Prepared for:

Talen Energy
835 Hamilton St., Suite 150
Allentown, PA 18101

CLOSURE PLAN

Per Requirements of 40 CFR §257.73(c)

Montour SES Ash Landfill 3
Washingtonville, Pennsylvania

Prepared by:

Geosyntec consultants

10211 Wincopin Circle, Floor 4
Columbia, Maryland 21044

Project Number ME1207A

October 2016

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1. INTRODUCTION

1.1 Organization and Terms of Reference

Geosyntec Consultants (Geosyntec) has prepared this Closure Plan for Talen Generation, LLC (Talen) to demonstrate compliance of the existing Montour SES Ash Landfill 3 (Ash Landfill 3) in Washingtonville, Pennsylvania with the closure requirements of the Federal Coal Combustion Residuals (CCR) Rule. On 17 April 2015, the USEPA published the final rule for disposal of CCR from electric power utilities under Subtitle D of the Resource Conservation and Recovery Act (RCRA), contained in Section 257 of Title 40 of the Code of Federal Regulations (40 CFR 257 Subpart D), referred to here as the CCR Rule. Section 257.102 contains the requirements for conducting closure of CCR landfills. In this Closure Plan, the specific requirements of §257.102 are identified and addressed.

This Closure Plan was prepared by Mr. Mike Nolden, E.I.T., and it was reviewed in accordance with Geosyntec's internal review policy by Mr. Michael Houlihan, P.E. and Mr. Thomas Ramsey, P.E., all of Geosyntec. Mr. Ramsey is a registered Professional Engineer in the Commonwealth of Pennsylvania.

1.2 Site Location

Montour SES is located in Washingtonville, Montour County, Pennsylvania. The site can be found on a United State Geological Survey 7.5-minute topographic map for the Washingtonville Quadrangle (Figure 1). Ash Landfill 3 is located within the Montour SES site, southeast of the generating station.

1.3 Landfill Description

Ash Landfill 3, also called Ash Area 3 or Ash Storage Area 3, is a CCR landfill constructed in 1990 to accept coal combustion residuals produced by the Montour SES, as described by Form R of the Pennsylvania Department of Environmental Protection (PADEP) Class II Residual Waste Disposal Facility permit renewal (PADEP Permit) application package (PPL 2007). Ash Landfill 3 has been in service since 1991 (PPL 2007).

Ash Landfill 3 is regulated under the Pennsylvania Residual Waste Regulations of Title 25 PA Code, Chapters 287 and 288. The unit is permitted as a PADEP Residual Waste Disposal Facility. Ash Landfill 3 was constructed and is operated under a renewal of Permit No. 300987 for a Landfill—Class II (PADEP 2007), which was issued in August 2007.

Ash Landfill 3 was designed as a two-phase landfill with each phase comprising three levels, as shown on Drawing E-195972-3 in Appendix A. Currently, landfilling operations have only been performed in Phase I. The portion of the permit area designated for Phase II remains undeveloped. Ash Landfill 3 is lined with a liner system that includes a 30-mil polyvinyl chloride geomembrane (Attachment 1 to Form 1R of PPL 2007).

A closure plan was submitted to and approved by PADEP as part of the residual waste disposal permit. It is included as Attachment 1 of Form 18R of PPL (2007) (Appendix B). The approved closure plan is for closure in place. As such, §257.102(b)(1)(ii) is not applicable.

2. CCR RULE REQUIREMENTS FOR WRITTEN CLOSURE PLAN (§257.102(B))

2.1 Written Closure Plan (§257.102(b)) Requirements

As described in §257.102(b) of the CCR Rule, a written closure plan must be prepared for Ash Landfill 3 that describes the steps necessary to close the CCR unit at any point during the active life of the CCR unit consistent with recognized and generally accepted good engineering practices. The written closure plan must include, at a minimum, the information specified in paragraphs (b)(1)(i) through (vi) of §257.102, including:

(i) A narrative description of how the CCR unit will be closed in accordance with §257.102.
(ii) If closure of the CCR unit will be accomplished through removal of CCR, a description of the procedures to remove the CCR and decontaminate the CCR unit in accordance with paragraph §257.102(c).
(iii) If closure of the CCR unit will be accomplished by leaving CCR in place, a description of the final cover, designed in accordance with paragraph §257.102(d), and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover will achieve the performance standards specified in paragraph §257.102(d).
(iv) An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR unit.
(v) An estimate of the largest area of the CCR unit ever requiring a final cover as required by paragraph §257.102(d) at any time during the CCR unit's active life.
(vi) A schedule for completing all activities necessary to satisfy the closure criteria, including an estimate of the year in which all closure activities will be completed as well as duration of such activities. The schedule should provide sufficient information to describe the sequential steps that will be taken to close the CCR unit, including identification of major milestones such as coordinating with and obtaining necessary approvals and permits from other agencies, construction of the final cover, and the estimated timeframes to complete each step or phase of CCR unit closure. If the owner or operator of a CCR unit estimates that the time required to complete closure will exceed the timeframes specified in paragraph §257.102(f)(1), that is within six months of commencement of closure activities, supporting information must be provided to request an extension. The schedules should consider the requirements of §257.102(e) (Initiation of Closure Activities) and §257.102(f) (Completion of Closure Activities).

In addition, the owner or operator of the CCR landfill must comply with the requirements of §257.102(g), (h), (i), and (j), which pertain to notification of intent to close, notification of closure, deed notations, and recordkeeping requirements, respectively.

2.2 Compliance with Closure Requirements

Part 3 of this document presents the written closure plan required by the CCR Rule. The table below summarizes where the CCR Rule requirements are addressed in this document.

Geosyntec consultants

RULE SECTION	RULE REQUIREMENT	LOCATION WHERE ADDRESSED IN DOCUMENT
§257.102(b)(1)(i)	Narrative of How Unit will be Closed with CCR in Place	Section 3.1
§257.102(b)(1)(ii)	Narrative of How Unit Will be Closed by Removal of CCR Removal	NA
§257.102(b)(1)(iii)	Description of Final Cover	Section 3.2
	Discussion of How Final Cover System will Meet Performance Standard of §257.102(d)	Section 3.3
§257.102(b)(1)(iv)	CCR Maximum Inventory Estimate	Section 3.4
§257.102(b)(1)(v)	Closure Area Estimate	Section 3.5
§257.102(b)(1)(vi)	Schedule for Completing Closure Activities	Section 3.6
§257.102(b)(4)	Written Certification by a Qualified Professional Engineer that the Written Closure Plan meets the requirements of §257.102(b)	Section 4

3. CLOSURE PLAN

3.1 Description of Closure

Per §257.102(b)(1)(i), this section provides a narrative description of the unit closure. This description is consistent with the approved Closure Plan for PADEP Permit 300987, which is included as Attachment 1 of Form 18R of PPL (2007).

Ash Landfill 3 will be closed by leaving CCR in place, constructing an alternative final cover over the active area of the unit, and complying with other requirements of the CCR Rule. The closure of each cell of the unit will occur as each cell reaches its capacity, according to the intermediate development plan shown on drawings E-195969, E-195970, and E-195971 of Appendix A.

3.2 Description of Final Cover

Per §257.102(b)(1)(iii), the following paragraphs provides a description of the proposed alternative final cover in accordance with the requirements of §257.102(d)(3)(ii).. The proposed final cover is shown in detail in Section 10-10 of Drawing E-195971.

The final cover is designed with geosynthetic and soil-like components and is designed to have a permeability less than or equal to the Ash Landfill 3 liner system, which is constructed with similar soil-like components and a 30-mil PVC geomembrane that has equivalent permeability to the geomembrane of the cover system. The final cover will comprise (from bottom to top):

- 40-mil PVC geomembrane;
- 12-oz geotextile;
- 8-inch bottom ash drainage layer;
- geotextile filter layer; and
- 18-inch protective cover and vegetative support (i.e., erosion) layer capable of sustaining vegetation.

The final cover will be installed according to the requirements described in Specification PPC-2007 Site Development (Attachment 2a to Form 16R of PPL 2007). Prior to commencing closure construction activities, both geosynthetic and soil materials proposed for construction will be evaluated according to the approved Quality Control and Quality Assurance Plan (Attachment 5 to Form 16R of PPL 2007), to ensure that the specified materials achieve the design standard. The approved construction quality assurance program will be implemented to monitor that the final cover and associated features are constructed in accordance with the design documents and applicable regulations.

As an alternative final cover, the proposed final cover includes a 40-mil polyvinyl chloride (PVC) geomembrane and an 8-inch bottom ash lateral drainage layer, which will minimize the head on the geomembrane and thus, the infiltration through the final cover. Calculations demonstrating the capacity of the lateral drainage layer are presented in Attachment 5a to Form 16R of PPL (2007).

The combination of the geomembrane and the bottom ash drainage layer is expected to provide the necessary barrier to make the permeability of the final cover less than or equal to that of the liner system. Final cover percolation analysis presented in Appendix C.1 indicates that the proposed final cover will achieve an equivalent reduction in infiltration as the infiltration layer specified in §§257.102(d)(3)(i)(A) and (B) (§257.102(d)(3)(ii)(A)).

The geomembrane and bottom ash drainage layer will be overlain by a geotextile separator and an 18-inch soil layer, which will protect the underlying cover components and provide vegetative support to minimize erosion of the final cover (§257.102(d)(3)(ii)(B)). The cover soils will be obtained from the Ash Landfill 3 area and other onsite sources (Attachment 1 to Form 18R of PPL 2007). Sampling and analytical procedures to determine the suitability of proposed cover soils is discussed in Attachment H-1A of Form H of PPL (2007).

The proposed final cover will be constructed with geosynthetic and soil-like materials that are sufficiently flexible to accommodate local differential settlements and subsidence (§257.102(d)(3)(ii)(C), as demonstrated by the final cover settlement analysis presented in Appendix C.2 .

3.3 Performance Standard

The methods and materials of construction discussed above were specified such that the final cover meets the design standard described by the CCR Rule (§257.102(d)(1)) as described below.

- The unit will be closed in a manner to control and minimize, to the extent feasible, post-closure infiltration of liquid into the waste (§257.102(d)(1)(i)) by incorporating a low-permeability final cover that meets the requirements of §257.102(d)(3)(ii)A through C. The low permeability of the cover is achieved through the use of a geomembrane and geocomposite drainage layer, as described in Section 3.2. The final cover will preclude contact of surface water with underlying waste, thereby minimizing, to the extent feasible, releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.

- The surface of the final cover will be graded and include stormwater control features (i.e. bench drains) such that the cover system does not impound water, sediment, or slurry, even after settlement of the underlying waste has occurred (§257.102(d)(1)(ii)). A narrative description of the provisions for stormwater control is included in the unit Design Concept and Operating Plan (Attachment 1 to Form 1R of PPL 2007a). Approved stormwater management calculations are presented in Attachment 1 to Form I of PPL (2007a.). Results of the final cover settlement analysis indicate that the stormwater control features will continue to operate as designed following settlement of the unit.

- The approved Quality Control and Quality Assurance Plan (PPL 2007, Attachment 5 to Form 16R) will be implemented such that the final cover will be constructed as designed. The results of veneer slope stability analysis presented in Appendix C.3 indicate that the proposed final cover will maintain major slope stability and integrity throughout the closure and post-closure periods (§257.102(d)(1)(iii)).

- The final cover will be vegetated with native, non-woody vegetation requiring minimal maintenance such as mowing (§257.102(d)(1)(iv)). Revegetation and maintenance of the final cover system is discussed in Sections 5E and 5G of the approved closure plan. Proposed seed mixtures and other methods and materials for the revegetation of the final cover are presented in Attachments H4 through H11 to Form H of PPL (2007a).
- Closure activities will be initiated and completed in accordance with the conceptual closure schedule described in Section 3.6 of this document and Sections 2 and 3 of the approved closure plan. This schedule of closure activities presumes that significant work will be completed by Talen prior to the decision to close the unit, leaving only final capping and vegetative establishment work remaining for the following six months of the closure period. Using this approach, in the opinion of Geosyntec, completion of closure would be performed in the shortest amount of time consistent with recognized and generally accepted good engineering practice (§257.102(d)(1)(v)).

3.4 Maximum Inventory of CCR

The CCR Rule (§257.102(b)(1)(iv)) requires that the written closure plan provide an estimate of the maximum inventory of CCR on site over the active life of the CCR unit. However, the preamble to the CCR Rule states that if portions of the unit are routinely closed, only the active portion should be considered for inventory. Because Ash landfill 3 is to be filled and closed in three separate cells per phase, the maximum amount of CCR onsite during the active life of the unit is dependent on which cell is active at the time of closure. At the time of the preparation of this closure plan, Phase I, Level III is active. The estimated maximum inventory of CCR in Phase I, Level III is 330,794 cubic yards (Attachment 1 to Form 1R of PPL 2007).

3.5 Maximum Area Requiring a Final Cover

The CCR Rule (§257.102(b)(1)(v)) requires that the written closure plan provide an estimate of the largest area of the CCR unit requiring final cover at any one time in the CCR unit's active life. However, the preamble to the CCR Rule states that if portions of the unit are routinely closed, only the active portion should be considered to require closure. Because Ash landfill 3 is to be filled and closed in three separate per phase, the largest area requiring final cover is dependent on which cell is active and requiring final closure. At the time of the preparation of this closure plan, Phase I, Level II is active. The approximate area of Phase I, Level III requiring closure is 11 acres (based on the illustration on Drawing E-195969 of Appendix A).

3.6 Closure Schedule

Ash Landfill 3 is expected to remain open and active throughout the remaining operating life of the facility, if beneficial use of CCR continues. When a decision is made to close the unit, closure activities will commence within 30 days of the final receipt of waste (per the requirements of

§257.102(e)(1)(i)) and all closure activities will be completed, as required by §257.102(f)(1)(i), within six months of the commencement of closure activities.

The conceptual schedule below lists major milestones expected during closure activities. The time to reach each milestone, starting from the commencement of closure activities, are included.

Milestone	Maximum Anticipated Time for Completion (from date of decision to close unit)
Final Closure System Design	Prior to Commencing Closure
Approval and Permits Obtained from PADEP	Prior to Commencing Closure
Commencement of Closure System Construction Activities	Within 30 days of final receipt of CCR
Complete Construction of Closure System	Within 6 months of commencing closure

4. CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

Per §257.102(b)(4), the owner or operator of the unit must obtain a written certification from a qualified professional engineer that the written closure plan meets the requirements of the CCR Rule.

Certification for Written Closure Plan

CCR Unit: Montour SES Ash Landfill 3

Certification

I, **Thomas B. Ramsey**, a registered professional engineer in the Commonwealth of Pennsylvania certify that the Written Closure Plan for the Montour SES Ash Landfill 3 is in compliance with requirements of 40 CFR §257.102(b). This certification is based on my review of information described in this certification report.

Printed Name	Thomas B. Ramsey		
PE License Number	PA071551	**State**	Pennsylvania
Signature		**Date**	12 OCTOBER 2016

Seal

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
THOMAS BRUCE RAMSEY
ENGINEER
No. 071551

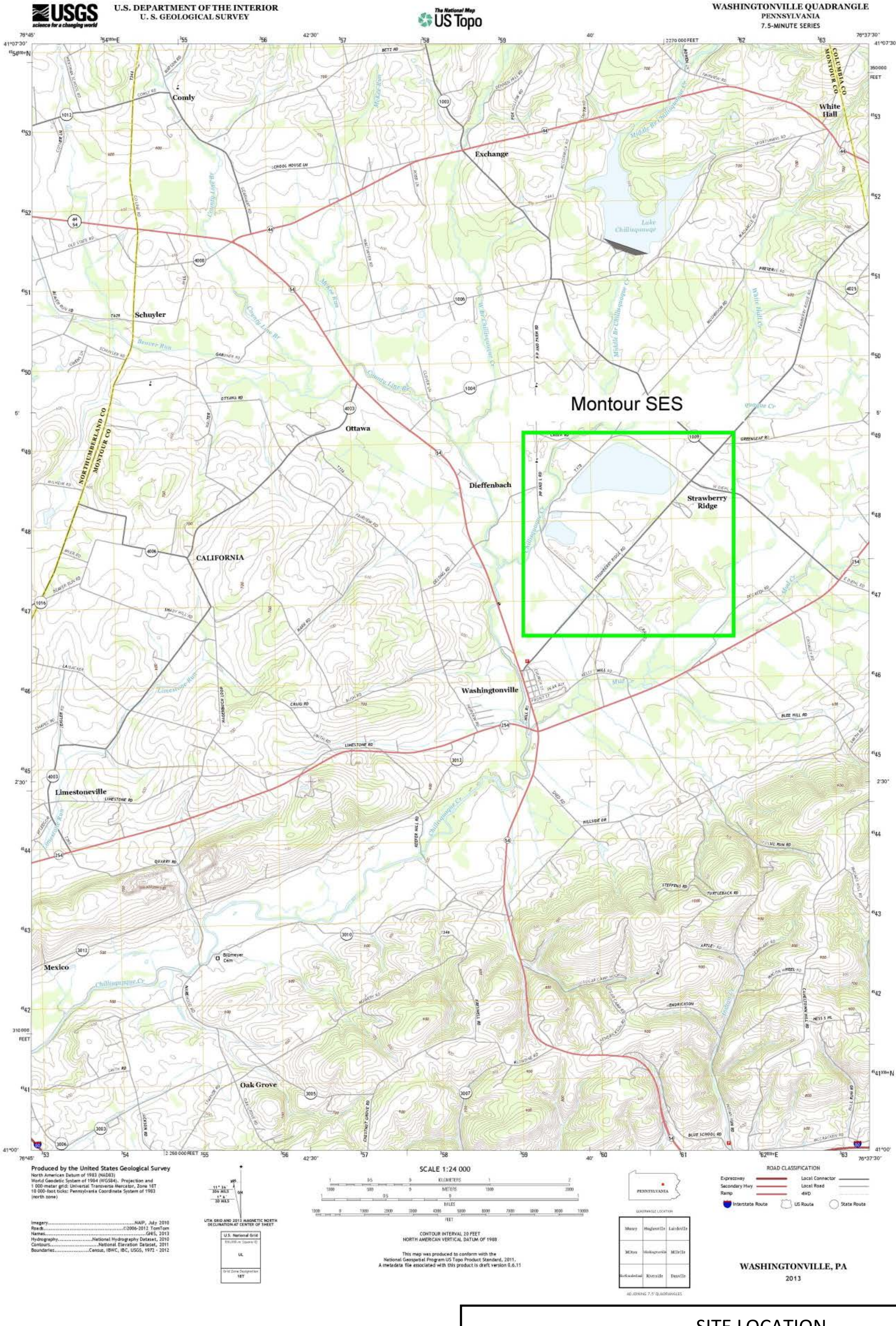
5. REFERENCES

PADEP (2007). "Permit for Solid Waste Disposal and/or Processing Facility FORM NO. 8." Pennsylvania Department of Environmental Protection, Bureau of Land Recycling and Waste Management. August 2007.

PPL (2007). "PPL Montour, LLC – Ash Area #3 Permit Renewal Application – SWP 300987." PPL Services Corporation. Allentown, PA. March 2007.

United States Environmental Protection Agency (USEPA) (2015). "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule." Chapter 40 Code of Federal Regulations, Parts 257 and 261. 17 April 2015.

FIGURE



SITE LOCATION
MONTOUR SES

WASHINGTONVILLE, PA

Geosyntec consultants

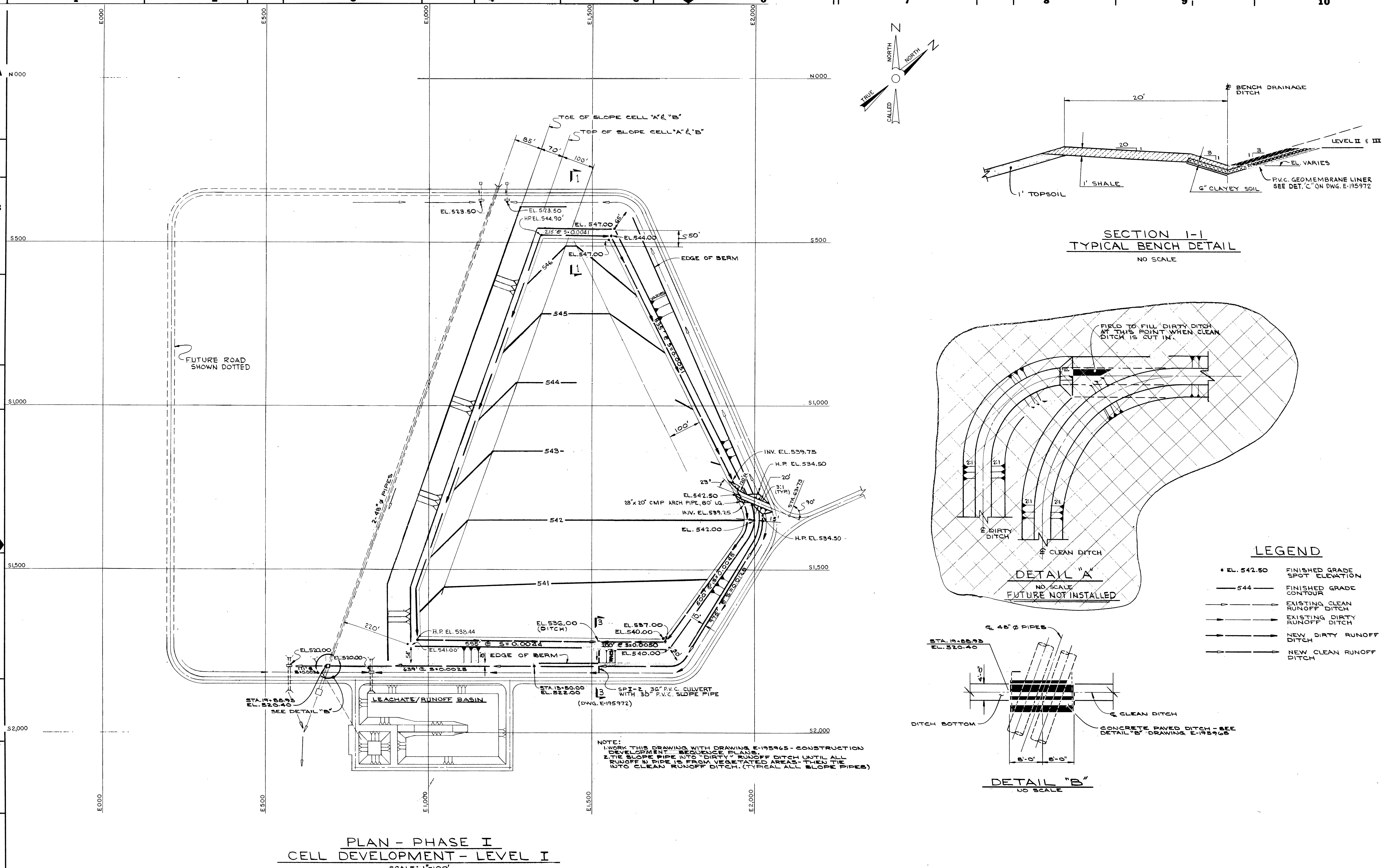
FIGURE

1

Columbia, MD | 12 April 2016

APPENDIX A

Relevant Drawings



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LEACHATE UNDERDRAIN SYSTEM	E-195966-SHT. 2	INTERMEDIATE CELL DEVELOPMENT - SLOPE PIPE DETAILS	E-195972
STREAM PROFILE, SECTIONS, AND DETAILS	E-195968	BILL OF MATERIAL	A-195980

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
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LOC CODE: H-H70
DESCRIPTION: CELL DEVELOPMENT LEVEL I

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W.O. 045155-000

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ER-
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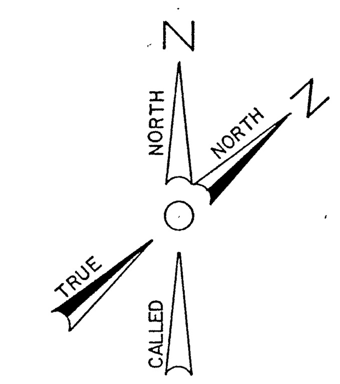
DATE- 1-19-84
DRAWN- TEC
CHECKED- FAC
LEADER- A.L.M.
APPR'D- WJB
APPR'D-

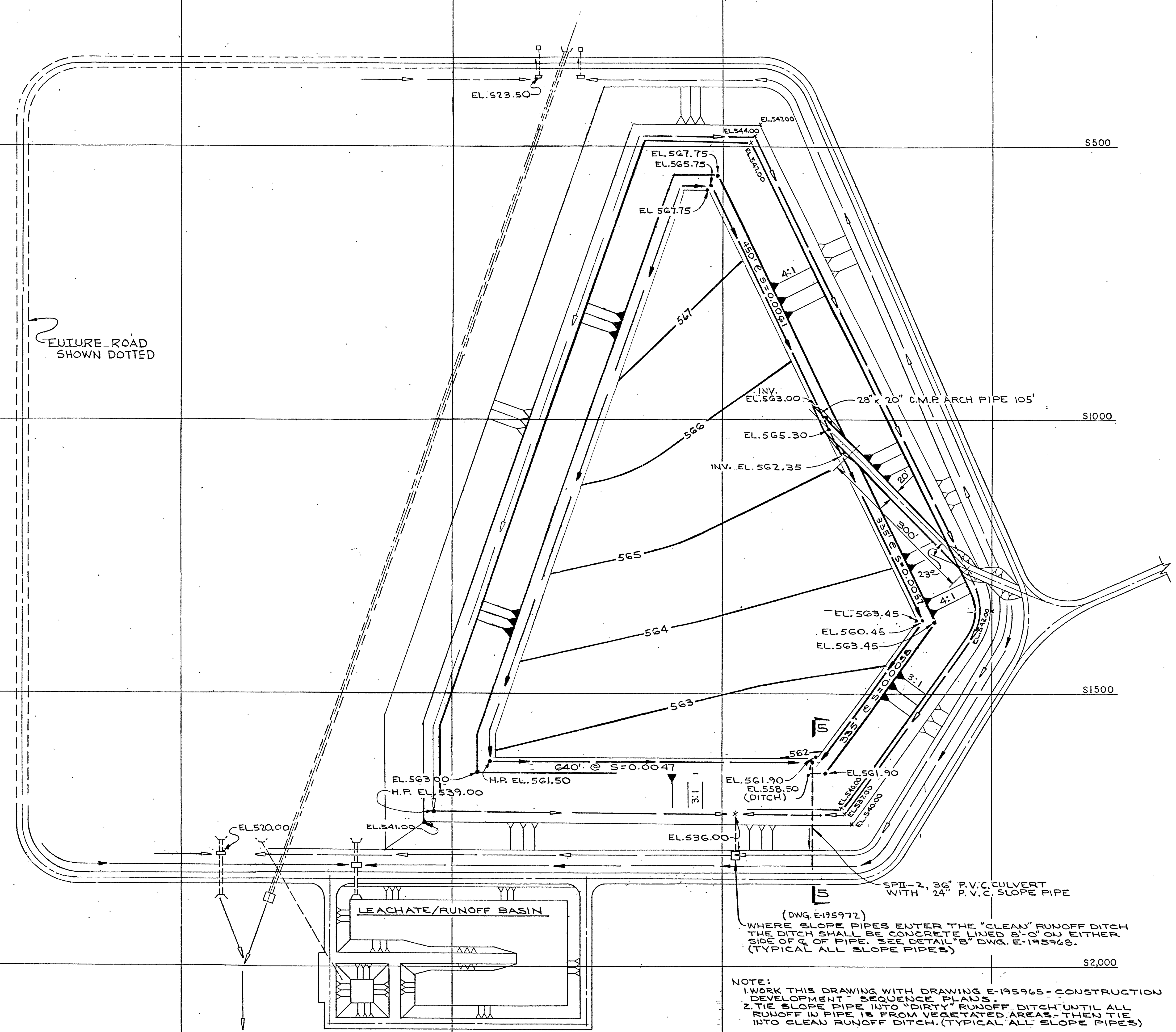
MONTOUR S.E.S.
ASH DISPOSAL AREA NO. 3
INTERMEDIATE DEVELOPMENT - PHASE I LEVEL I

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA. SHEET 1 OF 3

APPROVED 1/30/84 John A. Stefanik

E-195969-2





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2. TIE SLOPE PIPE INTO "DIRTY" RUNOFF DITCH UNTIL ALL RUNOFF IN PIPE IS FROM VEGETATED AREAS - THEN TIE INTO CLEAN RUNOFF DITCH. (TYPICAL ALL SLOPE PIPES)

PLAN - PHASE I
CELL DEVELOPMENT - LEVEL II
SCALE: 1"=100'

LEGEND

• EL. 565.50	FINISHED GRADE SPOT ELEVATION
—565—	FINISHED GRADE CONTOUR
—▷—	EXISTING CLEAN RUNOFF DITCH
—▶—	EXISTING DIRTY RUNOFF DITCH
—▶—	NEW DIRTY RUNOFF DITCH
—▷—	NEW CLEAN RUNOFF DITCH
x EL. 542.50	EXISTING GRADE SPOT ELEVATION

WORK THIS DRAWING WITH E-195965

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ER-	ASH DISPOSAL AREA NO. 3
SCALE- AS SHOWN	INTERMEDIATE DEVELOPMENT - PHASE I LEVEL II
DATE-	
DRAWN- DM	
CHECKED-	PENNSYLVANIA POWER & LIGHT COMPANY
LEADER-	ALLENTOWN, PA. SHEET 2 OF 3
APPR'D-	APPROVED John A. Stefanik 4/18/96
APPR'D-	E-195969-0

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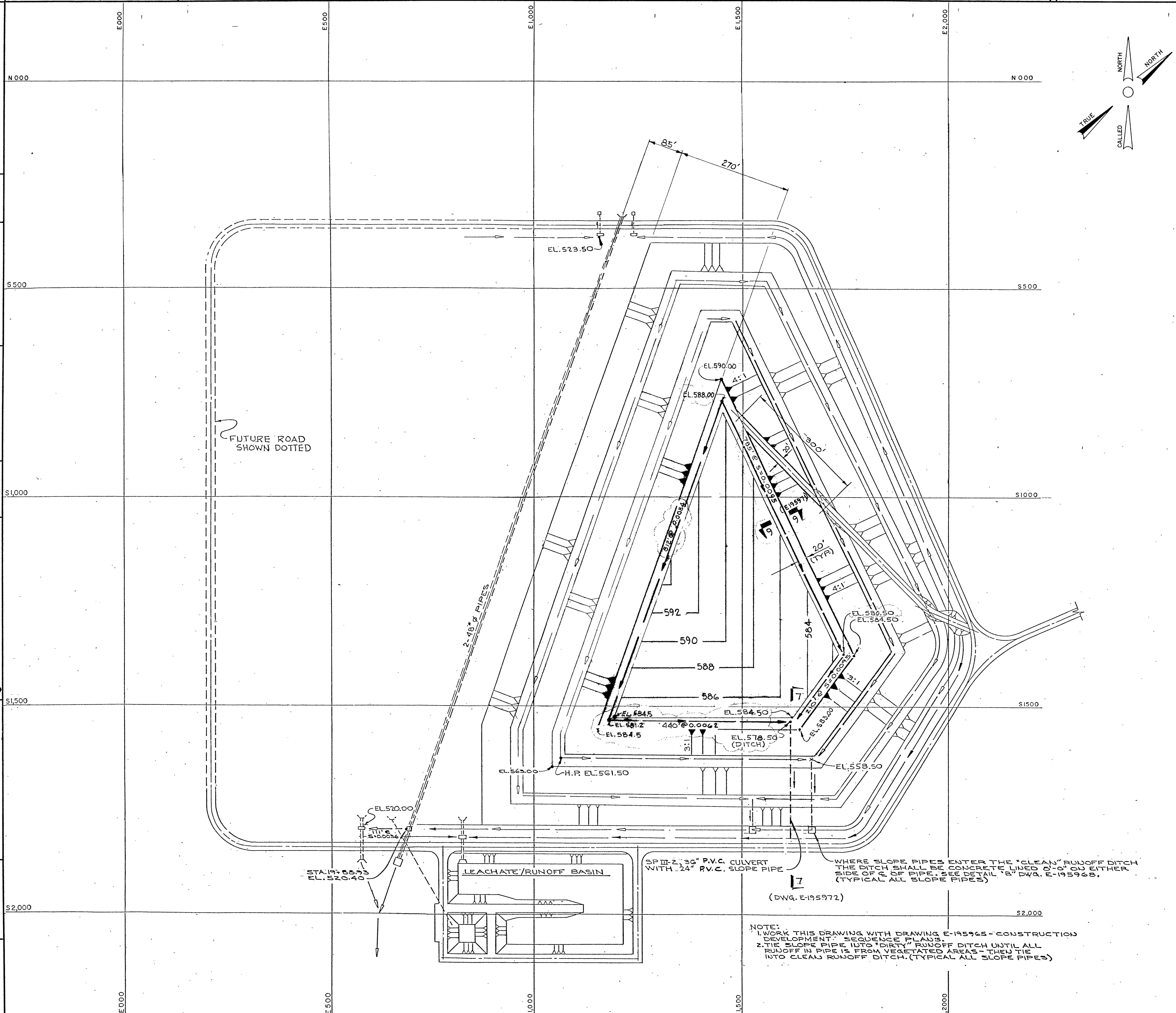
INTERMEDIATE DEVELOPMENT - PHASE II	E-195970																

H-H70 CELL DEVELOPMENT LEVEL II C



PLAN – PHASE I
CELL DEVELOPMENT – LEVEL III
SCALE: 1"=100'

LEGEND

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—▶—	EXISTING DIRTY RUNOFF DITCH
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x EL. 563.45	EXISTING GRADE SPOT ELEVATION

NOTE:
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2. TIE SLOPE PIPE INTO "DIRTY" RUNOFF DITCH UNTIL ALL RUNOFF IN PIPE IS FROM VEGETATED AREAS - THEN TIE INTO CLEAN RUNOFF DITCH. (TYPICAL ALL SLOPE PIPES)

WORK THIS DRAWING WITH E-195965

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BILL OF MATERIAL	A-185980

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
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LOC CODE: H-H70
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SORT: C

ER- 750501
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SCALE- AS NOTED
DATE-
DRAWN- DM
CHECKED-
LEADER-
APPR'D-
APPR'D-

MONTOUR S.E.S.
ASH DISPOSAL AREA NO. 3
INTERMEDIATE DEVELOPMENT - PHASE I LEVEL III

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.
SHEET 3 OF 3

APPROVED John A. Stefanik 4/18/96

E-195969

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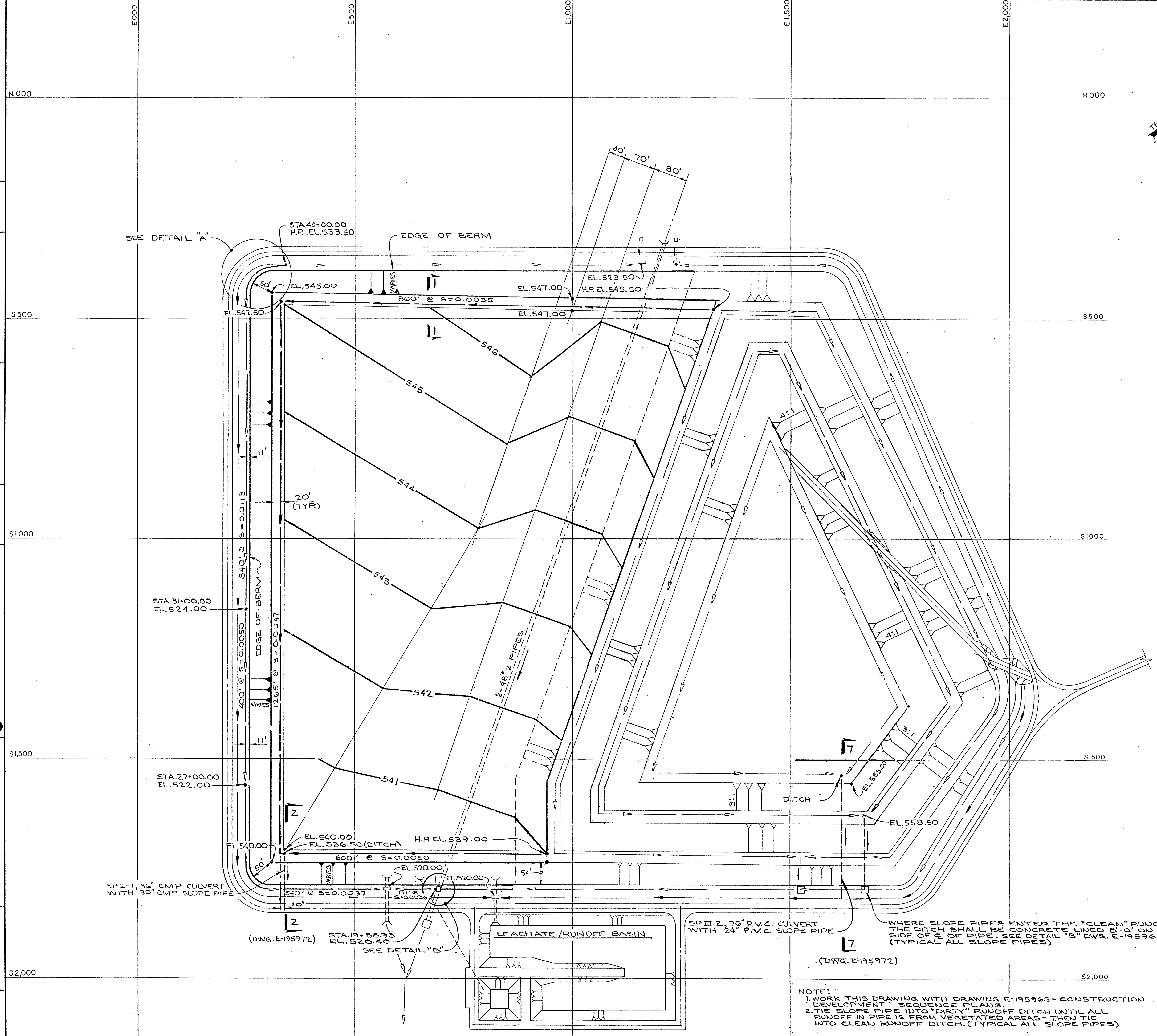

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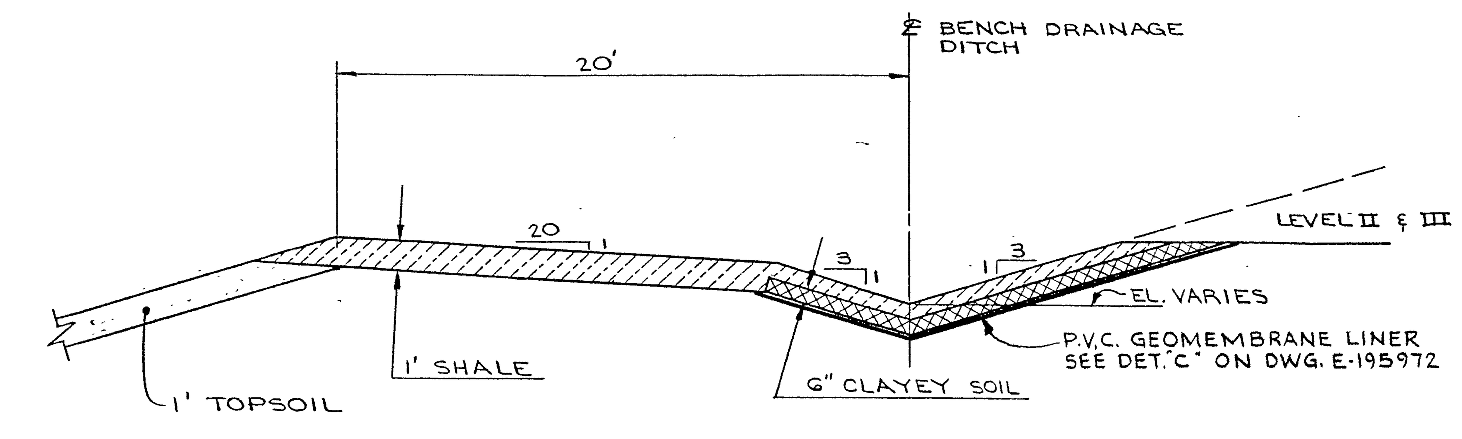
PLAN - PHASE II
CELL DEVELOPMENT - LEVEL I
SCALE: 1"=100'



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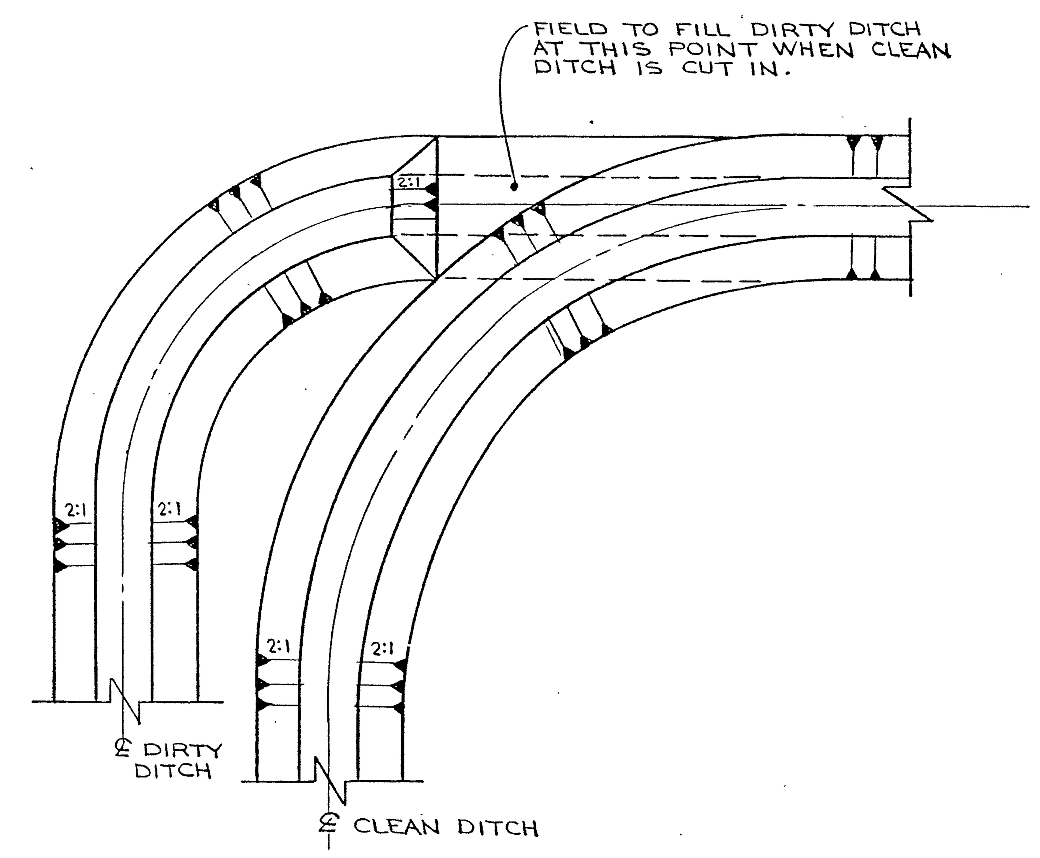

DETAIL "A"
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LEGEND

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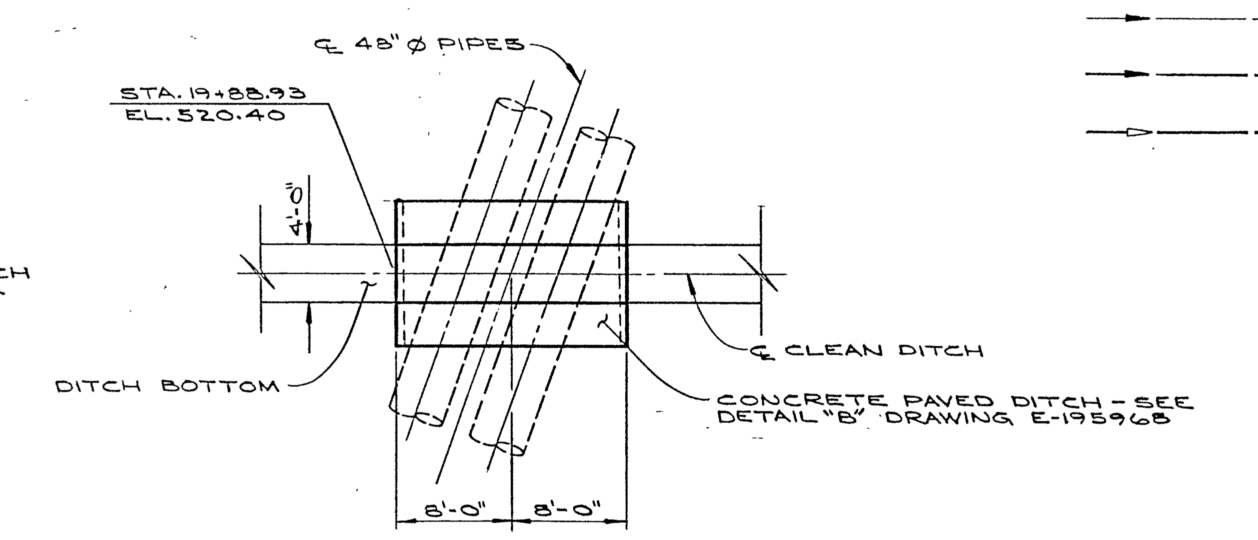
- EXISTING DIRTY RUNOFF DITCH
- NEW DIRTY RUNOFF DITCH
- NEW CLEAN RUNOFF DITCH



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LEACHATE UNDERDRAIN SYSTEM	E-195966-SHT.2	INTERMEDIATE CELL DEVELOPMENT - SLOPE PIPE DETAILS	E-195972
STREAM PROFILE, SECTIONS, AND DETAILS	E-195968	BILL OF MATERIAL	A-195980

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED

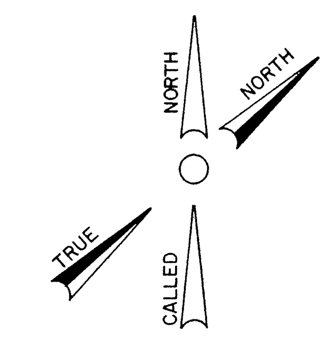
ER- 750501
ER-
SCALE-AS SHOWN
DATE-
DRAWN- DM
CHECKED-
LEADER-
APPR'D-
APPR'D-

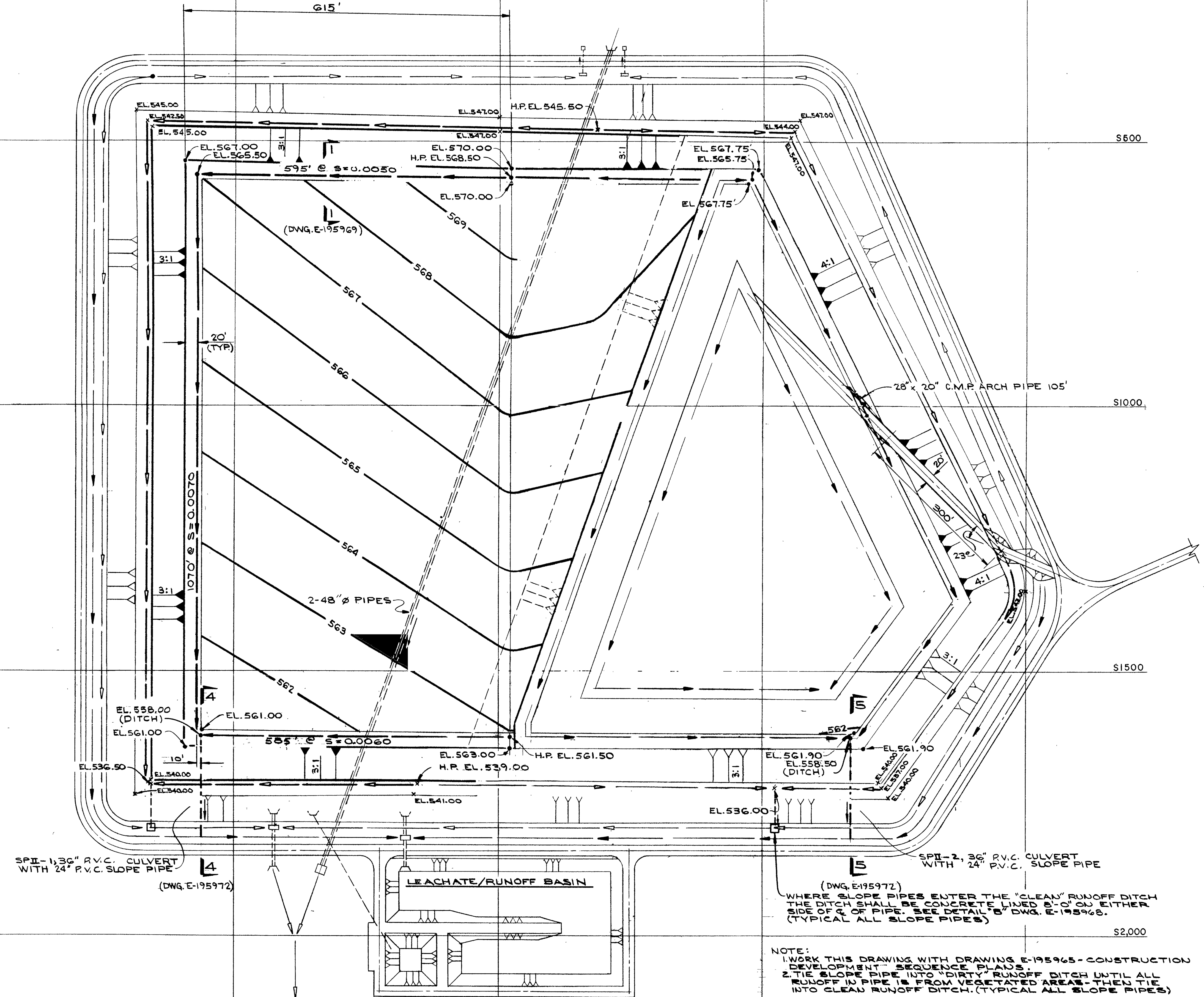
MONTOUR S.E.S.
ASH DISPOSAL AREA NO. 3
INTERMEDIATE DEVELOPMENT-PHASE II LEVEL I

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA. SHEET 1 OF 2

APPROVED John A. Stefanik 4/18/96

E-195970-0





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2. TIE SLOPE PIPE INTO "DIRTY" RUNOFF DITCH UNTIL ALL RUNOFF IN PIPE IS FROM VEGETATED AREAS - THEN TIE INTO CLEAN RUNOFF DITCH. (TYPICAL ALL SLOPE PIPES)

LEGEND

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	NEW CLEAN RUNOFF DITCH
x EL.542.50	EXISTING GRADE SPOT ELEVATION

PLAN - PHASE II
CELL DEVELOPMENT - LEVEL II

SCALE: 1"=100'

WORK THIS DRAWING WITH E-195965

W.O. 045155-000

REFERENCE TITLE	NUMBER
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INTERMEDIATE DEVELOPMENT - PHASE II LEVEL III	E-195971
BILL OF MATERIAL	A-195980

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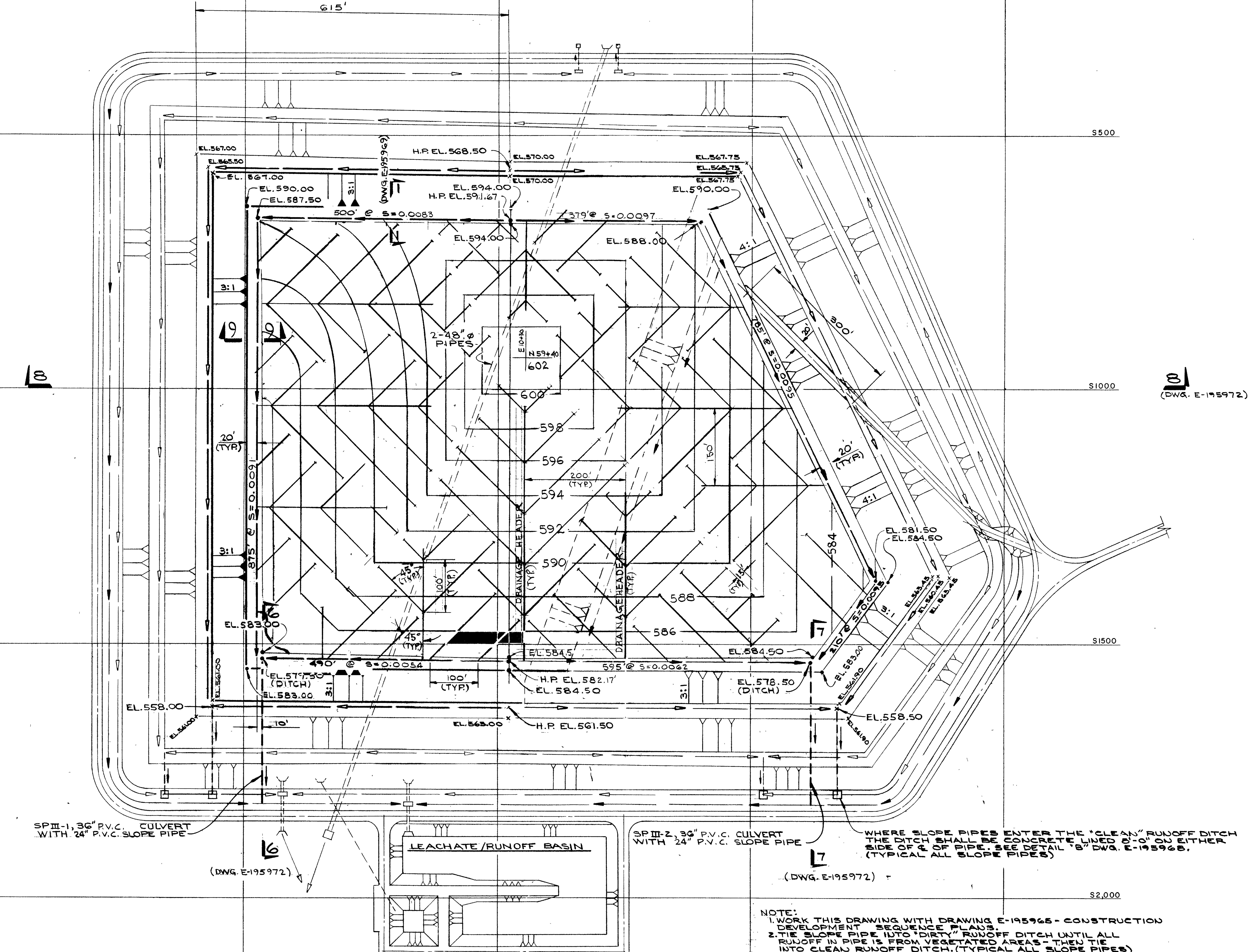
CHECKED- FAC
LEADER- A.L.M.
APPR'D- WJB
APPR'D-

MONTOUR S.E.S.
ASH DISPOSAL AREA NO. 3
INTERMEDIATE DEVELOPMET - PHASE II LEVEL II

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA. SHEET 2 OF 2

APPROVED 1/30/84 John A. Stefanik

E-195970-2



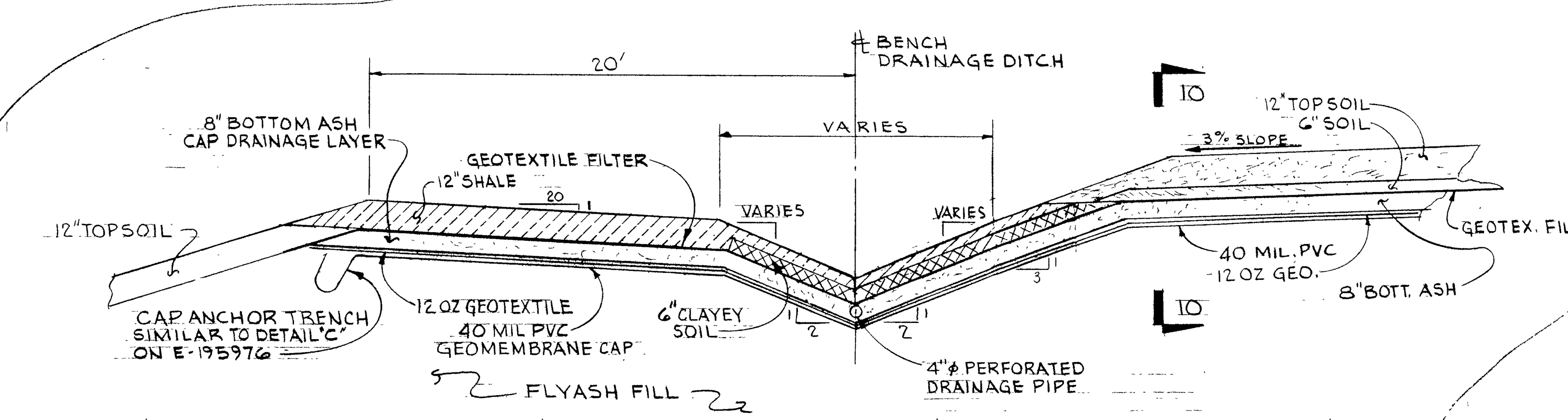
NOTE:
1. WORK THIS DRAWING WITH DRAWING E-195965 - CONSTRUCTION DEVELOPMENT SEQUENCE PLANS.
2. TIE SLOPE PIPE INTO "DIRTY" RUNOFF DITCH UNTIL ALL RUNOFF IN PIPE IS FROM VEGETATED AREAS - THEN TIE INTO CLEAN RUNOFF DITCH. (TYPICAL ALL SLOPE PIPES)

PLAN – PHASE II
CELL DEVELOPMENT – LEVEL III

SCALE: 1"=100'

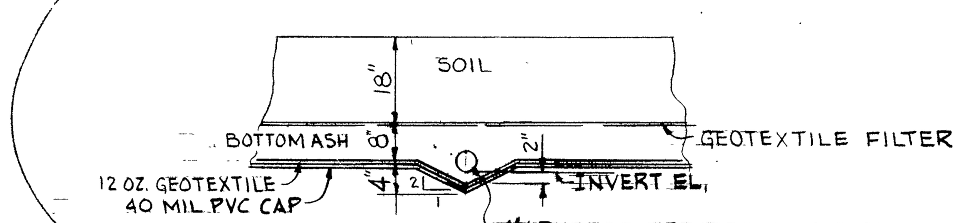
LEGEND

• EL. 588.50	FINISHED GRADE SPOT ELEVATION
—586—	FINISHED GRADE CONTOUR
—▷—	EXISTING CLEAN RUNOFF DITCH
—▶—	EXISTING DIRTY RUNOFF DITCH
—▶—	NEW DIRTY RUNOFF DITCH
—▷—	NEW CLEAN RUNOFF DITCH
x EL. 563.48	EXISTING GRADE SPOT ELEVATION



SECTION 9-9
LEVEL III BENCH DETAIL

NO SCALE



SECTION 10-10

NO SCALE

WORK THIS DRAWING WITH E-195965

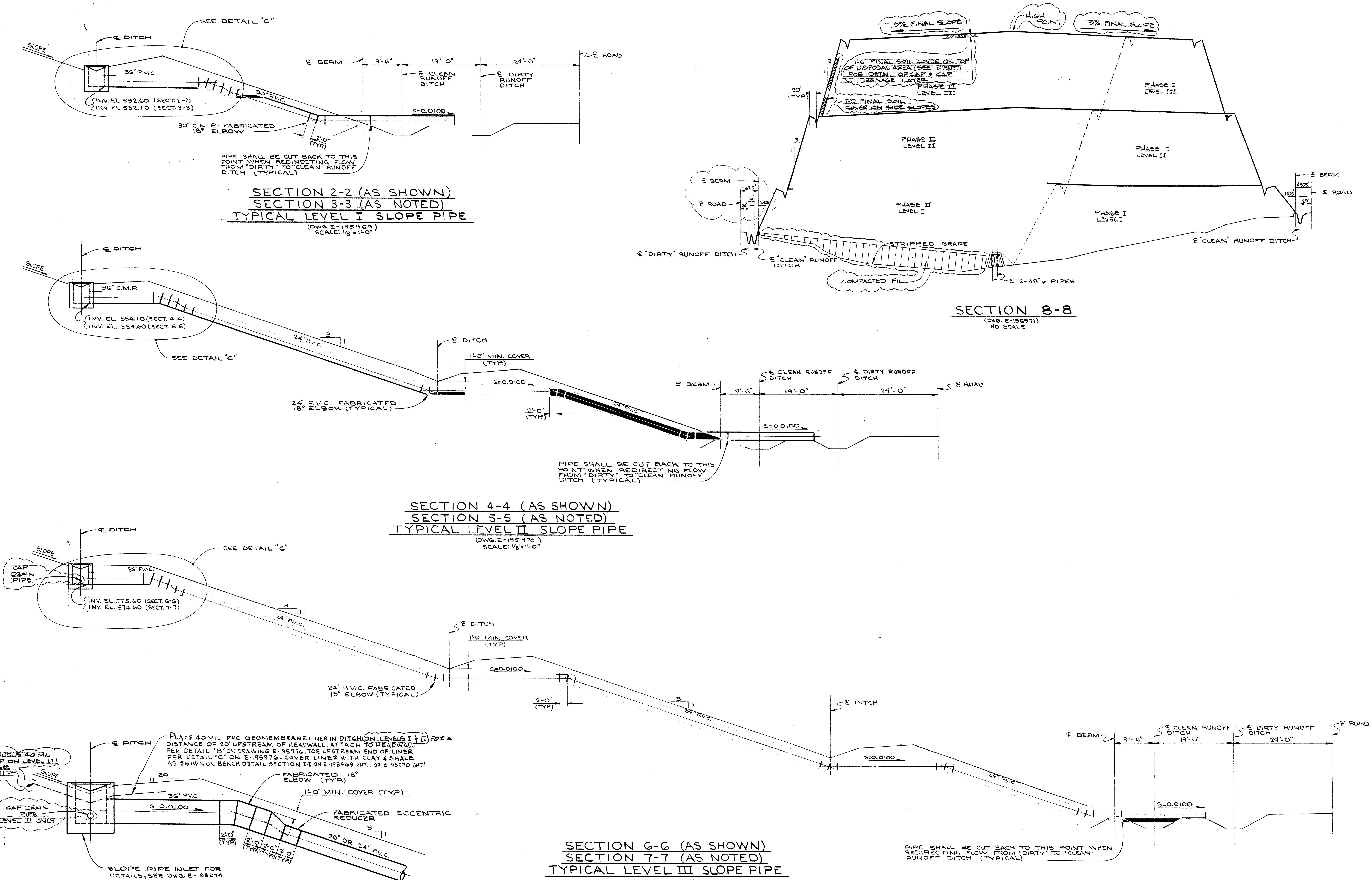
W.O. 045155-000

ER-480230	MONTOUR S.E.S. ASH DISPOSAL AREA NO. 3 INTERMEDIATE DEVELOPMENT - PHASE II LEVEL III
ER-	
SCALE- AS NOTED	
DATE- 1-19-84	
DRAWN- TEC	
CHECKED- FAC	PENNSYLVANIA POWER & LIGHT COMPANY ALLENTOWN, PA.
LEADER- A.L.M.	
APPR'D- WJB	APPROVED 1/20/84 John A. Stefanik — E-195971-3
APPR'D-	

REFERENCE TITLE	NUMBER
INTERMEDIATE DEVELOPMENT - PHASE I	E-195969
INTERMEDIATE DEVELOPMENT - PHASE II	E-195970
BILL OF MATERIAL	A-195980

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
3	4-15-97	750501	REVISE GRADING AND ADDED CAP & COVER	DM		
2	4-11-96	750501	REVISE GRADING AND UP DATE TITLE	D.M.		
1	6-6-85	103069	CHANGED SLOPE PIPE LOCATIONS.	G.H.C.	A.L.M.	A.L.M.

LOC CODE: H-H70 | DESCRIPTION: CELL DEVELOPMENT LEVEL III | SORT: C



SECTION 2-2 (AS SHOWN)
SECTION 3-3 (AS NOTED)
TYPICAL LEVEL I SLOPE PIPE
(DWG. E-195969)
SCALE: 1/8"=1'-0"

SECTION 8-8
(DWG. E-195971)
NO SCALE

SECTION 4-4 (AS SHOWN)
SECTION 5-5 (AS NOTED)
TYPICAL LEVEL II SLOPE PIPE
(DWG. E-195970)
SCALE: 1/8"=1'-0"

SECTION 6-6 (AS SHOWN)
SECTION 7-7 (AS NOTED)
TYPICAL LEVEL III SLOPE PIPE
(DWG. E-195971)
SCALE: 1/8"=1'-0"

DETAIL "C"
TYPICAL SLOPE PIPE
INSTALLATION WITH INLET

WORK THIS DRAWING WITH E-195965

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER
INTERMEDIATE CELL DEVELOPMENT - LEVEL I	E-195969	DROP INLET, SLOPE PIPE INLET, PRECAST MH'S AND SUMP	E-195974
INTERMEDIATE CELL DEVELOPMENT - LEVEL II	E-195970		
INTERMEDIATE CELL DEVELOPMENT - LEVEL III	E-195971		
BILL OF MATERIAL	A-195980		

NO.	DATE	ER.	REVISION	BY	CH.	APPROVED
3	4-18-97	150501	CHGD SECT 8-8, ADDED PIPE TO DET. C & CHGD LINER NOTES	JTE		
2	4-18-96	150501	CHANGED TITLE AND UPDATED DWG	JTE		
1	6-6-86	103069	CHANGED SLOPE PIPE INLET & INVERT ELEV'S.	G.H.C.	A.L.M.	A.L.M.

LOC CODE: H-H70
DESCRIPTION: SLOPE PIPE SECTS. & DET'S
SORT: C

W.O. 045155-000
ER-480230
ER-
SCALE- AS NOTED
DATE- 1-19-84
DRAWN- T.E.C.
CHECKED- FAC
LEADER- A.L.M.
APPR'D- WJB
APPR'D-

MONTOUR S.E.S.
ASH DISPOSAL AREA NO.3
INTERMEDIATE CELL DEVELOPMENT - SLOPE PIPE
SECTIONS AND DETAILS

PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.

APPROVED 1/20/84 John R. Stefanik

E-195972-3

APPENDIX B

Approved Closure Plan

(Attachment 1 to Form 18R of PPL 2007)

Form 18R
NARRATIVE

Section B. CLOSURE PLAN

General Description of Landfill Development

Ash Disposal Area No. 3 is an existing captive residual waste disposal facility for the Montour Steam Electric Station of PPL Montour, LLC. Montour SES is a coal fired electrical generating station located in Derry Township, Montour County Pennsylvania. Ash Area No. 3 is located south of the power plant. It is a lined landfill covering approximately 51 acres that is used primarily for the disposal of fly ash and other combustion wastes produced from burning coal at the plant along with smaller quantities of other plant residual wastes. The site is divided into eastern and western segments by a small stream that flows across the site. This stream is now carried in twin 4- foot diameter pipes that were installed as part of the site development.

The disposal area will have three levels each approximately 25 feet in height with three horizontal to one vertical side slopes. Each level will have a 20-foot-wide bench. The first level covers 50.6 acres and will be divided into four disposal cells of approximately the same size. The A and B disposal cells totaling 28.9 acres are on the east side of the stream enclosure pipes and the C and D disposal cells totaling 21.7 acres are on the west side. At this time (June 1996) only the A and B cells have been developed and used for disposal. The C and D cells will not be developed until the A and B cells have reached their design capacity.

Topsoil from the A and B cells were stripped from each cell prior to preparing the subgrade and constructing the liner system. Stripped topsoil was stockpiled at the site and is used for final cover. The final cover is placed on the landfill slopes as disposal progresses and the fill expands vertically.

A Leachate/Runoff Basin approximately three acres in size was constructed for the disposal area. All runoff from the active A and B cells and from intermediate construction activities is directed to the basin for sediment removal as will be construction runoff from the future C and D cells when developed. All leachate collected in the underdrain system is also directed to the basin, but directly into the basin sump.

The Leachate/Runoff Basin is divided into two sections. The larger portion is designed primarily for sediment removal and control of storm water flows. The smaller section contains the pumping station and sump into which the larger section discharges. A ramp permits excavating equipment to enter the larger section and remove any accumulations of fly ash sediment. The sediment removed from the basin is redeposited on the ash pile. Runoff and leachate which have entered the Leachate/Runoff Basin is pumped to the Detention Basin at the power plant for treatment in existing waste water treatment facilities.

The silos, administration building, maintenance buildings and other facilities needed to support the operation of Ash Area No. 3 existed at the time the landfill was constructed. Located at the ash silo area to the east of the landfill are two 2,500 ton capacity steel silos that store the fly ash until it is unloaded for beneficial use or disposal. Located near the silos are two buildings. The 62' x 42' building adjacent to the silos houses the silo auxiliary equipment and silo electrical switchgear. Across the road from this building is the 142' x 58' crew and maintenance building. This building contains three vehicular bays for storage and maintenance of construction equipment used for waste disposal operations as well as offices and washroom facilities for the disposal contractor and the PPL MONTOUR, LLC Ash Site Coordinator. Both buildings are of steel- framed, metal- sided construction.

A scale is located off of the entrance road to the silo area. The scale has a capacity of 60 tons and is used to weigh both the waste sent to the disposal area as well as fly ash and bottom ash that is sold for beneficial use.

1. ***Plan for decontamination and removal of equipment, structures and related material from the facility.***

It is not known if Ash Area No. 3 will last the life of the Montour Steam Electric Station. If it does not, the fly ash silos, silo area buildings and the weigh scale will remain as part of ash disposal operations supporting a future waste disposal landfill site. This future landfill may be on adjacent power plant property or may be at an off-site location. If it does last the life of the power plant, the silos, buildings and scale will be demolished along with the other power plant structures.

Site roadways will remain indefinitely to provide access to the landfill and the leachate pumping facility for maintenance purposes. The leachate pumping system will remain in place and be maintained until leachate quality improves to the point where it can be discharged directly from the landfill without treatment and agency approval is obtained to do so.

Ash Area No. 3 does not accept waste streams that would necessitate having to decontaminate disposal equipment or structures, hence, no decontamination procedures will need to be implemented upon closure.

It is anticipated that the site will be returned to no-till agricultural use after the landfill reaches its design capacity. All ash surfaces will have a soil and vegetative cover. Clean runoff from the site will be discharged to the stream via the clean runoff ditches, while all leachate will continue to be directed to the sump and then pumped to the power plant for treatment. The Leachate/Runoff Basin and the remaining dirty runoff ditches will be filled in, topsoiled, and seeded. The sediment, the PVC liner, and liner bedding and cover material will all be removed from the L/R Basin and sent to a landfill prior to filling in the basin.

2. *An estimate of the year in which final closure will occur, including an explanation of the basis for the estimate.*

The landfill capacity calculations are Attachment 2 to form 1R. For the capacities calculated the expected lives of the various cells and levels were derived and are shown below. The calculations assume a fly ash density of 91 pounds per cubic foot and an average disposal rate of 225,000 tons per year at 15% moisture content or about 160,000 cubic yards per year. The fly ash disposal rate is very dependent on beneficial use demand in addition to being dependent on the amount of coal burned and the ash content of the coal.

	A and B Cells	C and D Cells
Level 1	40 Months	54 Months
Level 2	44 Months	55 Months
Level 3	25 Months	48 Months
Total	109 Months	157 Months

Total Landfill 266 Months or 22 Years and 2 Months
(assumes complete beneficial use of Fly Ash)

Approximately 756,000 cubic yards of capacity have been used through the end of 2005. Only Level 1 of the A and B Cells has been completely filled. Approximately 50% of Level 2 capacity has been used. The most recent capacity report (for 2005 report year) lists a remaining capacity of 3,928,000 tons and an indefinite remaining life because of the small, actual annual disposal volumes.

The synthetic gypsum temporary storage facilities will not impact the disposal of wastes from PPL generating station operations because the area that will be utilized is inactive and not needed for the small volume of wastes being disposed of in the landfill.

If approved for disposal starting in 2008 and if beneficial use of the fly ash continues, wastewater treatment plant sludge will be the largest waste stream (up to 36,000 cubic yards per year) taken to Ash Area No. 3. This annual disposal volume will accelerate the filling of the A and B cells over current rates but the total volume of all wastes will only be about 25% of the originally expected fly ash disposal rate. Level 2 may be filled within 8 years. Level 3 disposal will then have to be reconfigured so that the necessary area is still reserved for the temporary storage of gypsum while providing for continued disposal of approved wastes in the A and B Cells.

On the basis of the above projections, Ash Area No. 3 - A & B Cells should be filled to capacity around the end of the year 2015. and then cells C & D would have an indefinite life. Again, this is very dependent on the continued use of fly ash beneficially. Post-closure work will likely begin at the end of plant life in 2035.

3. If the facility will close in stages, a description of how and when the facility will begin and implement partial closure. (Schedule for closure)

Ash Area No. 3 is a landfill that is being developed in stages. The A and B cells have been constructed and are used for disposal. The C and D cells have not been developed and will not be constructed until the A and B cells have reached their design capacity. Cover soil is placed on the landfill slopes as disposal progresses and the fill expands vertically to its design limits. In this sense, the A and B cells will be closed and covered before the C and D cells. Under the assumptions described in Item 2 above, the A and B cells will reach their design capacity approximately at the end of the year 1999 while the C and D cells will not be filled until the year 2012.

4. A description of steps necessary for closure if the facility closes prematurely.

If the facility closes prematurely, very little extra work will be necessary for closure. Cover soil is placed on the landfill slopes as disposal progresses and the fill expands vertically to its design limits. Upon premature closure, all that will be needed is to grade the top level of ash to achieve positive drainage to the slope pipe drains and construct the cap and cap drainage layer. Cover soil will then be placed over the drainage layer and vegetated in the usual manner. Other closure steps will remain as described for non-premature closure.

5. A narrative description, including a schedule, of measures that are proposed to be carried out after closure of facility, including measures relating to:

A. Water quality monitoring.

Water quality monitoring will continue for the facility's monitoring wells, monitoring points and storm water outfall in accordance with the residual waste regulations and NPDES storm water regulations. Water quality monitoring procedures after closure will be the same as those implemented while the facility was in operation. The quarterly groundwater sampling schedule will be maintained. The Ash Disposal Area No. 3 Ground Water Sampling and Analysis Plan attached to Form 13R describes the sampling locations, sampling procedures, sampling schedule, laboratory procedures and QAQC procedures in detail.

B. Gas control monitoring.

The wastes disposed in this landfill do not generate gasses. Gas control monitoring is not required for this facility.

C. Leachate collection treatment and pumping.

Leachate will flow directly to the existing leachate pumping facility sump. It will then be pumped to the power plant for treatment along with other waste water at the power plant's Waste Water Detention Basin which is equipped with pH control equipment.

D. Erosion and Sedimentation Control.

An erosion and sedimentation control plan will be prepared for facility closure. It will be prepared and submitted to the DEP and the Montour County Conservation District for approval prior to the start of post-closure work. Since final cover soil is placed on the landfill slopes as disposal progresses, the E&S control plan will primarily address the filling in of the Leachate/Runoff Basin.

The permanent erosion and sedimentation control measure for the facility will be the establishment of permanent vegetation on the cover soil that is placed over the ash and over the L/R Basin.

E. *Re-vegetation and regrading, including maintenance of final cover.*

Grading to Manage Runoff

To reduce storm water handling requirements during operation, runoff is segregated into "clean" runoff and "dirty" runoff. Clean runoff is runoff from undisturbed areas and from disturbed areas which have been covered with topsoil and revegetated. Dirty runoff is runoff from unvegetated areas (including the stripped subgrade during construction), from the active ash cells on the ash disposal pile, and from inactive cells which have been covered with topsoil and seeded, but on which the vegetation has not yet been established.

Clean and dirty runoff ditches are constructed in parallel around the landfill during operations. The dirty runoff ditch is constructed first and intercepts dirty runoff from the ash pile and conveys it to the Leachate/Runoff Basin for treatment. After vegetation has been established on the completed ash cells, a clean runoff ditch is constructed between the pile and the dirty runoff ditch. This ditch intercepts the clean runoff before it enters the dirty runoff ditch and diverts it around the Leachate/Runoff Basin to the natural stream at the south end of the site.

Between perimeter access road stations 40+00 and 63+00 on the north side of the landfill, the dirty runoff ditch will be cleaned and then converted to a clean runoff ditch. Clean runoff will be discharged beneath the access road to the inlet end of the stream enclosure.

The landfill will have three levels each approximately 25 feet in height. The working surface of active cells will be sloped at approximately one percent towards dirty runoff ditches at the south end of the ash pile. The final vegetated soil cover surface of Level 3 will have a 3% slope. When a level reaches its 25-foot height, the permanent bench and bench drainage ditch is established by sloping the outer 20 feet of the ash cell away from the edge. The bench and ditch are then covered with shale or some other nonerodible material. The bench drainage ditch intercepts runoff from the top of the pile preventing erosion of the landfill slopes. The outside slopes of the completed cell are then covered with soil and seeded. Discharge from the bench drainage ditches is through slope pipes which discharge into either the clean or dirty runoff ditches, as applicable, at the base of the pile. Runoff is considered to be dirty until vegetation is established on the slopes of the cell on the above level. Slope pipes will discharge on concrete splash pads to prevent scouring of the ditch.

At the time of closure the only unvegetated surfaces will be the top of Level 3 of the C and D cells and a portion of the Level 3 slopes. Runoff from all other landfill surfaces will have been directed to the clean runoff ditches and diverted around the Leachate/Runoff Basin to the natural stream at the south end of the site.

Final grades of the closed facility, if utilized to its maximum design capacity, will be as shown on the drawing E-195971.

Soil Cover and Vegetation

The soil cover over the landfill slopes will be 12" thick. The soil cover on the top surface of Level 3 will be 18" thick so that the land can be returned to no-till agriculture. Cover soils will be obtained from the site and from a soil borrow area on company owned property located west of the landfill. The seed mixture and methods used to establish the permanent vegetation are detailed in Form H and its Attachments.

Maintenance of Final Cover

Areas with inadequate vegetation cover will be reseeded. If necessary, eroded soil will be replaced, surfaces regraded and soil amendments, seed and/or mulch will be applied. To the extent possible, and if practical, remedial vegetation work will be done in a manner that avoids disturbance of existing vegetation. If weather is prohibitive to establishment of vegetation, soils will be mulched to reduce erosion until successful seeding can be done. Damage to cover by burrowing animals will be controlled and repaired as needed.

F. Access control.

The access control measures currently in force for the active landfill will be continued after this basin is closed. There are locked gates at the entrances to the facility. The silo area is fenced and gated to prevent access from public highway LR 414. Access to the landfill and leachate/runoff collection basin from the silo area is also controlled via a gate in the silo area fence on the west side. The temporary ends of the loop road around the landfill have also been gated. All gates are padlocked to prevent unauthorized access when the site is unattended.

G. Other maintenance activities.

The landfill will require little maintenance after closure; however, inspections of the completed fill will be made and the necessary maintenance performed. The landfill inspections will be covered under an existing formalized inspection program. Inspections will be performed twice per year by qualified personnel. They will also be made after unusually heavy rainfalls. The top of the pile and slopes will be inspected for sinkholes, erosion, cracking, slumping, sliding and the condition of the vegetation. Drainage ditches and culverts will be checked for erosion, pipe blockages, sediment and other debris. The leachate pumps will be inspected to ensure that they are in operating condition.

Routine maintenance may include repairing erosion damage and cleaning debris from inlets, pipes and ditches as well as maintenance of the vegetative cover as described in Item 1.E above.

6. ***Description of means by which funds will be made available to cover cost of post closure operations, which shall include an assessment of projected post-closure maintenance costs, a description of how the funds will be raised, a description of relevant legal documents , and a description how the funds will be managed prior to closure.***

PPL Montour, LLC will continue to own its closed residual waste disposal facilities. The Power Plant associated with each facility will include budgeted money for maintenance of the facility each year. It is expected that maintenance costs will be less for the facility after it is closed then when it was in service. Current maintenance costs budgeted is approximately $50,000 per year. Operating costs, primarily related to monitoring ground water wells and leachate pumping, will continue to be PPL MONTOUR, LLC's responsibility.

7. ***The name, address, and telephone number at which operator can be reached during post closure period.***

Mr. Michael Munroe
Manager - Generation Assets
PPL MONTOUR, LLC - Montour SES
P.O. Box 128
Washingtonville, PA 17884
Telephone 570-437-1201

B. POST-CLOSURE LAND USE PLAN

1. ***How the proposed post-closure land use is to be achieved and the necessary support activities which may be needed to achieve the proposed land use.***

The proposed post-closure land use is no-till agriculture on the top of the final lift of the landfill. This will be the end result of placing sufficient soil cover on the surface during post-closure work. No other support activities are necessary to achieve this use. The side slopes of the landfill are too steep for agriculture and will be open space. Agriculture will be no-till to avoid the possibility of damaging the cap and cap drainage layer.

2. ***The consideration which has been given to making the proposed post-closure land use consistent with landowner plans and applicable state and local land use plans and programs.***

The landfill is a captive landfill owned and operated by PPL MONTOUR, LLC for power plant ash disposal. After closure it will be owned and maintained by PPL MONTOUR, LLC. PPL MONTOUR, LLC discussed the post-closure use of the land with the PA Department of Agriculture. This has led to a decision to return the land to no-till agricultural production. The Department has recommended that warm season grasses and switchgrass in particular, be grown on the landfill. This use will accomplish two things: it will mitigate the loss of farmland that resulted from the construction of the facility and the switchgrass will provide small game habitat desired by the Game Commission.

APPENDIX C

Final Cover System Analyses

Appendix C.1

Final Cover Percolation Analysis

MONTOUR SES ASH LANDFILL 3

FINAL COVER PERCOLATION ANALYSIS

PURPOSE

The purpose of this analysis is to evaluate the estimated percolation through the proposed final cover of Montour Steam Electric Station Ash Landfill 3 (Ash Landfill 3) in Washingtonville, Pennsylvania. Specifically, this analysis compares the estimated percolation through the proposed final cover to the estimated percolation through the final cover prescribed by the Federal Coal Combustion Residuals (CCR) Rule. The proposed final cover is considered an alternative cover under the CCR Rule.

This calculation was completed to support the preparation of a written closure plan for Ash Landfill 3. The Closure Plan was prepared to demonstrate compliance of Ash Landfill 3 with the closure requirements of the Federal Coal Combustion Residuals (CCR) Rule §257.102. Section 257.102 requires, in part, that the unit is closed to control, minimize, or eliminate, to the extent feasible, post-closure infiltration of liquids into the waste. This analysis is required to demonstrate compliance of the final cover with the alternative final cover infiltration requirements of §257.102(d)(3)(ii)(A).

The remainder of this calculation package presents the following:

- description of the final cover;
- procedure;
- input parameters;
- results; and
- conclusions.

DESCRIPTION OF THE PROPOSED FINAL COVER

The proposed alternative final cover design (i.e., proposed final cover) is a geosynthetic cover system. The final cover design includes three components (from bottom to top):

- 40-mil polyvinyl chloride (PVC) geomembrane;
- 8-inch bottom ash drainage layer; and
- 18-inch protective cover and a vegetative support (i.e. erosion) layer.

The proposed final cover cross-section is shown in detail on Figure 1. The geotextile cushion layers were omitted from the proposed final cover for this analysis as they are not anticipated to affect the system's hydrologic performance.

Section 257.102(d)(3) of the CCR Rule includes requirements for the prescribed final cover system (CCR Rule-prescribed cover). Minimum requirements for the cover related to infiltration reduction are prescribed by §257.102(d)(3)(i)(A) through (C) as follows:

- permeability no greater than 1×10^{-5} cm/s;
- minimum 18-inch earthen infiltration layer; and
- minimum 6-inch erosion layer capable of sustaining native plant growth.

Based on these requirements, the CCR Rule-prescribed cover was assumed to include three components (from bottom to top):

- 18-inch earthen infiltration layer with hydraulic conductivity no greater than 1×10^{-5} cm/s;
- 8-inch bottom ash drainage layer; and
- 18-inch vegetative support (i.e. erosion) layer.

To allow for a relevant comparison of the infiltration layer of the proposed final cover and CCR Rule-prescribed cover, all other components of the final cover systems were assumed to be the same. Where specific material properties or layer thicknesses of the CCR Rule-prescribed cover are not prescribed by the CCR Rule (e.g., lateral drainage layer) or not the same as the proposed final cover (i.e., vegetative support layer thickness), the values of the proposed final cover were used to evaluate the CCR Rule-prescribed cover. The thicker vegetative support layer assumed for the CCR Rule-prescribed cover is a conservative assumption for this analysis.

PROCEDURE

Overview

The leakage through the surficial geomembrane was estimated as the sum of leakage by permeation through the geomembrane and as flow through defects in the geomembrane, after Giroud and Bonaparte (1989). The leakage was estimated as a flow rate considering a final cover area of 1 acre (4,000 m^2). The leakage through one acre of geomembrane due to permeation was computed as shown in Equation 1:

$$Q_g = \frac{m_g \times A}{T_g} \qquad \text{Equation 1}$$

Where:

Q_g = leakage rate due to geomembrane permeation (m^3/sec);

m_g = coefficient of migration of the geomembrane (m^2/sec);

A = considered surface area of geomembrane (m^2); and

T_g = geomembrane thickness (m).

The leakage through pinholes and holes was computed as shown in Equations 2 and 3, respectively.

$$Q_p = \frac{\pi \times \rho \times g \times h_w \times d^4}{128 \times \eta \times T_g}$$ Equation 2

Where:

- Q_p = leakage rate through pinholes (i.e., manufacturing defects) (m^3/s);
- h_w = depth of liquid on sacrificial geomembrane (m);
- ρ = density of water at 20° C (kg/m^3);
- g = acceleration due to gravity (m/s^2);
- d = pinhole diameter (m); and
- η = dynamic viscosity of water at 20° C (kg/m-s).

$$Q_h = C_B \times a \times \sqrt{2 \times g \times h_w}$$ Equation 3

Where:

- Q_h = leakage rate through holes (i.e., installation defects) (m^3/s);
- C_B = dimensionless coefficient = 0.6;
- a = hole area (m^2); and
- g = acceleration due to gravity (m/s^2).

The leakage through the CCR Rule-prescribed cover was estimated using Darcy's Law (Equation 4), as presented by Holtz and Kovacs (1981):

$$q = k \times \frac{\Delta h}{L} \times A$$ Equation 4

Where:

- q = leakage rate through CCR Rule-prescribed infiltration layer (m^3/s);
- k = hydraulic conductivity of earthen infiltration layer (m/s);
- Δh = head loss through infiltration layer (m);
- L = thickness of earthen infiltration layer (m); and
- A = cross-sectional area in direction of flow (m^2);

INPUT PARAMETERS

Geomembrane Properties and Defects

Based on the proposed final cover described above, the geomembrane was assumed to be a 40-mil (0.001 m) PVC geomembrane with a coefficient of migration (m_g) equal to 1.7 × 10^{-14} m^2/s (Giroud and Bonaparte 1989). The geomembrane was modeled with manufacturing defects (pinholes) and installation defects (holes).

This analysis assumes two pinholes per acre, corresponding to a manufacturer with a "good" quality control program (Schroeder et al. 1994a and 1994b). Pinhole diameter was taken as the larger of the two diameters modeled by Giroud and Bonaparte (1989).

Installation defects are the result of seaming faults and punctures during installation. Schroeder et al. (1994b) and Giroud and Bonaparte (1989) recommend using a flaw density of 1 hole per acre for intensively monitored projects. This analysis conservatively assumes two defects per acre, corresponding to installation with a "good" quality assurance program (Schroeder et al. 1994a). Giroud and Bonaparte (1989) recommends a 1 cm^2 (0.0001 m^2) hole for design calculations.

Other Input Parameters

Head on the geomembrane or earthen infiltration layer (h_w) was taken as 0.203 meters, which assumes the head is equal to the thickness of the lateral drainage layer. As required by the CCR Rule, the thickness of the earthen infiltration layer of the CCR Rule-prescribed cover is taken as 0.457 meters (18 inches) with a maximum hydraulic conductivity of 1×10^{-7} m/s (1×10^{-5} cm/s). Head loss through the earthen infiltration layer (Δh) is taken as the head on the geomembrane plus the thickness of the earthen infiltration layer. For both cover systems, the area of flow (A) is taken as 4,000 m^2 (1 acre).

RESULTS

Tables showing the input parameters and results of the leakage calculations for the proposed final cover and CCR Rule-prescribed cover are presented in Appendix A.

Leakage through the proposed final cover is estimated to be 2.4×10^{-4} m^3/s per acre of final cover. Leakage through the CCR Rule-prescribe final cover is estimated to be 5.8×10^{-4} m^3/s per acre of final cover.

CONCLUSION

As shown by the analysis and results presented in this calculation package, the Ash Landfill 3 proposed final cover, as designed, is expected to achieve an equivalent or greater reduction in infiltration as the CCR Rule-prescribed cover.

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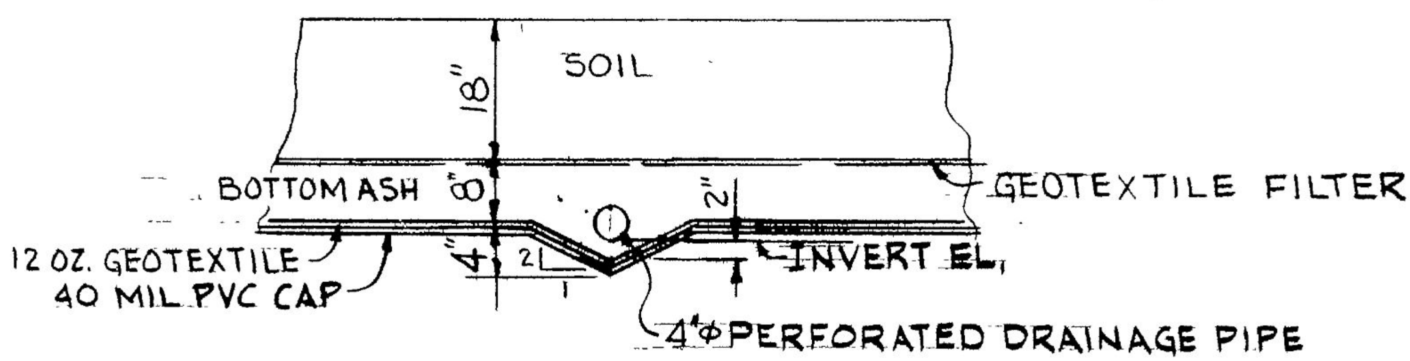
FIGURE



FINAL COVER CROSS-SECTION
MONTOUR ASH LANDFILL 3

Washingtonville, PA

Geosyntec consultants

FIGURE

1

Columbia, MD | 25 May 2016

APPENDIX A

CALCULATION TABLES

Leakage Through 1 Acre of Proposed Final Cover Geomembrane Infiltration Layer		
Permeation (1a)	6.8E-08	m^3/s
Pinhole Leakage (1b)	7.9E-07	m^3/s
Hole Leakage (1c)	2.4E-04	m^3/s
Total Leakage	2.4E-04	m^3/s

Notes (1) From Giroud and Bonaparte (1989): (a) Eqn 5; (b) Eqn 21; and (c) Eqn 22

head on GM	h_w	0.203	m
area considered	A	4000	m^2
GM thickness	T_g	0.001	m
GM coeff. migration	m_g	1.70E-14	m^2/s
pinhole frequency		2	(#/acre)
pinhole diameter	d	0.0003	m
hole frequency		2	(#/acre)
hole area	a	0.0001	m^2
density water	ρ	1000	kg/m^3
dynamic viscosity water	η	0.001	kg/m-s
accel. due to gravity	g	9.8	m/s^2
coefficient	C_B	0.6	

Leakage Through 1 Acre of CCR Rule-Prescribed Earthen Infiltration Layer		
Permeation (1)	5.8E-04	m^3/s

Notes (1) After Holtz and Kovacs (1981)

soil hydraulic conductivity	k	1.00E-07	m/s
head on liner	h_w	0.203	m
soil thickness	L	0.457	m
Cross-sectional Area	A	4000	m^2

Appendix C.2

Final Cover Settlement Analysis

MONTOUR SES ASH LANDFILL 3

FINAL COVER SETTLEMENT ANALYSIS

PURPOSE

The purpose of this engineering calculation is to provide an evaluation of the settlement of the proposed final cover system for existing Montour SES Ash Landfill 3 (Ash Landfill 3) in Washingtonville, Pennsylvania. The calculations provide an estimate of settlement of the final cover system due to primary compression of the coal combustion residual (CCR) waste following construction of the final cover system. Based on the calculated settlement, an analysis is made of the maximum differential settlement and the maximum tensile strains expected in the final cover system.

This calculation was completed to support the preparation of a written closure plan for Ash Landfill 3. The Closure Plan was prepared to demonstrate compliance of Ash Landfill 3 with the closure requirements of the Federal Coal Combustion Residuals (CCR) Rule §257.102. Section 257.102 requires, in part, that the unit is closed to preclude the probability of future impoundment of water, sediment, or slurry (§257.102(d)(1)(ii)) and that the final cover be designed and constructed to accommodate settlement and subsidence to minimize the disruption of the integrity of the final cover system (§257.102(d)(3)(i)(D)). An evaluation of the maximum expected differential settlement and tensile strain of the cover system is required to demonstrate that the Ash Landfill 3 final cover system will continue to effectively manage stormwater run-off and maintain integrity following settlement.

PROCEDURE

Construction of the final cover system will result in primary settlement of the underlying waste layer under the weight of the final cover system. Geosyntec (2012) reports that Tu et al. (2007) conducted compressibility tests on re-sedimented fly ash samples and found that coefficients of secondary compression were low, leading to the conclusion that secondary settlement of fly ash is negligible. Therefore, secondary settlement is not considered in this calculation.

A literature review of the compressibility and settlement behavior of CCR presented by Geosyntec (2012) (Appendix A) concludes that the compression of CCR occurs over a short period of time and is generally due to the reorientation of particles. Geosyntec (2012) references Yoon (2009), which reported that settlement of an instrumented test embankment constructed of CCR stabilized 5 months after the end of construction. Attachment 1 to Form 12R of PPL (2007) indicates that Ash Landfill 3 will be filled and operated in a series of six disposal sections. The estimated minimum active life of any one section requiring closure will be approximately 2 years and the active life of Ash Landfill 3 is approximately at least 22 years. Therefore, based on the 5-month stabilization period reported by Yoon (2009), upon final closure, a majority of the CCR waste placed in Ash Landfill 3 will have completed settlement under the stress of the overlying waste and only the additional vertical stress of the final cover will induce additional settlement.

Primary settlements of the waste and underlying materials were calculated using equations for conventional one-dimensional compression settlement of normally consolidated materials (i.e. $p_c' = \sigma'_{vo} < \sigma'_{vo} + \Delta\sigma$) as given below (Holtz and Kovacs 1981). This equation was entered into a Microsoft Excel™ spreadsheet to calculate the final settlements.

Primary Compression Settlement, S_p (or Δh)

$$S_p = \frac{C_C}{1+e_0} H \log\left(\frac{\sigma'_{vo} + \Delta\sigma}{\sigma'_{vo}}\right) \text{ for } p_c' = \sigma'_{vo} < \sigma'_{vo} + \Delta\sigma$$

where:
- S_p = primary settlement, ft;
- C_c = compression index;
- H = initial thickness of compressible layer, ft;
- σ'_{vo} = initial vertical effective stress, psf;
- p_c' = pre-consolidation pressure, psf; and
- $\Delta\sigma$ = increment of vertical effective stress, psf.

Using the total settlement calculated at each point along a cross section of the landfill, the differential settlement, grade change, and tensile strain between pairs of adjacent points along the geomembrane are calculated by the equations shown below.

Differential Settlement, Δs

$$\Delta s = \Delta h_1 - \Delta h_2$$

where

- Δh_1 = total settlement at Point 1 (ft)
- Δh_2 = total settlement at Point 2 (ft)

Grade Change

$$\text{Grade change \%} = (\Delta s / L) \times 100$$

where

L = horizontal distance between points of concern

Tensile Strain in Geomembrane

$$\varepsilon = \frac{8}{3}\left[\frac{\Delta s}{L}\right]^2 \times 100 \qquad \text{(Giroud 1977)}$$

INPUT PARAMETERS

Settlement of the final cover system due to waste settlement is evaluated along the generalized cross-section shown on Figure 1. This cross-section was selected as it transects both phases of the landfill, which best represents the final design conditions of Ash Landfill 3. Calculation of the final cover total settlement, grade change, and differential settlement is performed between sets of 13 points separated by a horizontal distance of approximately 180 ft or less. Those points, and their pre-settlement elevations are identified on Figure 1. The depth of waste at each point was estimated from the subgrade grading plan and the proposed final elevations of Ash Landfill 3.

The surcharge load from the placement of the final cover is calculated as the stress caused by the 1.5 ft cover/topsoil layer and 8-inch bottom ash drainage layer, which is to be placed above the geomembrane and below the cover/topsoil layer.

The material properties used in this settlement analysis are presented in the table below.

Material	Unit Weight (γ) (pcf)	Compression Index (C_c)	Initial Void Ratio (e_0)	Initial Thickness (ft)
CCR waste	108(1)	0.052(3)	0.62(4)	variable
Cover/Topsoil	110(2)	-	-	1.5
Drainage Layer	120(1)	-	-	0.67

Note
(1) Appendix A to Form 16R of PPL (2007)
(2) For low-plasticity clay (Coduto 2001)
(3) Average value for fly ash (Tu et al. 2007)
(4) Average value for Ottawa Sand (Holtz and Kovacs 1981)

Attachment 1 to Form 16R of PPL (2007) describes the proposed cover/topsoil as United States Department of Agriculture (USDA) silty clay loam, loam, silt loam, or silty clay, which can be classified as silts and clays under the United Soil Classification System (USCS) (USDA 1987). The unit weight selected for the cover/topsoil is, conservatively, the maximum for low-plasticity clay presented by Coduto (2001).

The unit weight of the CCR waste and bottom ash are taken from stability calculations included in Appendix A to Form 16R of PPL (2007). Geosyntec (2012) reported the selected compression index of the CCR waste as the average value resulting from laboratory compressibility studies performed by Tu et al. (2007). Fly ash gradation typically ranges from fine sand to silt with well-rounded to spherical particles (Geosyntec 2012). Therefore, the initial void ratio of the CCR waste was selected as a typical value for medium-dense Ottawa sand, assuming the CCR waste is compacted during landfilling (Attachment 1 to Form 1R of PPL 2007).

Technical references showing the respective material properties are included in Appendix B.

RESULTS

Table 1 presents the results of the waste settlement calculations due to primary compression. As indicated in the table, the maximum settlement of the final cover system is 0.09 ft. The maximum calculated grade change is 0.10 percent on the 3H:1V sideslope and 0.0005 percent on the top slope. These magnitudes in grade change are not expected to adversely affect the drainage system of the final cover system.

Finally, the maximum calculated strain in the cover system geosynthetics is less than 0.01 percent. This value of tensile strain is well below the recommended maximum value of 5 percent for high-density polyethylene (HDPE) geomembrane (Berg and Bonaparte 1993). Stress-stain behavior presented by Koerner (2012) indicates that the strain at failure of PVC geomembrane is greater than that of HDPE geomembrane. Therefore, the calculated tensile strains are not expected to damage the geomembrane.

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TABLE

TABLE 1
FINAL COVER SETTLEMENT DUE TO WASTE COMPRESSION
Montour Ash Landfill 3
Washingtonville, Pennsylvania

Surcharge from Final Cover	$\Delta\sigma_v$	246	psf
Compression Index of Waste	C_c	0.052	
Unit Weight of Waste	γ	108	pcf
Initial Void Ratioof Waste	e_0	0.62	

Location	Horizontal Distance (ft)	Waste Thickness (ft)	Depth to Midlayer (ft)			Initial Vert. Effective Stress (psf)			Final Vert. Effective Stress (psf)			Settlement (ft)			Total Settlement (ft)	Differential Settlement (ft)	Grade Change (%)	Strain (%)	Sideslope/Top Slope
			Top Layer	Middle Layer	Bottom layer	Top Layer	Middle Layer	Bottom layer	Top Layer	Middle Layer	Bottom layer	Top Layer	Middle Layer	Bottom layer					
1	0	0.0	0.0	0.0	0.0	0	0	0	246	246	246	0	0	0	0.00				
2	82	19.5	3.2	9.8	16.2	347	1053	1748	593	1299	1994	0.05	0.02	0.01	0.08	0.08	0.0969	0.0003	S
3	175	41.5	6.8	20.8	34.4	740	2241	3720	986	2487	3966	0.06	0.02	0.01	0.09	0.01	0.0090	0.0000	S
4	270	62.0	10.2	31.0	51.5	1105	3348	5558	1351	3594	5804	0.06	0.02	0.01	0.09	0.00	0.0032	0.0000	S
5	449	68.5	11.3	34.3	56.9	1221	3699	6140	1467	3945	6386	0.06	0.02	0.01	0.09	0.00	0.0003	0.0000	T
6	628	76.0	12.5	38.0	63.1	1354	4104	6813	1600	4350	7059	0.06	0.02	0.01	0.09	0.00	0.0003	0.0000	T
7	808	79.5	13.1	39.8	66.0	1417	4293	7126	1663	4539	7372	0.06	0.02	0.01	0.09	0.00	0.0001	0.0000	T
8	973	72.5	12.0	36.3	60.2	1292	3915	6499	1538	4161	6745	0.06	0.02	0.01	0.09	0.00	0.0003	0.0000	T
9	1138	66.0	10.9	33.0	54.8	1176	3564	5916	1422	3810	6162	0.06	0.02	0.01	0.09	0.00	0.0003	0.0000	T
10	1315	57.5	9.5	28.8	47.7	1025	3105	5154	1271	3351	5400	0.06	0.02	0.01	0.09	0.00	0.0005	0.0000	T
11	1454	40.5	6.7	20.3	33.6	722	2187	3630	968	2433	3876	0.06	0.02	0.01	0.09	0.00	0.0020	0.0000	S
12	1576	18.0	3.0	9.0	14.9	321	972	1614	567	1218	1860	0.05	0.02	0.01	0.08	0.01	0.0076	0.0000	S
12	1658	0.0	0.0	0.0	0.0	0	0	0	246	246	246	0.00	0.00	0.00	0.00	0.08	0.0956	0.0002	S

FIGURE

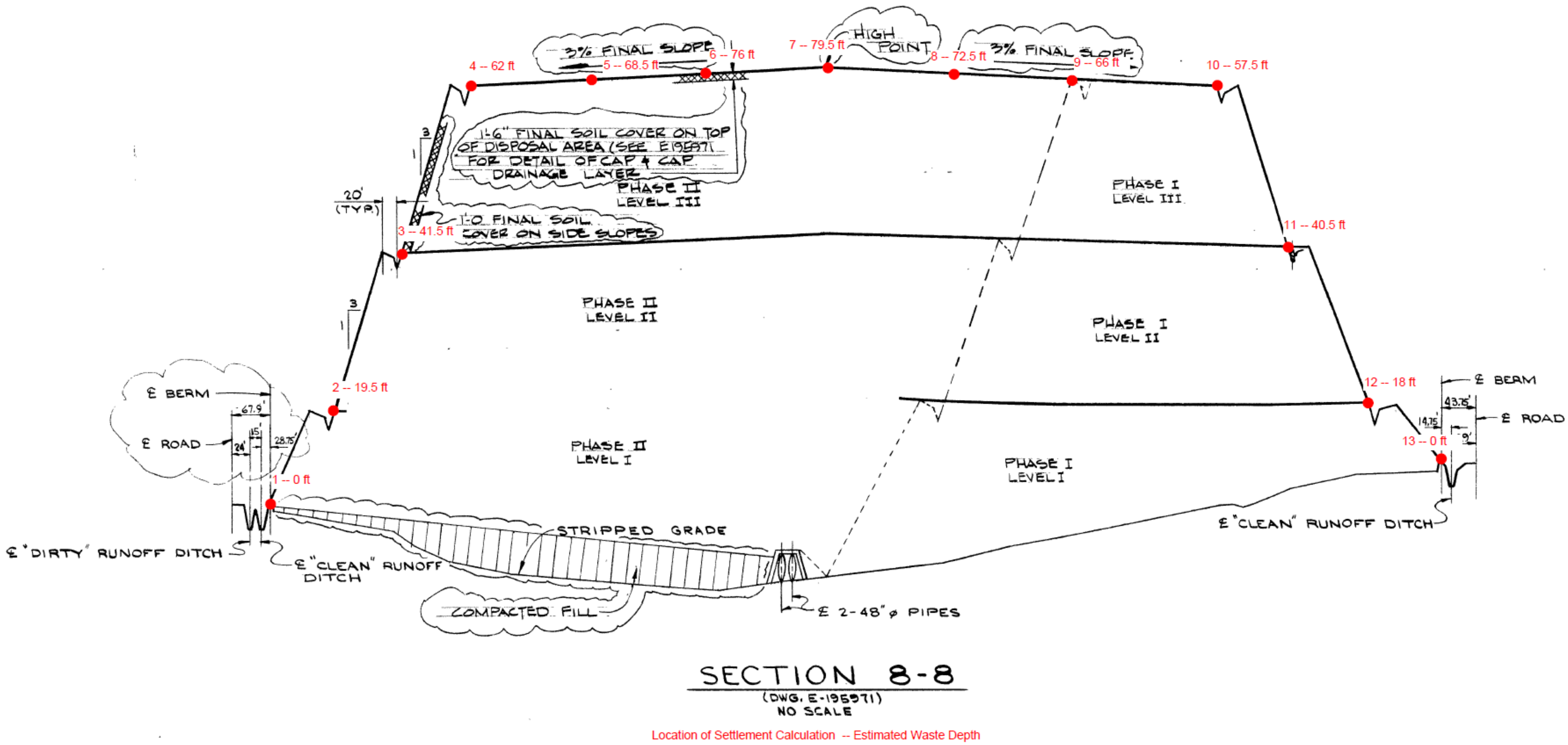


Figure 1 Generalized Landfill Cross Sections with Settlement Points

APPENDIX A

COMPRESSIBILITY OF CCB AND FINAL COVER SETTLEMENT

(GEOSYNTEC 2012)

APPENDIX B

MATERIAL PROPERTIES

TABLE 3.2 TYPICAL UNIT WEIGHTS (Coduto 2001)

Soil Type and Unified Soil Classification (See Figure 3.3)	Typical Unit Weight, γ — Above Groundwater Table (lb/ft³)	Above Groundwater Table (kN/m³)	Below Groundwater Table (lb/ft³)	Below Groundwater Table (kN/m³)
GP—Poorly-graded gravel	110–130	17.5–20.5	125–140	19.5–22.0
GW—Well-graded gravel	110–140	17.5–22.0	125–150	19.5–23.5
GM—Silty gravel	100–130	16.0–20.5	125–140	19.5–22.0
GC—Clayey gravel	100–130	16.0–20.5	125–140	19.5–22.0
SP—Poorly-graded sand	95–125	15.0–19.5	120–135	19.0–21.0
SW—Well-graded sand	95–135	15.0–21.0	120–145	19.0–23.0
SM—Silty sand	80–135	12.5–21.0	110–140	17.5–22.0
SC—Clayey sand	85–130	13.5–20.5	110–135	17.5–21.0
ML—Low plasticity silt	75–110	11.5–17.5	80–130	12.5–20.5
MH—High plasticity silt	75–110	11.5–17.5	75–130	11.5–20.5
CL—Low plasticity clay	80–110	12.5–17.5	75–130	11.5–20.5
CH—High plasticity clay	80–110	12.5–17.5	70–125	11.0–19.5

Soil Cover and Vegetative Layer γ = 110 pcf.

Unit weight of proposed cover soil assuming a USCS classification of low-plasticity clay (Coduto, 2001).

TABLE 11-2 Angle of Internal Friction of Cohesionless Soils*

No.	General Description	Grain Shape	D_{10} (mm)	C_u	Loose e	Loose φ(deg)	Dense e	Dense φ(deg)
1	Ottawa standard sand	Well rounded	0.56	1.2	0.70	28	0.53	35
2	Sand from St. Peter sandstone	Rounded	0.16	1.7	0.69	31	0.47	37†
3	Beach sand from Plymouth, MA	Rounded	0.18	1.5	0.89	29	—	—
4	Silty sand from Franklin Falls Dam site, NH	Subrounded	0.03	2.1	0.85	33	0.65	37
5	Silty sand from vicinity of John Martin Dam, CO	Subangular to subrounded	0.04	4.1	0.65	36	0.45	40
6	Slightly silty sand from the shoulders of Ft. Peck Dam, MT	Subangular to subrounded	0.13	1.8	0.84	34	0.54	42
7	Screened glacial sand, Manchester, NH	Subangular	0.22	1.4	0.85	33	0.60	43
8‡	Sand from beach of hydraulic fill dam, Quabbin Project, MA	Subangular	0.07	2.7	0.81	35	0.54	46
9	Artificial, well-graded mixture of gravel with sands No. 7 and No. 3	Subrounded to subangular	0.16	68	0.41	42	0.12	57
10	Sand for Great Salt Lake fill (dust gritty)	Angular	0.07	4.5	0.82	38	0.53	47
11	Well-graded, compacted crushed rock	Angular	—	—	—	—	0.18	60

*By A. Casagrande.

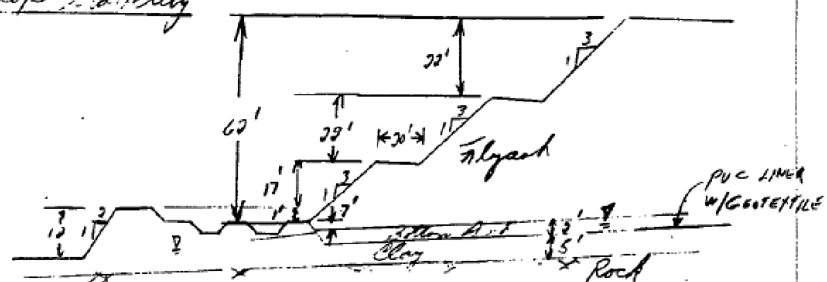
†The angle of internal friction of the undisturbed St. Peter sandstone is larger than 60° and its cohesion so small that slight finger pressure or rubbing, or even stiff blowing at a specimen by mouth, will destroy it.

‡Angle of internal friction measured by direct shear test for No. 8, by triaxial tests for all others.

Void ratio for loose and dense arrangements for Ottawa Sand (Holtz and Kovacs, 1981).

Dept.	**PENNSYLVANIA POWER & LIGHT COMPANY**	ER No. 480230
Date 1/25 19 84	**CALCULATION SHEET**	
Designed by JAB	PROJECT Montour	Sht. No. 1 of 5
Approved by / REVIEWED 6/96	Ash Area #2 Expansion (ASH AREA NO. 3)	

Final Design
Slope Stability



Typical Section @ South End

REF: KOERNER

Flyash	Clay	Bottom Ash	PVC LINER
$\gamma_m = 108$ pcf	$\gamma_m = 116$ pcf	$\gamma_m = 112$ pcf	$\delta = 21°$ TABLE 5.5 PVC TO GEOTXTILE
$\gamma_{sat} = 116$ pcf	$\gamma_{sat} = 120$ pcf	$\gamma_{sat} = 120$ pcf	$\delta = 30°$ GEOTEXTILE TO SANDY BOTTOM ASH
$\phi = 40°$	$\phi = 0$	$\phi = 35°$	
$c = 0$	$c = 1200$ pcf	$c = 0$	

$N_{AVG} \tan\delta = \left(\frac{62+7+2}{3}\right)(120 PCF) \tan 21° = 1635$ PSF > 1200 PSF CLAY

∴ CLAY WILL CONTROL SLIDING BLOCK FAILURE MODE

Computer Stability Analysis

Failure Mode	Minimum Factor of Safety	
Circular Arc	2.74	> 1.5
Sliding Block	2.45	> 1.5

∴ The embankment slopes are stable

Unit weights for CCR waste ('Flyash') and granular drainage layer ('Bottom Ash') (Appendix A to Form 16R of PPL 2007).

Appendix C.3

Final Cover Veneer Stability Analysis

MONTOUR SES ASH LANDFILL 3

FINAL COVER VENEER STABILITY ANALYSIS

INTRODUCTION

The objective of this engineering calculation is to evaluate the veneer stability of the proposed final cover system for existing Montour SES Ash Landfill 3 (Ash Landfill 3) in Washingtonville, Pennsylvania. Ash Landfill 3 is an active coal combustion residual (CCR) landfill.

This calculation was completed to support the preparation of a written closure plan for Ash Landfill 3. The Closure Plan was prepared to demonstrate compliance of Ash Landfill 3 with the closure requirements of the Federal Coal Combustion Residuals (CCR) Rule §257.102. Section 257.102(d)(1)(iii) requires that the unit is closed in a manner that will includes measures that provide for major slope stability to prevent sloughing or movement of the final cover during the closure and post closure period. An evaluation of the veneer slope stability of the cover system is required to demonstrate the Ash Landfill 3 final cover system will remain stable during the closure and post-closure period.

The analysis was performed as a back-calculation to establish the minimum required interface friction angle between any two layers of the final cover system to achieve the minimum required factor of safety.

PROCEDURE

Veneer stability of the final cover system was evaluated using the sliding wedge failure analysis method outlined by Giroud et al. (1995) for geosynthetic-soil layered systems along a critical interface of a finite slope length.

According to the United States Environmental Protection Agency (USEPA) technical manual "Solid Waste Disposal Facility Criteria" (USEPA 1993), when there is no imminent danger to human life or threat of major environmental impact, the minimum recommended slope stability factor of safety is 1.25. A veneer stability failure of the final cover system is unlikely to pose a threat to human life or the environment and a failure could be relatively easily repaired. The stability of the final cover system will be considered acceptable if the factor of safety is greater than or equal to 1.25.

The minimum interface friction angle (internal friction angle along slip surface) required to achieve a factor of safety of 1.25 was calculated using the following equation (Giroud et al. 1995):

$$FS = \lambda \frac{\tan\delta}{\tan\beta} + \frac{\gamma_{t(t-t_w^*)+\gamma_b t_w^*}}{\gamma_{t(t-t_w)+\gamma_{sat} t_w}} \frac{t}{h} \frac{\sin\phi}{2\sin\beta\cos\beta\cos(\beta+\phi)} + \frac{{}^{a}/_{\sin\beta}}{\gamma_{t(t-t_w)+\gamma_{sat} t_w}}$$

$$+ \frac{{}^{ct}/_{h}}{\gamma_{t(t-t_w)+\gamma_{sat} t_w}} \frac{\cos\phi}{\sin\beta\cos(\beta+\phi)} + \frac{{}^{T}/_{h}}{\gamma_{t(t-t_w)+\gamma_{sat} t_w}}$$

where

FS = factor of safety;

λ = $\frac{\gamma_{t(t-t_w)}+\gamma_b t_w}{\gamma_{t(t-t_w)}+\gamma_{sat} t_w}$ for failure surface above the geomembrane;

λ = 1 for failure surface below the geomembrane;

γ_t = total unit weight of soil (pounds per cubic foot (pcf));

γ_b = buoyant unit weight of soil (pcf);

γ_{sat} = saturated unit weight of soil (pcf);

δ = internal friction angle along slip surface (degrees);

β = slope angle (degrees);

a = interface adhesion (pounds per square foot (psf));

t = thickness of soil layer (feet (ft));

t_w = thickness of water flow along slope (ft);

t_w^* = thickness of water flow in toe of slope (ft);

h = height of slope (ft);

ϕ = internal friction angle of soil above critical surface (degrees);

c = cohesion of soil above critical surface (psf); and

T = tension in geosynthetics.

The thickness of water flow along the slope and toe of slope was assumed to be 4 inches (or 0.33 feet), which was calculated as the maximum head on the geomembrane in Attachment 5 to Form 16R of PPL (2007). The interface adhesion was conservatively assumed to be 0 psf, and the tension in the geosynthetics was set to be 0 lbs/ft for this analysis since good design practice is to avoid imparting tension into non-reinforcing geosynthetic components.

COVER SYSTEM AND SLOPE GEOMETRY

The veneer stability analysis was performed using the geometry and material properties of the Ash Landfill 3 final cover system. The final cover system comprises the following components, from bottom to top:

- 40-mil polyvinyl chloride (PVC) geomembrane;
- 12-oz geotextile;
- 8-inch bottom ash drainage layer;
- geotextile filter layer;
- 6-inch soil layer; and

- 12-inch topsoil layer capable of sustaining vegetation

The design grade of the Ash Landfill 3 top slopes is 3 percent. The design grade of the side slopes is 3 horizontal to 1 vertical (3H:1V) or 33 percent. Designed with the steeper grade, the side slopes are considered the critical slope in the veneer stability calculation.

A generalized cross section of Ash Landfill 3, showing the grade of the top and side slopes is presented as Figure 1.

MATERIAL PROPERTIES

The material properties used for veneer stability analysis are presented in the table below.

Material	Unit weight (pcf)	Saturated Unit Weight (pcf)	Friction Angle (deg)	Cohesion (psf)	Thickness (ft)
Cover/Topsoil	110 (1)	120 (1)	25 (3)	0	1.5
Granular Drainage Layer (2)	112	120	35	0	0.67

Notes
(1) Coduto (2001)
(2) Appendix A to Form 16R of PPL (2007)
(3) MnDOT (2007)

Attachment 1 to Form 16R of PPL (2007) describes the proposed cover/topsoil as United States Department of Agriculture (USDA) silty clay loam, loam, silt loam, or silty clay, which is assumed to have a friction angle of 25 degrees with no cohesion (MnDOT 2007). The unit weights selected for the cover/topsoil are for low-plasticity clay presented by Coduto (2001). The material properties of the bottom ash are taken from stability calculations included in Appendix A to Form 16R of PPL (2007).

References used for material properties are included in Appendix A.

As indicated above, the interface friction angle (i.e., friction angle between geosynthetics and geosynthetics or between geosynthetics and soil) was varied to identify the minimum interface shear strength that would yield the minimum required FS.

RESULTS

The minimum required interface friction angle to achieve FS of at least 1.25 was calculated for the critical slope using the Giroud Method (Giroud et al. 1995). Calculation tables are included as Appendix B.

The minimum required interface friction angle was calculated to be 23 degrees. Therefore, to satisfy the target factor of safety the interface shear strength envelope of the final cover system is characterized by a minimum interface friction angle of 23 degrees assuming no adhesion.

CONCLUSION

A veneer slope stability analysis was performed to estimate the minimum required interface friction angle to achieve minimum recommended factor of safety.

A review of available technical literature (Appendix C) indicates that the minimum required friction angle is achievable for the given final cover interfaces evaluated in this analysis.

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FIGURE

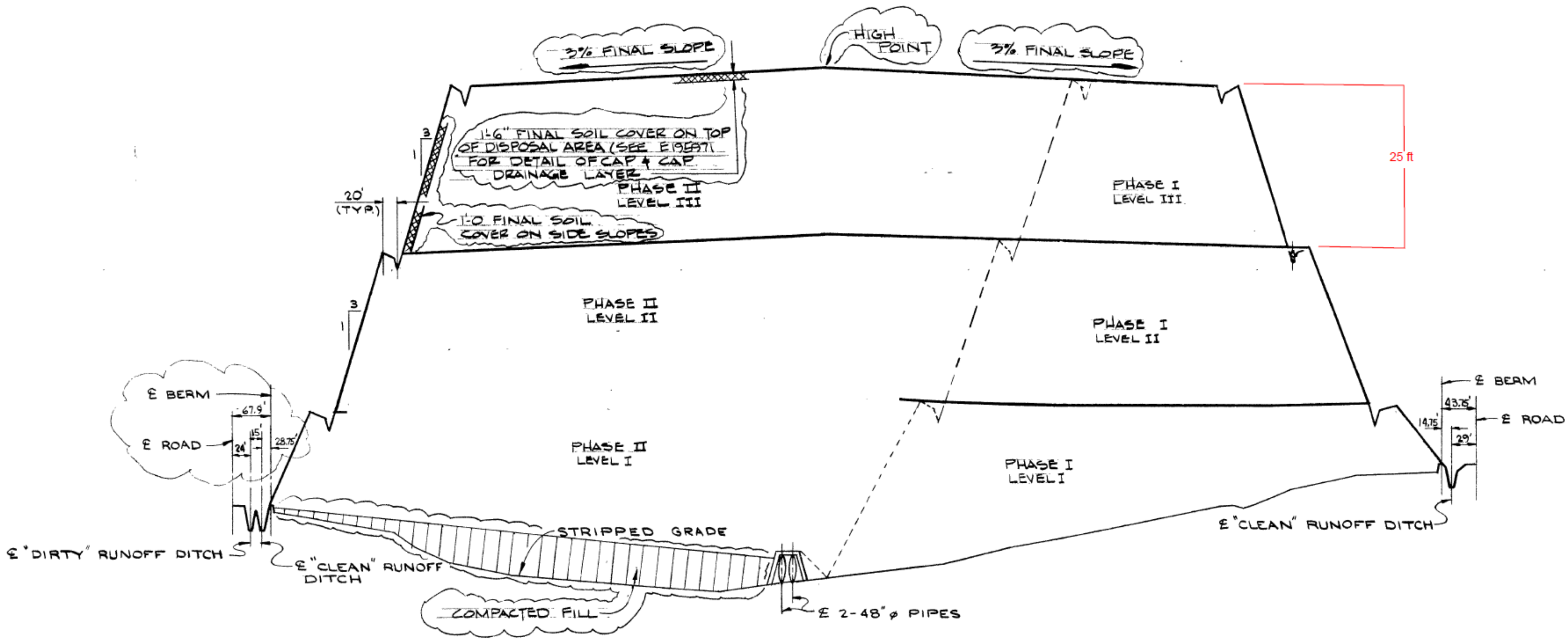


Figure 1 Generalized cross section of Ash Landfill 3 showing 3H:1V, 25-ft high side slopes (after PP&L Drawing E-195972-3)

APPENDIX A

TECHNICAL REFERENCES

TABLE 3.2 TYPICAL UNIT WEIGHTS (Coduto 2001)

Soil Type and Unified Soil Classification (See Figure 3.3)	Typical Unit Weight, γ: Above Groundwater Table (lb/ft^3)	Above Groundwater Table (kN/m^3)	Below Groundwater Table (lb/ft^3)	Below Groundwater Table (kN/m^3)
GP—Poorly-graded gravel	110–130	17.5–20.5	125–140	19.5–22.0
GW—Well-graded gravel	110–140	17.5–22.0	125–150	19.5–23.5
GM—Silty gravel	100–130	16.0–20.5	125–140	19.5–22.0
GC—Clayey gravel	100–130	16.0–20.5	125–140	19.5–22.0
SP—Poorly-graded sand	95–125	15.0–19.5	120–135	19.0–21.0
SW—Well-graded sand	95–135	15.0–21.0	120–145	19.0–23.0
SM—Silty sand	80–135	12.5–21.0	110–140	17.5–22.0
SC—Clayey sand	85–130	13.5–20.5	110–135	17.5–21.0
ML—Low plasticity silt	75–110	11.5–17.5	80–130	12.5–20.5
MH—High plasticity silt	75–110	11.5–17.5	75–130	11.5–20.5
CL—Low plasticity clay	80–110	12.5–17.5	75–130	11.5–20.5
CH—High plasticity clay	80–110	12.5–17.5	70–125	11.0–19.5

Cover/Topsoil
γ = 110 pcf
γ_{SAT} = 120 pcf

Unit weights of the cover/topsoil layer (Coduto 2001).

Table 3-2.10. Typical cohesion and angle of internal friction values.

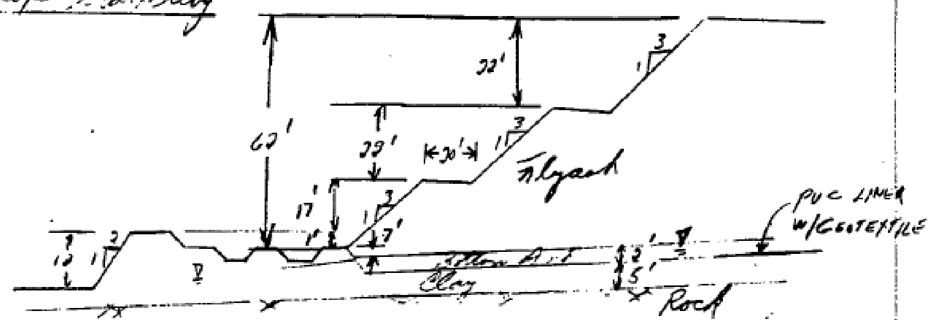
Mn/DOT Triangular Textural Classification	c Cohesion, kPa (psf): Compacted	Saturated	Φ Angle of Internal Friction (degrees)
Gravel	0	0	> 37
Sand	0	0	37 – 38
Loamy Sand	50 – 75 (1,000 - 1,500)	10- 20 (200 – 400)	31 – 34
Sandy Loam	50 – 75 (1,000 - 1,500)	10 - 20 (200 – 400)	31 – 34
Loam	60 – 90 (1,300 - 1,800)	10 - 20 (200 – 400)	28 – 32
Silt Loam	60 – 90 (1,300 - 1,800)	10 - 20 (200 – 400)	25 – 32
Sandy Clay Loam	50 – 75 (1,000 - 1,500)	10 – 20 (200 – 400)	31 – 34
Clay Loam	60 – 105 (1,300 - 2,200)	10 -20 (200 – 400)	18 – 32
Silty Clay Loam	60 – 105 (1,300 - 2,200)	10 - 20 (200 – 400)	18 – 32
Sandy Clay	50 – 75 (1,000 - 1,500)	10 - 20 (200 – 400)	31 – 34
Silty Clay	90 – 105 (1,800 - 2,200)	10 -20 (200 – 400)	18 – 32
Clay	90 – 105 (1,800 - 2,200)	10 - 20 (200 – 400)	18 - 28

Cover/Topsoil
Φ = 25 deg
c = 0 psf

Strength properties of the cover/topsoil layer (MNDOT 2007).

Dept. ______	PENNSYLVANIA POWER & LIGHT COMPANY	ER No. 480230
Date 4/25 19 84	CALCULATION SHEET	
Designed by JAB	PROJECT Montour	Sht. No. 1 of 5
Approved by ______	Ash Area #2 Expansion	
REVIEWED 6/96	(ASH AREA NO. 3)	

Final Design
Slope Stability



Typical Section @ South End

REF: KOGHNER

Flyash	Clay	Bottom Ash	PVC LINER
$\gamma_m = 108$ pcf	$\gamma_m = 116$ pcf	$\gamma_m = 112$ pcf	$\delta = 21°$ TABLE 5.5 PVC TO GEOTEXTILE
$\gamma_{sat} = 116$ pcf	$\gamma_{sat} = 120$ pcf	$\gamma_{sat} = 120$ pcf	$\delta = 30°$ GEOTEXTILE TO SAND (Bottom Ash)
$\phi = 40°$	$\phi = 0$	$\phi = 35°$	
$c = 0$	$c = 1200$ psf	$c = 0$	

$N_{AVG} \tan\delta = \left(\frac{62+7+3}{3}\right)(120\ PCF)\tan 21° = 1635$ PSF > 1200 PSF CLAY
∴ CLAY WILL CONTROL SLIDING BLOCK FAILURE MODE

Computer Stability Analysis

Failure Mode	Minimum Factor of Safety	
Circular Arc	2.74	> 1.5
Sliding Block	2.45	> 1.5

∴ The embankment slopes are stable

Material properties of the bottom ash drainage layer (Appendix A to Form 16R of PPL 2007).

APPENDIX B

VENEER STABILITY CALCULATION TABLES

Veneer Stability Factor of Safety Calculations
Montour SES Ash Landfill 3
Side Slopes (33%)

Drainage Layer Parameters	Value
Total unit weight of soil, γ_t (pcf)	110.6
Saturated unit weight of soil, γ_{sat} (pcf)	120
Unit weight of water, γ_w (pcf)	62.4
Buoyant unit weight of soil, γ_b (pcf)	57.6
Thickness of soil layer, t (ft)	2.17
Thickness of water flow along slope, t_w (ft)	0.33
Thickness of water flow in toe of slope, t^*_w (ft)	0.33
Slope angle, β (degrees)	18.40
Slope angle, β (radians)	0.321
Interface friction angle, δ (degrees)	23
Interface friction angle, δ (radians)	0.401
Interface adhesion, a (psf)	0
Soil internal friction angle, ϕ (degrees)	25
Soil internal friction angle, ϕ (radians)	0.436
Height of slope, h (ft)	25
Tension in geosynthetics, T (lbs/ft)	0
Soil cohesion, c (psf)	0
Factor of Safety	1.25

Calculated Factors

λ	0.915
λ (tan δ / tan β)	1.168
$[a / \sin\beta] / [\gamma_t (t-t_w) + \gamma_{sat} t_w]$	0.00
$[\gamma_t (t - t^*_w) + \gamma_b t^*_w] / [\gamma_t (t - t_w) + \gamma_{sat} t_w]$	0.915
t / h	8.86E-02
$\sin\phi / [(2\sin\beta\cos\beta) (\cos(\beta + \phi))]$	0.971
$[c\ t / h] / [\gamma_t (t - t_w) + \gamma_{sat} t_w]$	0
$\cos\phi / [(\sin\beta) (\cos(\beta + \phi))]$	3.952
$[T / h] / [\gamma_t (t - t_w) + \gamma_{sat} t_w]$	0

Notes, the Eq. 59 from Giroud (1995) is used for the veneer stability analysis with the following assumptions:

1. Finite slope; and
2. Partial water flow.

APPENDIX C

SOIL-GEOSYNTHETIC AND GEOSYNTHETIC-GEOSYNTHETIC INTERFACE STRENGTHS (KOERNER AND NAREJO 2005)

Table 6. Faille PVC against various geotextile interfaces.

Geotextile Type	Peak Friction (deg)	Residual Friction (deg)	Peak Adhesion (kPa)	Residual Adhesion (kPa)
Nonwoven, Needle Punched	27	23	0.2	0
Nonwoven, Heat Bonded	30	27	0	0
Woven, Slit Film	15	10	0	0

Table 9. Different geotextiles against granular soils.

Geotextile Type	Peak Friction (deg)	Residual Friction (deg)	Peak Adhesion (kPa)	Residual Adhesion (kPa)
Nonwoven, Needle Punched	33	33	0	0
Nonwoven, Heat Bonded	28	16	0	0
Woven, Slit Film	32	29	0	0