natural). Therefore, asphalt and concrete liners are not recommended for impoundments that contain highly concentrated water (e.g., fly ash, undiluted demineralizer regenerant), since leakage could result in groundwater quality standard exceedances. Both materials can be formulated to provide adequate resistance to the chemicals in power plant process waters. These types of liners are more practical than clay and HDPE in basins from which sludge is removed either occasionally or periodically because they are more resistant to damage by heavy machinery. Concrete is more resistant to damage than asphalt, but is also more expensive. Both will

require maintenance for sealing of cracks (if low permeability must be maintained). Asphalt's lower compressive strength makes it more susceptible to damage by mechanical equipment (i.e. front end loader) than concrete; however, it may be adequate if a reasonable level of care is taken. A reasonable approach may be to use concrete for smaller basins where sludge removal is more frequently necessary (one or more times per year) and to use asphalt for larger run-off basins where sludge removal is less frequent (once every couple years).

Category I: Fly Ash Settling/Disposal Impoundments

Fly ash management basins typically have concentrations of boron and sulfate that are higher than Illinois Class I groundwater quality standards. In addition, depending on redox conditions in the basins, some trace metals may have elevated concentrations. Illinois has based permit approvals for impoundments largely on expected performance of the proposed liner material in a site-specific setting for ultimate protection of Part 620 groundwater quality standards (Class I in most cases). Industry standards on liner permeabilities for ash impoundments exist based our knowledge of the Illinois approval process. Liner permeability of $1x10^{-7}$ cm/s or better is typical of what is required to obtain a permit from the IEPA Bureau of Water Section. However, liner permabilities of greater than 1×10^{-7} cm/s may be approved if fate and transport groundwater modeling indicates that this higher permeability is protective of groundwater quality standards.

Midwest Generation may also consider future closure of the ash impoundment when designing a liner. Unless a separate agreement is negotiated, ash impoundments are typically closed under solid waste landfill regulations, and an adjusted standard may be required if the liner of a newly constructed impoundment does not meet liner requirements (e.g. 5 ft of clay or 60 mil geomembrane) as specified in 35 Ill. Adm. Code Parts 811.306 through 811.308. Consideration may also be given to installing a leachate collection system, which would not be used until the impoundment was closed, and would again address potential Part 811 issues upon closure.

Category II: Metal Cleaning/Settling Basins

For basins containing metal cleaning wastes (prior to treatment) and/or high percentages of demineralizer regenerant, NRT recommends a liner capable of approximately $1x10^{-7}$ cm/s permeability due to the potential for highly concentrated waters with significant pH swings. A geomembrane liner material is recommended if non-neutral (i.e. acidic or caustic) conditions may be present from the metal cleaning wastes or demineralizer regenerant. If this is not a concern, an asphalt or concrete liner is recommended because it is more resistant to damage during sludge removal. Sludge cleaning and repair of a damaged liner is much easier with asphalt or concrete than with geomembranes.

Categories III and IV: Coal Pile Run-off Settling and Bottom Ash/Slag Settling Basins

From a regulatory perspective, liner permeabilities for coal pile run-off and bottom ash/slag settling basins are based on predicted site-specific performance and demonstration of protection of groundwater quality standards. Waters in these basins typically have concentrations of inorganic constituents, such as sulfate and sometimes boron, that are higher than Part 620 groundwater quality standards. Without the use of site-specific groundwater modeling, we referred to the Illinois regulations of sewage and livestock impoundments (Sewage: 35 Ill. Adm. Code Part 370.930(d)(2)(D); Livestock: 35 Ill. Adm. Code Part 506.205). These regulations specify a permeability of $1x10^{-7}$ cm/s, using a 2-foot thick clay liner or geosynthetic material. Due to Midwest's desire for low maintenance liners and the relatively low concentration waters managed in these basins (suggesting less stringent permeability requirements), NRT recommends asphalt or concrete for sludge removal reasons, or clay as an alternate to these materials.

Category V: Yard Run-off/General Run-off Basins

Permeabilities for yard or area run-off basins are specific to each impoundment drainage area, and are based on expected water quality and site drainage needs. Water quality concerns are not typically envisioned with these basins. Therefore, these basins are normally designed to meet stormwater drainage and detention requirements rather than liner permeability requirements. A design often employed at power plants is to include an engineered gravel bottom, which facilitates sediment clean-out by providing a visible and resistant base layer. Alternatively, if a yard run-off basin has the potential to contain oil residue and associated dissolved phase concentrations, lower liner permeabilities may be necessary (on the order of $1x10^{-5}$ to $1x10^{-6}$ cm/s). It may be possible to achieve this goal by compacting on-site soils if they contain sufficient clay and silt.

Impoundment Matrix
Midwest Generation

FACILITY LOCATION: WILL COUNTY (Adjacent to Chicago Sanitary and Ship Canal)

Impoundment ID	South Ash Impoundment 3	South Ash Impoundment 2	South Ash Impoundment 1	North Ash Impoundn
Use	Ash settling	Ash settling	Ash settling	Ash settling
Contributing Waters/ Waste	Ash settling	Ash settling	Ash settling	Ash settling
Discharge Point	Chicago Sanitary and Ship Canal	Chicago Sanitary and Ship Canal	Chicago Sanitary and Ship Canal	Chicago Sanitary and Canal
Primary Water Routing	WWTP & Outfall 002	WWTP & Outfall 002	WWTP & Outfall 002	WWTP & Outfall 0
Ranking Score of Impoundment Use	-3	-3	-3	-3
Approx. Width (ft)	234	178	195	167
Approx. Length (ft)	322	350	300	333
Approx. Depth (ft)	7	7	7	7
Estimated Capacity (ft^3)	532,200	505,900	461,700	506,500
Midwest Est. Capac. (ft^3)	530,000	510,000	460,000	520,000
Estimated Liner Surface Area (ft^2)	89,537	85,500	78,400	85,400
Liner Material	6-6" lifts Poz-O-Pac. bottom and sides	6-6" lifts Poz-O-Pac. bottom and sides	6-6" lifts Poz-O-Pac. bottom and sides	6-6" lifts Poz-O-Pac. b and sides
Liner Condition, if known	Poor	Poor	Poor	Poor
Liner Constructed in:	1977	1977	1977	1977
Ranking Score of Liner	1	1	1	1
Soil Boring (Depth)	WC-GT-4 (5'-10')	WC-GT-4 (5'-10')	WC-GT-3 (3'-8')	WC-GT-2 (5'-10')
Soil Description	Sandy fine to coarse gravel with clay	Sandy fine to coarse gravel with clay	Clayey gravelly fine to coarse sand	Sand with gravel
Revised Soil Description (1)	--	--	Clayey gravel with sand	--
USCS	GC	GC	*GC*	SC
Percent Passing #4	60	60	53	79
Percent Passing #200	23.3	23.3	19.7	11.9
Density (pcf)	128	128	103	92
Permeability (cm/sec)	3.65E-07	3.65E-07	1.86E-06	4.02E-03
Contamination Potential (2)	High	High	High	High
Stack Unit Designation	Silurian & some Devonian rocks, mostly dolomite	Silurian & some Devonian rocks, mostly dolomite	Silurian & some Devonian rocks, mostly dolomite	Silurian & some Dev rocks, mostly dolom
Ranking Score of Geologic Setting	-2	-2	-2	-2
Ranking Score for Receiving Water Sensitivity	0	0	0	0
Total Ranking Score	-4	-4	-4	-4
Recommended Replacement Liner Permeability and Material, By Category (3)	I	I	I	I

* = unable to perform permeability test, too much stone, not enough soil

** = remolded sample to obtain the dry density

USCS (in italics) determined by NRT using grain size distribution curve

E = Estimated Depth

NA = Not Available

-- = Not Applicable

(1) Where applicable, NRT revised soil descriptions to match grain size distributions and USCS.

(2) Based on ISGS Circulars 532 and 542, see technical memorandum No. 1 for further explanation.

(3) Reference NRT Technical Memorandum No. 1 for category descriptions.

Impoundment Matrix
Midwest Generation

FACILITY LOCATION: POWERTON (Adjacent to Illinois River)

Impoundment ID	Ash Surge Basin	Secondary Ash Settling Basin	Bypass Basin	Metal Cleaning Basin
Use	Ash settling	Ash settling	Ash surge bypass	Metal settling
Contributing Waters/ Waste	Ash sluice, slag tank overflow, demin regen, filter backwash, metal cleaning & east yard trnt eff.	Same as ash surge basin	Same as ash surge basin	Air heater, precip, econ. & rear pass wash water, demin regen (alt route)
Discharge Point	Illinois River	Illinois River	Illinois River	Illinois River
Primary Water Routing	Sec. Ash Settling Basin	Outfall 001	Sec. Ash Settling Basin	Ash Settling Basin
Ranking Score of Impoundment Use	-3	-3	-3	-2
Approx. Width (ft)	250	223	135	120
Approx. Length (ft)	960	324	256.5	350
Approx. Depth (ft)	14	10 E	10 E	12
Estimated Capacity (ft^3)	4,104,400	594,400	264,900	727,800
Midwest Est. Capac. (ft^3)	4,100,000	NA	NA	720,000
Estimated Liner Surface Area (ft^2)	354,600	77,600	39,500	83,200
Liner Material	2-6" lifts Poz-O-Pac on bottom, hypalon on sides	No liner	Unknown	2-6"lifts Poz-O-Pac on bottom, hypalon on sides
Liner Condition, if known	Poor	–	Unknown	Poor
Liner Constructed in:	1978	Unknown	Unknown	1978
Ranking Score of Liner	1	0	0	1
Soil Boring (Depth)	PS-GT-7 (10'-13')	PS-GT-5 (17'-19')	PS-GT-8 (10'-15')	PS-GT-6 (15'-20')
Soil Description	Sand w/silt and gravel	Clayey sand, trace gravel	Silty sand, trace clay	Fill: sand (fine to med.) trace gravel
Revised Soil Description (1)	--	–	–	–
USCS	SW-SM	*SC/SM*	SM	SP
Percent Passing #4	86	88	99	100
Percent Passing #200	7	44	14	5
Density (pcf)	118	93	115	113.5
Permeability (cm/sec)	2.20E-03	NA	2.31E-02	8.37E-03
Contamination Potential(2)	High	High	High	High
Stack Unit Designation	Henry Formation (sand & gravel)	Henry Formation (sand & gravel)	Henry Formation (sand & gravel)	Henry Formation (sand & gravel)
Ranking Score of Geologic Setting	-2	-2	-2	-2
Ranking Score for Receiving Water Sensitivity	0	0	0	0
Total Ranking Score	-4	-5	-5	-3
Recommended Replacement Liner Permeability and Material, By Category (3)	I	I	I	II

Revised

* = unable to perform permeability test, too much stone, not enough soil

** = remolded sample to obtain the dry density

USCS (in italics) determined by NRT using grain size distribution curve

E = Estimated Depth

NA = Not Available

– = Not Applicable

(1) Where applicable, NRT revised soil descriptions to match grain size distributions and USCS.

(2) Based on ISGS Circulars 532 and 542, see technical memorandum No. 1 for further explanation.

(3) Reference NRT Technical Memorandum No. 1 for category descriptions.

Impoundment Matrix
Midwest Generation

FACILITY LOCATION: WAUKEGAN (Adjacent to Lake Michigan)

Impoundment ID	East Ash Impoundment	West Ash Impoundment
Use	Ash settling	Ash settling
Contributing Waters/ Waste	Ash settling	Ash settling
Discharge Point	Lake Michigan	Lake Michigan
Primary Water Routing	WWTP - Outfall C01	WWTP - Outfall C01
Ranking Score of Impoundment Use	-3	-3
Approx. Width (ft)	437.5	437.5
Approx. Length (ft)	927.5	927.5
Approx. Depth (ft)	22.5	22.5
Estimated Capacity (ft^3)	7,705,900	7,705,900
Midwest Est. Capac. (ft^3)	7,700,000	6,500,000
Estimated Liner Surface Area (ft^2)	502,000	502,000
Liner Material	HDPE on bottom and sides	HDPE on bottom and sides
Liner Condition, if known	Excellent	Excellent
Liner Constructed in:	2002	2002
Ranking Score of Liner	10	10
Soil Boring (Depth)	WS-GT-5 (22'-27')	WS-GT-4 (22'-27')
Soil Description	Sand w/trace gravel	Sand w/trace gravel
Revised Soil Description [1]	--	--
USCS	SP	SP
Percent Passing #4	97	86
Percent Passing #200	0	2
Density (pcf)	96	114
Permeability (cm/sec)	1.00E-03	2.16E-02
Contamination Potential[2]	High	High
Stack Unit Designation	Surface mines/man-made land	Surface mines/man-made land
Ranking Score of Geologic Setting	-2	-2
Ranking Score for Receiving Water Sensitivity	-1	-1
Total Ranking Score	4	4
Recommended Replacement Liner Permeability and Material, By Category [3]	I	I

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(2) Based on ISGS Circulars 532 and 542, see technical memor
(3) Reference NRT Technical Memorandum No. 1 for category

Impoundment Matrix
Midwest Generation

FACILITY LOCATION: JOLIET 29 (Adjacent to Des Plaines River)

Impoundment ID	Ash Impoundment 1	Ash Impoundment 2	Ash Impoundment 3
Use	Ash settling	Ash settling	Clarifying pond
Contributing Waters/ Waste	Ash settling	Ash settling	Ash settling
Discharge Point	Des Plaines River	Des Plaines River	Des Plaines River
Primary Water Routing	Ash Impoundment 3	Ash Impoundment 3	Outfall 001g
Ranking Score of Impoundment Use	-3	-3	-3
Approx. Width (ft)	168	168	220
Approx. Length (ft)	419	419	340
Approx. Depth (ft)	19	19	15
Estimated Capacity (ft^3)	2,055,500	2,055,500	1,086,100
Midwest Est. Capac. (ft^3)	2,000,000	2,000,000	1,100,000
Estimated Liner Surface Area (ft^2)	154,700	154,700	103,200
Liner Material	2-6" lifts Poz-O-Pac liner on bottom and sides	2-6" lifts Poz-O-Pac liner on bottom and sides	2-6" lifts Poz-O-Pac liner on bottom and sides (based on 1&2)
Liner Condition, if known	Poor	Poor	Poor
Liner Constructed in:	1978	1978	1978
Ranking Score of Liner	1	1	1
Soil Boring (Depth)	JS-29-GT-1 (19'-24')	JS-29-GT-3 (19'-24')	JS-29-GT-4 (17'-22')
Soil Description	Sandy gravel, trace clay	Poorly graded gravel w/clay and sand	Limestone with fine to coarse sand
Revised Soil Description (1)	--	--	--
USCS	GW	GP-GC	GP
Percent Passing #4	36	27	28
Percent Passing #200	8.7	9	7
Density (pcf)	120	121**	124
Permeability (cm/sec)	2.96E-02	2.51E-02	NA*
Contamination Potential (2)	High	High	High
Stack Unit Designation	Silurian & some Devonian rocks, mostly dolomite	Silurian & some Devonian rocks, mostly dolomite	Silurian & some Devonian rocks, mostly dolomite
Ranking Score of Geologic Setting	-2	-2	-2
Ranking Score for Receiving Water Sensitivity	0	0	0
Total Ranking Score	-4	-4	-4
Recommended Replacement Liner Permeability and Material, By Category (3)	I	I	I

* = unable to perform permeability test, too much stone, not enough soil

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