MODULE 12

Module 12: Erosion and Sedimentation Controls
[§§77.458/77.461/77.466/77.525/77.527/77.531/Chapter 102]

12.1 Diversion Controls

Provide a plan for the collection and conveyance to a natural drainageway of the runoff from upslope undisturbed areas. Provide a separate general design for a temporary highwall diversion which limits the amount of runoff which can enter the pit (where applicable). Include design criteria, capacity calculations, profile of proposed channel slopes, typical cross-sections, required channel linings and applicable details on 12.1 Data Sheet.

Temporary diversion ditches are proposed to be installed above the more permanent erosion and sedimentation controls discussed in Section 12.2 below. The configuration of the diversion ditches is presented on the Exhibit 12 drawings. Design calculations for the diversion ditches are attached to Module 12. Additionally, the diversion ditches are presented on Form 12.1 Data Sheets as applicable.

12.2 Erosion and Sediment Control

Provide a plan for the control of erosion and sedimentation for lands within the permit area to be disturbed by mining activities. Include a narrative describing the implementation of the plan, and detailed design and construction plans and specifications for structures or facilities used in the plan. The plan must include each phase or phases of mining. Include design criteria, capacity calculations, profile of proposed channel slopes, typical cross-sections, required channel linings and applicable details on 12.1 Diversion/Collection Ditch Data Sheet for collection and interceptor ditches. Provide documentation of the capacity of the existing drainage system and the effect proposed mining activities will have on the drainage. Show discharge points to natural drainageways and culverts that intercept upslope drainage or carry drainage away from the site. Show facilities to scale on Modules 9 and 16 as appropriate.

Detailed, site development plans are presented on the Exhibit 12 permit drawings and overall site plans are provided on the Exhibit 9 permit drawings. The development of the Northern Tract Quarry will consist of three primary phases; including Phase 1, Phase 2, and Phase 3. Erosion and sediment (E&S) controls will be incrementally established during the quarry development. Six E&S plans (Stage 1 through Stage 6) are included in the Exhibit 12 permit drawings which depict the sequenced installation of the E&S controls.

The erosion and sediment controls (E&SCs) installed during Phase 1 of the quarry development, as shown on the E&SC Stage 1 plan, primarily include two collection ditches (CD-1 and CD-2), and adjacent access roads, encompassing the upper hilltop portion of the Northern Tract Quarry site. The ditches are designed to drain south towards the Pitts Quarry with a high point located near the northwest corner of the ditch layouts. The ditches will collect stormwater runoff from the upper portion of the Northern Tract Quarry and outlet into the Pitts Quarry. Once CD-1 and CD-2 are established, overburden soil and cap rock will be removed from the Phase 1 area to facilitate mining of the underlying metabasalt. The working surface of the Phase 1 area will be maintained to drain towards the existing Pitts Quarry.

The E&SCs of Phase 2 of the quarry development will primarily consist of a sedimentation pond (NT Pond No. 1) on the west side of the Northern Tract Quarry area. E&SC Stage 2 consists of an access road with an adjacent collection ditch (CD-3) will provide access to NT Pond No. 1 from the existing access road on the west side of the Pitts Quarry. A diversion ditch (DD-1) will direct runoff from the upstream, undisturbed area to a level spreader, north of NT Pond No. 1. After complete development of NT Pond No. 1 and collection ditch CD-3, diversion ditch, DD-1, will be removed. E&SC Stage 3 will continue the Phase 2 quarry development by adding another access road and associated collection ditch (CD-4) to provide accessibility from the pond area to the Phase 1 access road and ditch. Diversion ditch, DD-2, is established before CD-4 is started and directs undisturbed area runoff into the level spreader from E&SC Stage 2. After completion of CD-4, ditch CD-1 and a portion of CD-2 may be removed as overburden removal and mining in the Northern Tract Quarry is expanded. The top working surface of the overburden soil removal and mining area shall be maintained to drain towards the existing Pitts Quarry such that the watershed tributary to NT Pond No. 1 will be incrementally reduced subsequent to the removal of CD-1 and CD-2. Culverts C-1 and C-2 will convey runoff from CD-3 and CD-4, respectively, under the access roads to NT Pond No. 1. Sequential development of the Phase 2 E&SCs is depicted on the E&SC Stage 2 through Stage 4 plans provided with the Exhibit 12 permit drawings.

A second sedimentation pond (NT No. 2) will be established along the eastern perimeter of the Northern Tract Quarry during Phase 3 of the quarry development. The E&SC Stage 5 and Stage 6 plans depict the incremental installation of the pond and related features. Two diversion ditches, DD-3 and DD-4, will be installed above the proposed Phase 3 area to direct runoff from upstream, undisturbed areas into two temporary slopes pipes which discharge into two level spreaders near the eastern boundary of the site. After the diversion ditches are established, an access road will be established along the northern and southern end of the Phase 3 area, respectively. An access road, and adjacent Ditch CD-5, will provide access to NT No. 2 from the access road adjacent the Phase 2 ditch, CD-4. Ditch CD-6 and the

adjacent access road will connect the existing access road on the east side of the Pitts Quarry to NT Pond No. 2. Culverts C-3 and C-4 will direct runoff under the access roads and into NT No. 2. NT Pond No. 2 will initially be constructed in two chambers connected by a temporary connector ditch. After the access roads and pond chambers are completed, the temporary connector ditch will be removed and the two pond chambers will be connected by establishing the completed NT Pond No. 2.

32-inch diameter compost filter socks will be established along the downstream perimeter of all three phases to control runoff during the initial development of the E&SC structures. The compost filter socks are required until the permanent E&S controls are stabilized.

Permanent E&S controls consisting of collection ditches and sedimentation ponds are designed to safely convey a Soil Conservation Service (SCS) Type II, 100-year recurrence interval, 24-hour duration storm event considering completely disturbed watershed conditions. Designs for the proposed ditches, culverts, and sedimentation ponds are based on the Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Pollution Control Program Manual as applicable. Additional detail regarding the design of the proposed surface drainage controls can be found in the attached calculations. Form 12.1 Diversion/Collection Ditch Data Sheets have been completed for each proposed ditch and are attached to this module. Design calculations for the sedimentation ponds are provided in Module 13.

12.3 Haul Roads

Provide the following information for each haul road to be constructed, reconstructed or used in the operation:

Note: Activities proposed to be conducted under General permit for Temporary Road Crossings (BMR-GP-101) and General Permit for Access Road Crossings (BMR-GP-102) must include a completed Notification Form, with attachments, for the respective General Permit (i.e., Form 5600-FM-MR0054 for BMR-GP-101 and Form 5600-FM-MR0059 for BMR-GP-102). BMR-GP-102 may not be used for haul roads.

a) Location; show on Exhibit 9 (and Exhibit 18 if road will remain as part of postmining land use);

Haul road locations are shown on Exhibit 9.

b) Description and typical cross-sections showing the construction of the haul road including existing ground, grades, slopes, culvert locations, outlet protection and other drainage control;

Several roads will be established around the perimeter of the Northern Tract Quarry site to provide access for operation, monitoring, inspections, and maintenance activities. Typical cross-sections of access roads are shown on Exhibit 12. The roads are configured to have longitudinal slopes ranging from 0.01 ft/ft to 0.12 ft/ft. The roads typically outlet into each respective sedimentation pond through a culvert or an engineered road crossing (Texas Crossing). A berm, as required or needed, will be established on the outer perimeter of each road for safety purposes. Alternatively, a post and cable barrier, concrete jersey barrier, or guiderail will be used instead of a berm.

c) Measures to control and prevent erosion and sedimentation; include proposed spacing of sediment traps, turnouts, culverts, check dams, etc.;

The surface of the proposed haul roads will be covered with an aggregate road surfacing where needed to stabilize the area or facilitate vehicular travel. The adjacent cut/fill slopes will be revegetated, as applicable, incrementally as their development progresses. Additionally, each haul road will be constructed with a cross slope to drain into an adjacent road gutter to control runoff during storm events. Sedimentation ponds will be constructed to collect rainfall runoff from the road gutters and other adjacent areas during construction, normal facility operations, and road removal/reclamation. Refer to Module 13, the permit drawings package, and the Calculation Brief for additional information regarding the sedimentation ponds.

d) Plan for reclamation after mining is completed;

The roads will generally be backfilled and/or regraded to establish the approximate original contour (AOC).

e) If the haul road involves the crossing of any intermittent or perennial stream or wetland include Module 14 Streams/Wetlands;

The Northern Tract Quarry haul roads will not impact any streams or wetlands.

f) Will a PennDOT highway occupancy permit be needed? ☐ Yes ☒ No

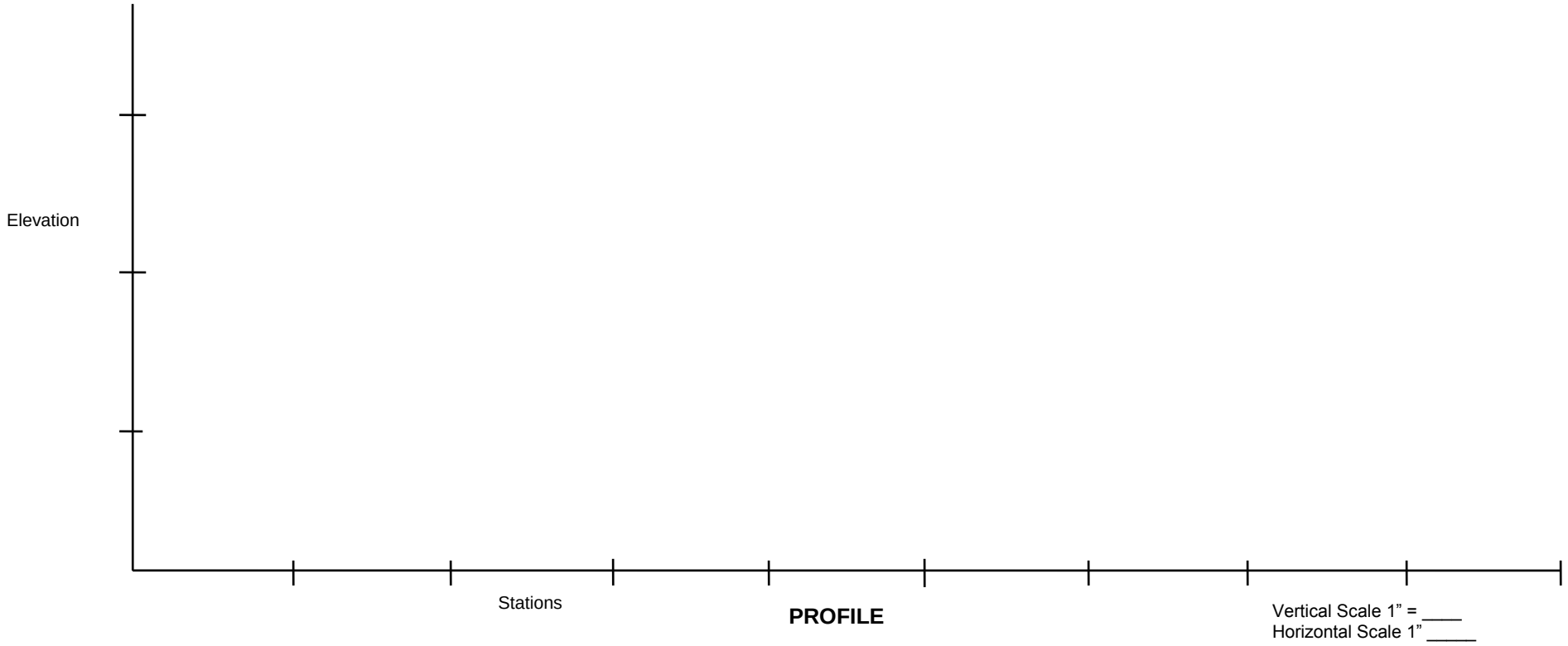
If yes, PennDOT Occupancy Permit number must be submitted prior to permit activation.

12.1 Diversion/Collection Ditch Data Sheet

Title:	Site:	Company:	Permit Number:
Prepared by:	Telephone Number:	Date:	Sheet _____ of _____

Design Calculations:

Station		Drainage Area acres	Design Storm (yrs.)	Average Watershed Slope (%)	Curve Number	Peak Discharge Q cfs	Channel Bed Slope (%)	Freeboafd (ft.)	Channel Lining	Manning's Coefficient (n)	Channel Bottom Width (ft)	Channel Side Slopes	Flow Area (sq.ft.)	Flow Depth (ft.)	Top Flow Width (ft.)	Flow Velocity (ft/sec)	Q Available cfs	With Freeboard		
Start / End	Elevation																	Channel Depth (ft.)	Top Channel Width (ft.)	Q Available cfs



PROFILE

Vertical Scale 1" = ____
Horizontal Scale 1" _____

MODULE 12 - CALCULATION BRIEF

MODULE 12 - CALCULATION BRIEF

DECEMBER 2017

NORTHERN TRACT QUARRY
SPECIALTY GRANULES LLC
HAMILTONBAN AND LIBERTY TOWNSHIPS
ADAMS COUNTY, PENNSYLVANIA

SECTION	TABLE OF CONTENTS	REVISION
A	DIVERSION DITCH DESIGN	0
B	COLLECTION DITCH DESIGN	0
C	DITCH RIGID LINING DESIGN	0
D	COLLECTION AND DIVERSION DITCH FORM 12.1	0
E	CULVERT - HYDRAULIC DESIGN	0
F	CULVERT - STRUCTURAL DESIGN	0
G	LEVEL SPREADER DESIGN	0

SECTION A

DIVERSION DITCH DESIGN

D'APPOLONIA

By:	MJD	Date: 11/22/16	Subject:	Diversion Ditch Design	Sheet No.: 1 of 10
Chkd. By:	AMR	Date: 12/6/2016		Initial Site Development	Proj. No.: 152596A

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DIVERSION DITCH DESIGN
NORTHERN TRACT QUARRY, CHARMIAN SITE
SPECIALTY GRANULES INC.
ADAMS COUNTY, PENNSYLVANIA

PURPOSE

Design of the channels is based on Pennsylvania Department of Environmental Protection (PADEP) and Mine Safety and Health Administration (MSHA) regulations as applicable. The channels will be designed to divert runoff from upslope undisturbed areas and convey it to level spreaders. Watershed maps are available in Attachment 5.

CHANNEL DESIGN REQUIREMENTS

PADEP Erosion and Sediment Pollution Control Program Manual (Chapter 102)

Channel Type	Design Frequency (years)	Minimum Required Freeboard (ft)
Temporary	2 or 1.6 cfs/acre	0.5
Temporary*	5 or 2.25 cfs/acre	0.5
Permanent	10 or 2.75 cfs/acre	0.5

* Special Protection Watershed

PADEP Engineering Manual for Mining Operations

Design Frequency (years)	Minimum Required Freeboard (ft)
10	0.5

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 2 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-1

Location: Diversion Ditch DD-1 shall divert runoff upslope of Collection Ditch CD-3 and NT Pond No. 1.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	2.75 cfs/acre		
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	11.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	4	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	2	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	RECM	RECM	
	Lining Product	P300	P300	Lining Product
		Unvegetated	Unvegetated	(Liner Design Software Output avaiable in Attachment 4)
	Allowable Velocity (fps)	9.0	9.0	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 3 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-1

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0315	0.0315			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	0.76	0.76	ft		
Velocity Head	0.27	0.27			
Froude Number	1.01	1.01			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.15	4.15	ft/sec		
Q Available at Channel Design Depth	84.8	84.8	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	10.0	10.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	5.0	5.0	ft		
Bottom Width:Depth Ratio	2.6	2.6			
Wetted Perimeter	5.4	5.4	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.5	0.5			
Flow Area	2.7	2.7	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**0.76**	**0.76**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.3**	**1.3**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	4.15	4.15	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	RECM	RECM			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	P300 Unvegetated	P300 Unvegetated			

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 4 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-2

Location: Diversion Ditch DD-2 shall divert runoff upslope of Collection Ditch CD-4

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	2.75 cfs/acre		
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	11.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.040	ft/ft	
	Area of Tributary Watershed	4	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	2	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	RECM	RECM	
	Lining Product	P300	P300	Lining Product
		Unvegetated	Unvegetated	(Liner Design Software Output avaiable in Attachment 4)
	Allowable Velocity (fps)	9.0	9.0	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 5 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-2

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0315	0.0654			
Critical Slope	0.02	0.08	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	0.76	0.76	ft		
Velocity Head	0.27	0.15			
Froude Number	1.01	0.70			
Flow Type	Supercritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.15	3.15	ft/sec		
Q Available at Channel Design Depth	84.8	57.8	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	10.0	10.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	5.0	5.6	ft		
Bottom Width:Depth Ratio	2.6	2.2			
Wetted Perimeter	5.4	6.1	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.5	0.6			
Flow Area	2.7	3.5	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**0.76**	**0.91**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.3**	**1.4**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	4.15	3.15	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	RECM	RECM			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	P300 Unvegetated	P300 Unvegetated			

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 6 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-3

Location: Diversion Ditch DD-3 shall divert runoff upslope of Collection Ditch CD-5 and NT Pond No. 2.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	2.75 cfs/acre		
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	13.8	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.040	ft/ft	
	Area of Tributary Watershed	5	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	3.5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	RECM	RECM	
	Lining Product	P300	P300	Lining Product
		Unvegetated	Unvegetated	(Liner Design Software Output avaiable in Attachment 4)
	Allowable Velocity (fps)	9.0	9.0	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 7 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-3

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0324	0.0276			
Critical Slope	0.02	0.01	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	0.68	0.68	ft		
Velocity Head	0.27	0.54			
Froude Number	1.00	1.60			
Flow Type	Subcritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.14	5.88	ft/sec		
Q Available at Channel Design Depth	110.0	182.4	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	11.5	11.5	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	6.2	5.6	ft		
Bottom Width:Depth Ratio	5.1	6.7			
Wetted Perimeter	6.5	5.8	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.5	0.4			
Flow Area	3.3	2.4	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**0.68**	**0.52**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.2**	**1.0**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	4.14	5.88	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	RECM	RECM			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	P300 Unvegetated	P300 Unvegetated			

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 8 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-4

Location: Diversion Ditch DD-4 shall divert runoff upslope of Collection Ditch CD-6 and NT Pond No. 2.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	2.75 cfs/acre		
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	13.8	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	5	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	3.5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	RECM	RECM	
	Lining Product	P300	P300	Lining Product
		Unvegetated	Unvegetated	(Liner Design Software Output avaiable in Attachment 4)
	Allowable Velocity (fps)	9.0	9.0	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 11/22/16 Subject: Diversion Ditch Design Sheet No.: 9 of 10
Chkd. By: AMR Date: 12/6/2016 Initial Site Development Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Temporary Diversion Ditch & Sed Trap Design\Diversion Ditch-R1.xls

Diversion Ditch DD-4

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0324	0.0324			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	0.68	0.68	ft		
Velocity Head	0.27	0.27			
Froude Number	1.00	1.00			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.14	4.14	ft/sec		
Q Available at Channel Design Depth	110.0	110.0	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	11.5	11.5	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	6.2	6.2	ft		
Bottom Width:Depth Ratio	5.1	5.1			
Wetted Perimeter	6.5	6.5	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.5	0.5			
Flow Area	3.3	3.3	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**0.68**	**0.68**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.2**	**1.2**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	4.14	4.14	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	RECM	RECM			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	P300 Unvegetated	P300 Unvegetated			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 10 of 10
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

REFERENCES

1) Soil Survey of Adams County, United States Department of Agriculture, Soil Conservation Service, September 1983.

2) Urban Hydrology for Small Watersheds, 2nd Edition, Technical Release Number 55 (TR-55), United States Department of Agriculture, Soil Conservation Service, June 1986.

3) NOAA, Point Precipitation Frequency Estimates

4) Design of Erosion Protection Mats, Cowherd, et. al., Bowser-Morner Associates, Inc.

5) Erosion and Sediment Pollution Control Program Manual, Pennsylvania Department of Environmental Protection - Office of Water Management, March 2012.

6) Engineering Manual for Mining Operations, Pennsylvania Department of Environmental Protection - Bureaus of Mining and Reclamation and District Mining Operations, 1999.

7) Standard Specifications for Highway Bridges - 17th Edition, American Association of State Highway and Transportation Officials, 2002.

8) Engineering and Design Manual - Coal Refuse Disposal Facilities, Mine Safety and Health Administration

9) North American Green Erosion Control Materials Design Software - Version 5.0 North American Green, Inc., 2004.

10) Design of Roadside Channels with flexible linings, US Department of Transportation, Federal Highway Administration, September 2005.

VARIABLES

T	= channel top width at the water surface (ft)
P	= wetted perimeter (ft)
R	= hydraulic radius = A/P (ft)
A	= cross-sectional area of the channel (sqft)
n	= Manning's "n"
d	= flow depth
D	= channel depth
V	= velocity
Q	= flow rate
τ_d	= maximum shear stress in straight section
τ_b	= maximum shear stress in a bend
τ_a	= allowable shear stress
$V_{allowable}$	= allowable velocity
D_{50}	= 50th percentile diameter
S_c	= critical slope (ft/ft)
D_m	= mean depth of flow = A/T
Rc	= Radius of channel bend

ATTACHMENT 4

North American Green Software Output

Tensar International Corporation
5401 St. Wendel-Cynthiana Road
Poseyville, Indiana 47633
Tel. 800.772.2040
Fax 812.867.0247
www.nagreen.com

Erosion Control Materials Design Software
Version 5.0

Project Name: SGI
Project Number: 84066
Channel Name: DD-1

Discharge	11
Peak Flow Period	24
Channel Slope	0.02
Channel Bottom Width	2
Left Side Slope	2
Right Side Slope	2
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Silt Loam

P300 - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
P300 Unvegetated	Straight	11 cfs	4.15 ft/s	0.76 ft	0.032	2 lbs/ft2	0.94 lbs/ft2	2.12	STABLE	E
P300 Reinforced Vegetation	Straight	11 cfs	2.32 ft/s	1.12 ft	0.07	8 lbs/ft2	1.39 lbs/ft2	5.74	STABLE	E
Underlying Substrate	Straight	11 cfs	2.32 ft/s	1.12 ft	--	2 lbs/ft2	0.092 lbs/ft2	21.82	STABLE	--

North American Green
5401 St. Wendel-Cynthiana Rd.
Poseyville, Indiana 47633
Tel. 800.772.2040
Fax 812.867.0247
www.nagreen.com

Control Materials Design Software
Version 5.0

Project Name: Northern Tract
Project Number: 119351
Channel Name: DD-2

Discharge	11.0
Peak Flow Period	24
Channel Slope	.04
Channel Bottom Width	2
Left Side Slope	2
Right Side Slope	2
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Silt Loam

P300 - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
P300 Unvegetated	Straight	11 cfs	5.21 ft/s	0.64 ft	0.033	2 lbs/ft2	1.6 lbs/ft2	1.25	STABLE	E
P300 Reinforced Vegetation	Straight	11 cfs	3.15 ft/s	0.91 ft	0.065	8 lbs/ft2	2.28 lbs/ft2	3.51	STABLE	E
Underlying Substrate	Straight	11 cfs	3.15 ft/s	0.91 ft	--	2 lbs/ft2	0.194 lbs/ft2	10.28	STABLE	--

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Poseyville, Indiana 47633
Tel. 800.772.2040
Fax 812.867.0247
www.nagreen.com

Erosion Control Materials Design Software
Version 5.0

Project Name: SGI
Project Number: 84066
Channel Name: DD-3

Discharge	13.8
Peak Flow Period	24
Channel Slope	0.02
Channel Bottom Width	3.5
Left Side Slope	2
Right Side Slope	2
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Silt Loam

P300 - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
P300 Unvegetated	Straight	13.8 cfs	4.14 ft/s	0.68 ft	0.032	2 lbs/ft2	0.85 lbs/ft2	2.34	STABLE	E
P300 Reinforced Vegetation	Straight	13.8 cfs	2.46 ft/s	1.01 ft	0.067	8 lbs/ft2	1.27 lbs/ft2	6.32	STABLE	E
Underlying Substrate	Straight	13.8 cfs	2.46 ft/s	1.01 ft	--	2 lbs/ft2	0.096 lbs/ft2	20.87	STABLE	--

North American Green
5401 St. Wendel-Cynthiana Rd.
Poseyville, Indiana 47633
Tel. 800.772.2040
Fax 812.867.0247
www.nagreen.com

Control Materials Design Software
Version 5.0

Project Name: Northern Tract
Project Number: 119351
Channel Name: DD-3

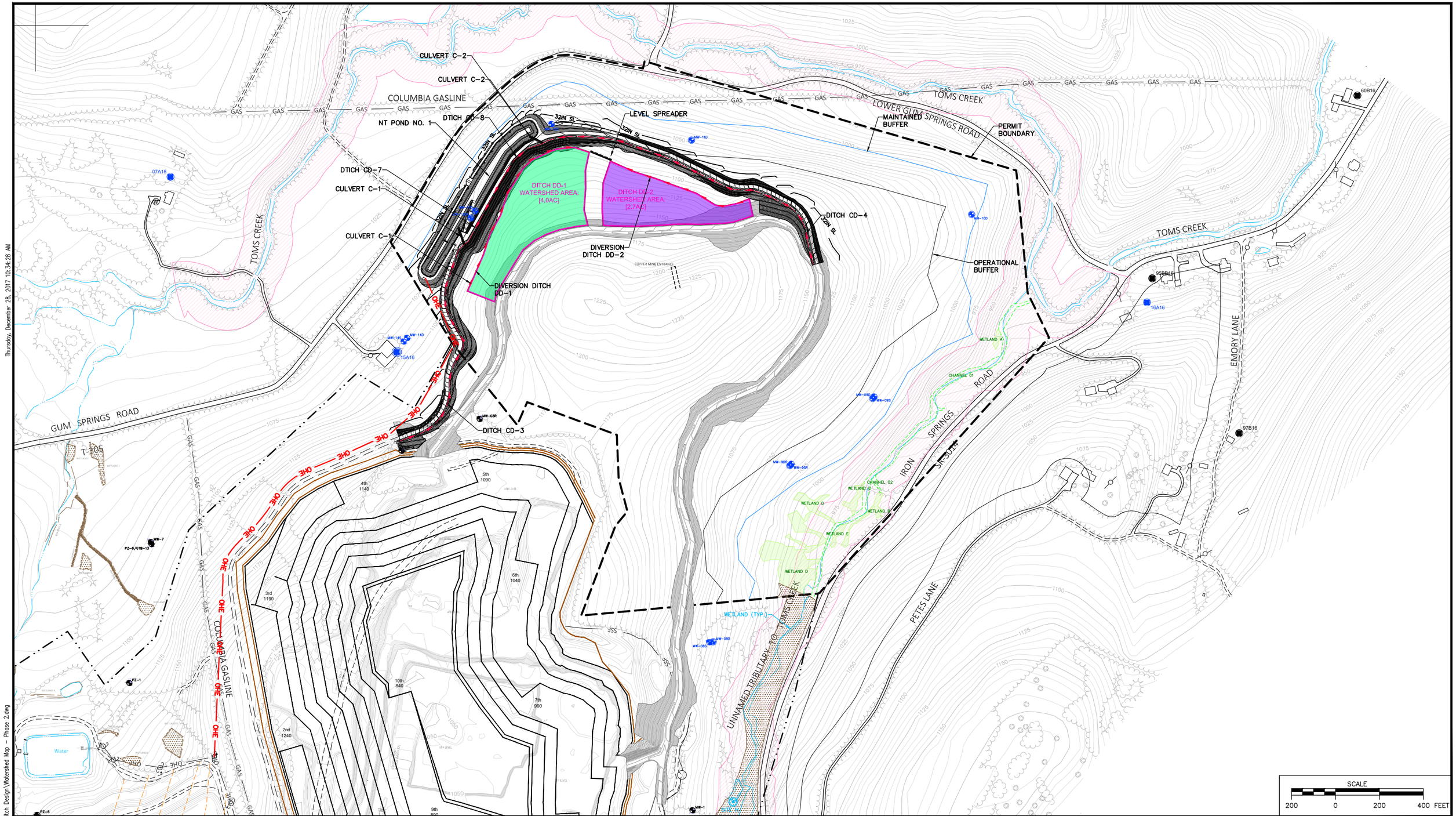
Discharge	13.8
Peak Flow Period	24
Channel Slope	0.04
Channel Bottom Width	3.5
Left Side Slope	2
Right Side Slope	2
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Silt Loam

P300 - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
P300 Unvegetated	Straight	13.8 cfs	5.16 ft/s	0.57 ft	0.033	2 lbs/ft2	1.43 lbs/ft2	1.39	STABLE	E
P300 Reinforced Vegetation	Straight	13.8 cfs	3.28 ft/s	0.82 ft	0.064	8 lbs/ft2	2.05 lbs/ft2	3.91	STABLE	E
Underlying Substrate	Straight	13.8 cfs	3.28 ft/s	0.82 ft	--	2 lbs/ft2	0.195 lbs/ft2	10.28	STABLE	--

ATTACHMENT 5

Watershed Maps



NOTES / REVISIONS

REV.	REVISION DESCRIPTION	MADE BY	CHKD BY	DATE
4				
3				
2				
1				

ISSUED FOR | DATE

SEAL:

D'APPOLONIA
701 RODI ROAD, FLOOR 2
PITTSBURGH, PENNSYLVANIA 15235-4559
(412) 856-9440 FAX (412) 856-9535

SGI

PROJECT NUMBER: 152596
FILE NAME: Watershed Map – Phase 2.dwg

DRAWN BY: MJD | DATE: 12/18/2017
CHECKED BY: CHKD BY | DATE: DATE

SPECIALTY GRANULES LLC

CHARMIAN SITE

E&SC PHASE 2 AND E&SC PHASE 3
WATERSHED MAP

SCALE: AS SHOWN | DRAWING NO. 1 | REV 0

Thursday, December 28, 2017 10:34:28 AM

N:\2015\152596 - SGI\Northern Tract\Ditch Design\Watershed Map - Phase 2.dwg

Thursday, December 28, 2017 10:45:53 AM

N:\2015\152596 - SGI\Northern Tract\Ditch Design\Watershed Map - Stage 5.dwg

OPERATIONAL BUFFER

PERMIT BOUNDARY

COLUMBIA GASLINE

GAS

TOMS CREEK

LOWER GUM SPRINGS ROAD

CULVERT C-3

60B16

07A16

MAINTAINED BUFFER

DIVERSION DITCH DD-3

DITCH DD-3 WATERSHED AREA [5.0AC]

NT POND NO. 2

TEMPORARY SLOPE PIPE

DITCH CD-9

95BB16

16A16

DITCH CD-10

DITCH DD-4 WATERSHED AREA [5.0AC]

WETLAND A

LEVEL SPREADER

EMORY LANE

DIVERSION DITCH DD-4

CHANNEL 01

NT POND2 TEMPORARY CONNECTION DITCH

NT POND NO. 2

97B16

GUM SPRINGS ROAD

T-305

IRON SPRINGS ROAD

CHANNEL 02

WETLAND C

WETLAND B

WETLAND E

CULVERT C-3

WETLAND D

PETES LANE

UNNAMED TRIBUTARY TO TOMS CREEK

WETLAND (TYP.)

15A16

MW-03R

MW-3

MW-7

PZ-6/GTB-13

PZ-1

PZ-5

MW-1

BORING 14

Water

4th 1140

5th 1090

3rd 1190

6th 1040

10th 840

7th 990

2nd 1240

9th 890

SCALE

200 0 200 400 FEET

NOTES / REVISIONS

ISSUED FOR	DATE	REV.	REVISION DESCRIPTION	MADE BY	CHKD BY	DATE
		4				
		3				
		2				
		1				

SEAL:

D'APPOLONIA
701 RODI ROAD, FLOOR 2
PITTSBURGH, PENNSYLVANIA 15235-4559
(412) 856-9440 FAX (412) 856-9535

SGI

PROJECT NUMBER: 152596

FILE NAME: Watershed Map - Stage 5.dwg

DRAWN BY: MJD | DATE: 12/18/2017

CHECKED BY: CHKD BY | DATE: DATE

SPECIALTY GRANULES LLC

CHARMIAN SITE

E&SC PHASE 5
WATERSHED MAP

SCALE: AS SHOWN | DRAWING NO. 1 | REV 0

SECTION B

COLLECTION DITCH DESIGN

D'APPOLONIA

By:	MJD	Date: 07/01/16	Subject: Northern Tract Quarry	Sheet No.:	1 of 37
Chkd. By:	AMR	Date: 10/22/16	Collection Ditch Design	Proj. No.:	152596A

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COLLECTION DITCH DESIGN
NORTHERN TRACT QUARRY, CHARMIAN SITE
SPECIALTY GRANULES, LLC
ADAMS COUNTY, PENNSYLVANIA

PURPOSE

The purpose of this calculation is to design the collection ditches for the three phased, intial site development of the Northern Tract Quarry. Design of the ditches are based on Pennsylvania Department of Environmental Protection (PADEP) regulations as applicable. All ditches will be designed to convey the 100-year, 24-hour storm event while meeting PADEP freeboard requirements.

RAINFALL DATA

The following rainfall depths were adopted from Reference #3 and available in Attachment 1.

24-hr Storm Frequency	Depth (Inches)
2-yr	3.25
100-yr	8.03

CHANNEL DESIGN REQUIREMENTS

PADEP Erosion and Sediment Pollution Control Program Manual (Chapter 6) Reference #5

Channel Type	Minimum Required Freeboard (ft)
Temporary	0.5
Permanent	0.5

WATERSHED AREAS

The collection ditch watersheds were delineated in AutoCAD Civil 3D and summarized in the table below. Refer to Attachment 5 for watershed maps.

Subbasin	Area (acres)
CD-1	11.33
CD-2	33.97
CD-3	4.50
CD-4	7.92
CD-5	6.85
CD-6	8.43
CD-7	1.75
CD-8	1.60
CD-9	4.11
CD-10	4.40

SITE SOILS

The hydrologic soil groups and site soils present in the Northern Tact Quarry was determined using the United States Department of Agriculture, Natural Resources Conservation Service Web Soil Survey. The site soils are classified as Hydrologic Soil Group (HSG) B. The soil survey report is provided in Attachment 2. The entire watershed area was assumed to be disturbed during initial development of the quarry.

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 2 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
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TIME OF CONCENTRATION

The time of concentration was evaluated using methodology presented in Technical Release No. 55 (TR-55) (Ref. #2). A summary is provided below; complete calculations generated from AutoDesk Storm and Sanitary Analysis are presented Attachment 3.

Subbasin CD-1

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.112	Sheet	0.12	Disturbed	-	4.08	7.68
706	0.093	Shallow Concentrated	-	Unpaved	4.92	2.39	
435	0.020	Channel	0.035	-	-	1.21	

Subbasin CD-2

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.081	Sheet	0.12	Disturbed	-	4.65	10.69
795	0.120	Shallow Concentrated	-	Unpaved	5.59	2.37	
1523	0.020	Channel	0.035	-	-	3.67	

Subbasin CD-3

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.231	Sheet	0.12	Disturbed	-	3.06	4.85
26	0.480	Shallow Concentrated	-	Unpaved	11.18	0.04	
1090	0.100	Channel	0.035	-	-	1.75	

Subbasin CD-4

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.234	Sheet	0.12	Disturbed	-	3.04	4.87
230	0.287	Shallow Concentrated	-	Unpaved	8.64	0.44	
515	0.020	Channel	0.035	-	-	1.39	

Subbasin CD-5

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.370	Sheet	0.12	Disturbed	-	2.53	4.54
100	0.500	Shallow Concentrated	-	Unpaved	11.41	0.15	
745	0.025	Channel	0.035	-	-	1.86	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 3 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Subbasin CD-6

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.261	Sheet	0.12	Disturbed	-	2.91	5.29
58	0.341	Shallow Concentrated	-	Unpaved	9.42	0.10	
784	0.030	Channel	0.035	-	-	1.76	
295	0.100	Channel	0.035	-	-	0.43	
53	0.060	Channel	0.035	-	-	0.09	

Subbasin CD-7

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.295	Sheet	0.12	Disturbed	-	2.77	3.42
155	0.450	Shallow Concentrated	-	Unpaved	10.82	0.24	
10	1.000	Shallow Concentrated	-	Unpaved	16.13	0.01	
134	0.020	Channel	0.035	-	-	0.40	

Subbasin CD-8

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.270	Sheet	0.12	Disturbed	-	2.87	4.00
259	0.310	Shallow Concentrated	-	Unpaved	8.98	0.48	
219	0.020	Channel	0.035	-	-	0.65	

Subbasin CD-9

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.351	Sheet	0.12	Disturbed	-	2.59	3.79
450	0.235	Shallow Concentrated	-	Unpaved	7.82	0.96	
83	0.020	Channel	0.035	-	-	0.24	

Subbasin CD-10

Length (ft)	Slope (ft/ft)	Flow Type	Mannin g's n	Surface Cover	Est. Vel. (fps)	Flow Time (min)	Total TOC (min)
100	0.337	Sheet	0.12	Disturbed	-	2.63	3.53
226	0.428	Shallow Concentrated	-	Unpaved	10.56	0.36	
186	0.020	Channel	0.035	-	-	0.54	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 4 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
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HYDROLOGIC SUMMARY

Peak flow quantities were calculated using Autodesk Storm and Sanitary Analysis. Refer to Attachment 3 for the complete SSA output report.

Subbasin	Peak Discharge (cfs)	Runoff Volume (cf)
CD-1	100.0	261,500
CD-2	285.0	784,500
CD-3	50.0	104,000
CD-4	77.0	183,000
CD-5	70.0	158,000
CD-6	80.0	194,600
CD-7	16.8	40,400
CD-8	15.5	37,000
CD-9	42.0	97,000
CD-10	45.0	102,000

DITCH SUMMARY

Ditches with multiple lining types are both acceptable as options for the specified limits. Where no lining type is addressed, it is assumed the limits of the ditch will be excavated into competent cap rock.

	Limits	Design Depth (ft)	Bottom Width (ft)	Lining Type
CD-1	0+00 to 14+08	2.0	5.0	NAG P550/R-4 Riprap
CD-2	0+00 to 37+73	3.5	5.0	NAG P550/R-4 Riprap
CD-3	0+00 to7+50	3.0	3.0	R-4 Riprap/Fabriform
	7+50 to 10+80	3.0	3.0	---
CD-4	0+00 to 8+00	3.0	5.0	R-4 Riprap/Fabriform
	8+00 to 15+00	3.0	5.0	---
CD-5	0+00 to 4+25	3.0	5.0	---
	4+25 to 16+00	3.0	5.0	R-4 Riprap/Fabriform
CD-6	0+00 to 12+55	3.0	3.5	R-5 Riprap/Fabriform
	12+55 to 14+70	3.0	3.5	---
CD-7	0+00 to 3+06	1.0	2.0	---
CD-8	0+00 to 2+88	1.0	2.0	---
CD-9	0+00 to 5+79	2.0	1.0	---
CD-10	0+00 to 7+02	2.0	1.0	---

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 5 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
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Channel Number CD-1 (P550)

Location: Western side of Phase 1 site development.
The ditch parallels a 15' access road with a 4.0' berm. The soil berm and access road will provide the minimum required freeboard depth.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Shear Stress		
			Units	
	Peak Discharge	100.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	11.3	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	RECM	RECM	
	Lining Product	P550	P550	Lining Product
		Vegetated	Vegetated	(RECM liner is assumed vegetated for hydraulic design.)
	Allowable Shear Stress (psf)	12	12	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 6 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-1 (P550)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0409	0.0409			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.81	1.81	ft		
Velocity Head	0.55	0.55			
Froude Number	0.91	0.91			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.94	5.94	ft/sec		
Q Available at Channel Design Depth	109.4	109.4	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	13.0	13.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	12.6	12.6	ft		
Bottom Width:Depth Ratio	2.6	2.6			
Wetted Perimeter	13.5	13.5	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.2	1.2			
Flow Area	16.8	16.8	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.91**	**1.91**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.9	0.9		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Freeboard from Soil Berm	4.0	4.0			
Minimum required Channel Depth	**1.9**	**1.9**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	2.38	2.38	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	12.00	12.00	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	RECM	RECM			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	P550 Vegetated	P550 Vegetated			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 7 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-1 (Riprap)

Location: Western side of Phase 1 site development.
The ditch parallels a 15' access road with a 4.0' berm. The soil berm and access road will provide the minimum required freeboard depth.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	100.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	11.3	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Rock	Rock	
	Lining Product	Riprap R-4	Riprap R-4	Lining Product
	Allowable Velocity (fps)	9	9	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 8 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-1 (Riprap)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0418	0.0418			
Critical Slope	0.03	0.03	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.81	1.81	ft		
Velocity Head	0.53	0.53			
Froude Number	0.89	0.89			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.84	5.84	ft/sec		
Q Available at Channel Design Depth	106.9	106.9	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	13.0	13.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	12.7	12.7	ft		
Bottom Width:Depth Ratio	2.6	2.6			
Wetted Perimeter	13.6	13.6	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.3	1.3			
Flow Area	17.1	17.1	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.93**	**1.93**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.8	0.8		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Freeboard from Soil Berm	4.0	4.0			
Minimum required Channel Depth	**1.9**	**1.9**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	5.84	5.84	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Rock	Rock			
D_{50}	6	6	in		
Lining Product/Retardance Class	Riprap R-4	Riprap R-4			

D'APPOLONIA

By: MJD	Date: 07/01/16	Subject:	Northern Tract Quarry	Sheet No.:	9 of 37
Chkd. By: AMR	Date: 10/22/16		Collection Ditch Design	Proj. No.:	152596A

N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-2 (P550)

Location: Eastern side of Phase 1 site development.
The ditch parallels a 15' access road with a 4.0' berm. The soil berm and access road will provide the minimum required freeboard depth.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Shear Stress		
			Units	
	Peak Discharge	285.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	34	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	RECM	RECM	
	Lining Product	P550	P550	Lining Product
		Vegetated	Vegetated	(RECM liner is assumed vegetated for hydraulic design.)
	Allowable Shear Stress (psf)	12.0	12.0	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.5**	**3.5**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 10 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-2 (P550)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0346	0.0346			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	3.14	3.14	ft		
Velocity Head	1.22	1.22			
Froude Number	1.13	1.13			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	8.85	8.85	ft/sec		
Q Available at Channel Design Depth	418.3	418.3	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	19.0	19.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	16.8	16.8	ft		
Bottom Width:Depth Ratio	1.7	1.7			
Wetted Perimeter	18.2	18.2	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.8	1.8			
Flow Area	32.0	32.0	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**2.95**	**2.95**	ft		
Freeboard					
Stable flow?	Yes	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.7	0.7			
Freeboard	0.7	0.7		*F = 0.25 d≥ 0.5*	(Ref. #6)
Freeboard from Soil Berm	4.0	4.0			
Minimum required Channel Depth	**3.0**	**3.0**	ft		
Design Channel Depth	**3.5**	**3.5**	ft		
Lining					
Shear Stress at Flow Depth	3.68	3.68	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	12.00	12.00	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	RECM	RECM			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	P550 Vegetated	P550 Vegetated			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 11 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-2 (Riprap)

Location: Eastern side of Phase 1 site development.
The ditch parallels a 15' access road with a 4.0' berm. The soil berm and access road will provide the minimum required freeboard depth.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	285.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	34	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Rock	Rock	
	Lining Product	Riprap R-4	Riprap R-4	Lining Product
	Allowable Velocity (fps)	9	9	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.5**	**3.5**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 12 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-2 (Riprap)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0388	0.0388			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	3.14	3.14	ft		
Velocity Head	1.03	1.03			
Froude Number	1.02	1.02			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	8.16	8.16	ft/sec		
Q Available at Channel Design Depth	373.2	373.2	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	19.0	19.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	17.5	17.5	ft		
Bottom Width:Depth Ratio	1.6	1.6			
Wetted Perimeter	18.9	18.9	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.8	1.8			
Flow Area	34.9	34.9	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**3.11**	**3.11**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.8	0.8			
Freeboard	1.9	1.9		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Freeboard from Soil Berm	4.0	4.0			
Minimum required Channel Depth	**3.1**	**3.1**	ft		
Design Channel Depth	**3.5**	**3.5**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	8.16	8.16	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Rock	Rock			
D_{50}	6	6	in		
Lining Product/Retardance Class	Riprap R-4	Riprap R-4			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 13 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-3 (Riprap)

Location: Begins at an existing access road on the west side of the Pitts Quarry to N.T. Pond 1.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	50.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.100	ft/ft	
	Area of Tributary Watershed	4.5	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	3	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Rock	Rock	
	Lining Product	Riprap R-4	Riprap R-4	Lining Product
	Allowable Velocity (fps)	9	9	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.0**	**3.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 14 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-3 (Riprap)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0432	0.0470			
Critical Slope	0.03	0.04	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.48	1.48	ft		
Velocity Head	0.37	1.05			
Froude Number	0.82	1.62			
Flow Type	Subcritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.85	8.24	ft/sec		
Q Available at Channel Design Depth	186.2	383.0	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	15.0	15.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	9.6	7.6	ft		
Bottom Width:Depth Ratio	1.8	2.6			
Wetted Perimeter	10.3	8.1	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.0	0.7			
Flow Area	10.3	6.1	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.64**	**1.15**	ft		
Freeboard					
Stable flow?	Yes	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		*F = 0.25 d≥ 0.5*	(Ref. #6)
Minimum required Channel Depth	**2.1**	**1.6**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	4.85	8.24	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Rock	Rock			
D_{50}	6	6	in		
Lining Product/Retardance Class	Riprap R-4	Riprap R-4			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 15 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-3 (Unimat)

Location: Begins at an existing access road on the west side of the Pitts Quarry to N.T. Pond 1.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Shear Stress		
			Units	
	Peak Discharge	50.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.100	ft/ft	
	Area of Tributary Watershed	4.5	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	3	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Other	Other	
	Lining Product	Rigid Lined Channels	Rigid Lined Channels	Lining Product
	Manning's Coefficient	0.035	0.035	
	Allowable Shear Stress (psf)	28.3	28.3	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.0**	**3.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 16 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-3 (Unimat)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.48	1.48	ft		
Velocity Head	0.50	1.61			
Froude Number	1.00	2.14			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.67	10.20	ft/sec		
Q Available at Channel Design Depth	229.8	513.8	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	15.0	15.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	8.9	6.9	ft		
Bottom Width:Depth Ratio	2.0	3.0			
Wetted Perimeter	9.6	7.4	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.9	0.7			
Flow Area	8.8	4.9	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.48**	**0.99**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.6	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**2.1**	**1.5**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	1.85	6.15	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	28.30	28.30	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rigid Lined Channels	Rigid Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 17 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-4 (Riprap)

Location: Begins at northern side of N.T. Pond 1 and continues up to connect to the ditch and access road of Phase 1.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary			
	Design Criteria	100-year Storm			See attached TR-55 Calculations
	Design Method	Permissible Velocity			
			Units		
	Peak Discharge	77.0	cfs		
Geometry	Minimum Channel Bed Slope	0.020	ft/ft		
	Maximum Channel Bed Slope	0.100	ft/ft		
	Area of Tributary Watershed	7.92	acres		
	Condition of Watershed	Disturbed			
	Channel Side Slope (Left)	2	:H:1V		
	Channel Side Slope (Right)	2	:H:1V		
	Channel Bottom Width	5	ft		
Lining		**Min Slope**	**Max Slope**		
	Lining Type	Rock	Rock		
	Lining Product	Riprap R-4	Riprap R-4	Lining Product	
		0.03	0.03		
	Allowable Velocity (fps)	4.58	4.58		
Freeboard					
	Freeboard Design Criterion	DEP			
	Channel Design Depth	**3.0**	**3.0**	ft	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 18 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-4 (Riprap)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0428	0.0467			
Critical Slope	0.03	0.03	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.57	1.57	ft		
Velocity Head	0.44	1.25			
Froude Number	0.86	1.68			
Flow Type	Subcritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.35	8.96	ft/sec		
Q Available at Channel Design Depth	242.6	497.4	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	17.0	17.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	11.8	9.7	ft		
Bottom Width:Depth Ratio	2.9	4.3			
Wetted Perimeter	12.6	10.2	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.1	0.8			
Flow Area	14.4	8.6	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.71**	**1.17**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.7	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**2.4**	**1.7**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	5.35	8.96	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Rock	Rock			
D_{50}	6	6	in		
Lining Product/Retardance Class	Riprap R-4	Riprap R-4			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 19 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-4 (Unimat)

Location: Begins at northern side of N.T. Pond 1 and continues up to connect to the ditch and access road of Phase 1.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Shear Stress		
			Units	
	Peak Discharge	77.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.100	ft/ft	
	Area of Tributary Watershed	7.92	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Other	Other	
	Lining Product	Rigid Lined Channels	Rigid Lined Channels	Lining Product
	Manning's Coefficient	0.035	0.035	
	Allowable Shear Stress (psf)	28.3	28.3	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.0**	**3.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 20 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-4 (Unimat)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.57	1.57	ft		
Velocity Head	0.59	1.87			
Froude Number	1.03	2.19			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	6.19	10.98	ft/sec		
Q Available at Channel Design Depth	296.8	663.7	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	17.0	17.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	11.2	9.0	ft		
Bottom Width:Depth Ratio	3.2	5.0			
Wetted Perimeter	11.9	9.5	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.0	0.7			
Flow Area	12.4	7.0	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.54**	**1.00**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.7	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**2.3**	**1.5**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	1.92	6.25	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	28.30	28.30	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rigid Lined Channels	Rigid Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 21 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-5 (Riprap)

Location: Connects N.T. Pond 1 to north side of N.T. Pond 2.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	70.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.100	ft/ft	
	Area of Tributary Watershed	6.85	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Rock	Rock	
	Lining Product	Riprap R-4	Riprap R-4	Lining Product
		0.03	0.03	
	Allowable Velocity (fps)	4.73	4.73	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.0**	**3.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 22 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-5 (Riprap)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0432	0.0473			
Critical Slope	0.03	0.03	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.49	1.49	ft		
Velocity Head	0.42	1.16			
Froude Number	0.84	1.65			
Flow Type	Subcritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.18	8.64	ft/sec		
Q Available at Channel Design Depth	240.4	491.5	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	17.0	17.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	11.5	9.5	ft		
Bottom Width:Depth Ratio	3.1	4.5			
Wetted Perimeter	12.3	10.0	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.1	0.8			
Flow Area	13.5	8.1	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.64**	**1.12**	ft		
Freeboard					
Stable flow?	Yes	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		*F = 0.25 d≥ 0.5*	(Ref. #6)
Minimum required Channel Depth	**2.1**	**1.6**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	5.18	8.64	ft/s		
Maximum Permissible Velocity	9	9	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Rock	Rock			
D_{50}	6	6	in		
Lining Product/Retardance Class	Riprap R-4	Riprap R-4			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 23 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-5 (Unimat)

Location: Connects N.T. Pond 1 to north side of N.T. Pond 2.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary			
	Design Criteria	100-year Storm			See attached TR-55 Calculations
	Design Method	Shear Stress			
			Units		
	Peak Discharge	70.0	cfs		
Geometry	Minimum Channel Bed Slope	0.020	ft/ft		
	Maximum Channel Bed Slope	0.100	ft/ft		
	Area of Tributary Watershed	6.85	acres		
	Condition of Watershed	Disturbed			
	Channel Side Slope (Left)	2	:H:1V		
	Channel Side Slope (Right)	2	:H:1V		
	Channel Bottom Width	5	ft		
Lining		**Min Slope**	**Max Slope**		
	Lining Type	Other	Other		
	Lining Product	Rigid Lined Channels	Rigid Lined Channels	Lining Product	
	Manning's Coefficient	0.035	0.035		
	Allowable Shear Stress (psf)	26.2	26.2		
Freeboard					
	Freeboard Design Criterion	DEP			
	Channel Design Depth	**3.0**	**3.0**	ft	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 24 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-5 (Unimat)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.49	1.49	ft		
Velocity Head	0.56	1.77			
Froude Number	1.03	2.18			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	6.03	10.67	ft/sec		
Q Available at Channel Design Depth	296.8	663.7	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	17.0	17.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	10.9	8.8	ft		
Bottom Width:Depth Ratio	3.4	5.3			
Wetted Perimeter	11.6	9.2	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.0	0.7			
Flow Area	11.6	6.6	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.46**	**0.95**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.7	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**2.1**	**1.5**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	1.83	5.93	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	26.20	26.20	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rigid Lined Channels	Rigid Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 25 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-6 (Riprap)

Location: Begins at an existing access road on the east side of the Pitts Quarry to the the Northern Tract Quarry N.T. Pond 3.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Permissible Velocity		
			Units	
	Peak Discharge	80.0	cfs	
Geometry	Minimum Channel Bed Slope	0.030	ft/ft	
	Maximum Channel Bed Slope	0.100	ft/ft	
	Area of Tributary Watershed	8.43	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	3.5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Rock	Rock	
	Lining Product	Riprap R-5	Riprap R-5	Lining Product
	Allowable Velocity (fps)	11.5	11.5	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.0**	**3.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 26 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-6 (Riprap)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0490	0.0526			
Critical Slope	0.04	0.04	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.81	1.81	ft		
Velocity Head	0.52	1.13			
Froude Number	0.91	1.50			
Flow Type	Subcritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.78	8.54	ft/sec		
Q Available at Channel Design Depth	215.5	366.5	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	15.5	15.5	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	11.1	9.3	ft		
Bottom Width:Depth Ratio	1.8	2.4			
Wetted Perimeter	12.0	10.0	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.2	0.9			
Flow Area	13.8	9.4	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.90**	**1.46**	ft		
Freeboard					
Stable flow?	No	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.8	0.5		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**2.7**	**2.0**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	N/A	N/A	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	N/A	N/A	lb/ft^2		
Channel Velocity	5.78	8.54	ft/s		
Maximum Permissible Velocity	11.5	11.5	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Rock	Rock			
D_{50}	9	9	in		
Lining Product/Retardance Class	Riprap R-5	Riprap R-5			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 27 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-6 (Unimat)

Location: Begins at an existing access road on the east side of the Pitts Quarry to the the Northern Tract Quarry N.T. Pond 3.

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Shear Stress		
			Units	
	Peak Discharge	80.0	cfs	
Geometry	Minimum Channel Bed Slope	0.030	ft/ft	
	Maximum Channel Bed Slope	0.100	ft/ft	
	Area of Tributary Watershed	8.43	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	2	:H:1V	
	Channel Bottom Width	3.5	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Other	Other	
	Lining Product	Rigid Lined Channels	Rigid Lined Channels	Lining Product
	Manning's Coefficient	0.035	0.035	
	Allowable Shear Stress (psf)	23.6	23.6	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**3.0**	**3.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 28 of 37
Chkd. By: AMR Date: 10/22/16 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design.xls

Channel Number CD-6 (Unimat)

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.81	1.81	ft		
Velocity Head	0.85	2.05			
Froude Number	1.25	2.20			
Flow Type	Supercritical	Supercritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	7.40	11.48	ft/sec		
Q Available at Channel Design Depth	301.7	550.9	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	15.5	15.5	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	9.9	8.2	ft		
Bottom Width:Depth Ratio	2.2	3.0			
Wetted Perimeter	10.7	8.8	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.0	0.8			
Flow Area	10.8	7.0	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.61**	**1.19**	ft		
Freeboard					
Stable flow?	Yes	Yes		$0.7S_c < S < 1.3S_c$	(Ref. #5)
Minimum Required Freeboard	0.5	0.5			
Freeboard	0.5	0.5		*F = 0.25 d≥ 0.5*	(Ref. #6)
Minimum required Channel Depth	**2.1**	**1.7**	ft		
Design Channel Depth	**3.0**	**3.0**	ft		
Lining					
Shear Stress at Flow Depth	3.01	7.40	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	23.60	23.60	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rigid Lined Channels	Rigid Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 29 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-7

Location: Above NT Pond No.1, flowing towards culvert C-1 and collection ditch CD-3
*Ditch CD-7 does not account for freeboard, any overtopping flow will be captured in NT Pond No.1

INPUT

Hydraulic & Hydrologic	Channel type	Temporary			
	Design Criteria	100-year Storm			See attached TR-55 Calculations
	Design Method	Shear Stress			
			Units		
	Peak Discharge	16.8	cfs		
Geometry	Minimum Channel Bed Slope	0.020	ft/ft		
	Maximum Channel Bed Slope	0.020	ft/ft		
	Area of Tributary Watershed	1.75	acres		
	Condition of Watershed	Disturbed			
	Channel Side Slope (Left)	2	:H:1V		
	Channel Side Slope (Right)	1	:H:1V		
	Channel Bottom Width	2	ft		
Lining		**Min Slope**	**Max Slope**		
	Lining Type	Other	Other		
	Lining Product	Rock Lined Channels	Rock Lined Channels	Lining Product	
	Manning's Coefficient	0.035	0.035		
	Allowable Shear Stress (psf)	10	10		
Freeboard					
	Freeboard Design Criterion	DEP			
	Channel Design Depth	**1.0**	**1.0**	ft	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 30 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-7

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.01	1.01	ft		
Velocity Head	0.31	0.31			
Froude Number	0.93	0.93			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.49	4.49	ft/sec		
Q Available at Channel Design Depth	14.7	14.7	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	5.0	5.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	5.1	5.1	ft		
Bottom Width:Depth Ratio	1.9	1.9			
Wetted Perimeter	5.8	5.8	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.6	0.6			
Flow Area	3.7	3.7	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.05**	**1.05**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
*Minimum Required Freeboard	0.0	0.0			
*Freeboard	0.0	0.0		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.0**	**1.0**	ft		
Design Channel Depth	**1.0**	**1.0**	ft		
Lining					
Shear Stress at Flow Depth	1.31	1.31	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	10.00	10.00	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rock Lined Channels	Rock Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 31 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-8

Location: Above NT Pond No.1, flowing towards culvert C-2 and collection ditch CD-4
*Ditch CD-8 does not account for freeboard, any overtopping flow will be captured in NT Pond No.1

INPUT

Hydraulic & Hydrologic	Channel type	Temporary			
	Design Criteria	100-year Storm			See attached TR-55 Calculations
	Design Method	Shear Stress			
			Units		
	Peak Discharge	15.5	cfs		
Geometry	Minimum Channel Bed Slope	0.020	ft/ft		
	Maximum Channel Bed Slope	0.020	ft/ft		
	Area of Tributary Watershed	1.6	acres		
	Condition of Watershed	Disturbed			
	Channel Side Slope (Left)	2	:H:1V		
	Channel Side Slope (Right)	1	:H:1V		
	Channel Bottom Width	2	ft		
Lining		**Min Slope**	**Max Slope**		
	Lining Type	Other	Other		
	Lining Product	Rock Lined Channels	Rock Lined Channels	Lining Product	
	Manning's Coefficient	0.035	0.035		
	Allowable Shear Stress (psf)	10	10		
Freeboard					
	Freeboard Design Criterion	DEP			
	Channel Design Depth	**1.0**	**1.0**	ft	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 32 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-8

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	0.96	0.96	ft		
Velocity Head	0.30	0.30			
Froude Number	0.92	0.92			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	4.40	4.40	ft/sec		
Q Available at Channel Design Depth	14.7	14.7	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	5.0	5.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	5.0	5.0	ft		
Bottom Width:Depth Ratio	2.0	2.0			
Wetted Perimeter	5.6	5.6	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.6	0.6			
Flow Area	3.5	3.5	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.00**	**1.00**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
*Minimum Required Freeboard	0.0	0.0			
*Freeboard	0.0	0.0		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.0**	**1.0**	ft		
Design Channel Depth	**1.0**	**1.0**	ft		
Lining					
Shear Stress at Flow Depth	1.25	1.25	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	10.00	10.00	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rock Lined Channels	Rock Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 33 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
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Channel Number CD-9

Location: Above NT Pond No.2, flowing towards culvert C-4 and collection ditch CD-5
*Ditch CD-9 does not account for freeboard, any overtopping flow will be captured in NT Pond No.2

INPUT

Hydraulic & Hydrologic	Channel type	Temporary		
	Design Criteria	100-year Storm		See attached TR-55 Calculations
	Design Method	Shear Stress		
			Units	
	Peak Discharge	42.0	cfs	
Geometry	Minimum Channel Bed Slope	0.020	ft/ft	
	Maximum Channel Bed Slope	0.020	ft/ft	
	Area of Tributary Watershed	4.11	acres	
	Condition of Watershed	Disturbed		
	Channel Side Slope (Left)	2	:H:1V	
	Channel Side Slope (Right)	1	:H:1V	
	Channel Bottom Width	1	ft	
Lining		**Min Slope**	**Max Slope**	
	Lining Type	Other	Other	
	Lining Product	Rock Lined Channels	Rock Lined Channels	Lining Product
	Manning's Coefficient	0.035	0.035	
	Allowable Shear Stress (psf)	10	10	
Freeboard				
	Freeboard Design Criterion	DEP		
	Channel Design Depth	**2.0**	**2.0**	ft

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 34 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-9

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.87	1.87	ft		
Velocity Head	0.51	0.51			
Froude Number	0.97	0.97			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.73	5.73	ft/sec		
Q Available at Channel Design Depth	48.0	48.0	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	7.0	7.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	6.7	6.7	ft		
Bottom Width:Depth Ratio	0.5	0.5			
Wetted Perimeter	7.9	7.9	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	0.9	0.9			
Flow Area	7.3	7.3	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.90**	**1.90**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
*Minimum Required Freeboard	0.0	0.0			
*Freeboard	0.0	0.0		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**1.9**	**1.9**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	2.37	2.37	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	10.00	10.00	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rock Lined Channels	Rock Lined Channels			

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 35 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\Northen Tract Ditch Design-R1.xls

Channel Number CD-10

Location: Above NT Pond No.2, flowing towards culvert C-3 and collection ditch CD-6
*Ditch CD-10 does not account for freeboard, any overtopping flow will be captured in NT Pond No.2

INPUT

Hydraulic & Hydrologic	Channel type	Temporary			
	Design Criteria	100-year Storm			See attached TR-55 Calculations
	Design Method	Shear Stress			
			Units		
	Peak Discharge	45.0	cfs		
Geometry	Minimum Channel Bed Slope	0.020	ft/ft		
	Maximum Channel Bed Slope	0.020	ft/ft		
	Area of Tributary Watershed	4.4	acres		
	Condition of Watershed	Disturbed			
	Channel Side Slope (Left)	2	:H:1V		
	Channel Side Slope (Right)	1	:H:1V		
	Channel Bottom Width	1	ft		
Lining		**Min Slope**	**Max Slope**		
	Lining Type	Other	Other		
	Lining Product	Rock Lined Channels	Rock Lined Channels	Lining Product	
	Manning's Coefficient	0.035	0.035		
	Allowable Shear Stress (psf)	10	10		
Freeboard					
	Freeboard Design Criterion	DEP			
	Channel Design Depth	**2.0**	**2.0**	ft	

D'APPOLONIA

By: MJD Date: 07/01/16 Subject: Northern Tract Quarry Sheet No.: 36 of 37
Chkd. By: QDW Date: 6/1/2017 Collection Ditch Design Proj. No.: 152596A
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Channel Number CD-10

OUTPUT

Hydraulic & Hydrologic	**Min Slope**	**Max Slope**			
Manning's Coefficient	0.0350	0.0350			
Critical Slope	0.02	0.02	ft/ft	$S_c = 14.56\, n^2 \frac{D_m}{R^{\frac{4}{3}}}$	(Ref. #5)
Critical Depth	1.93	1.93	ft		
Velocity Head	0.53	0.53			
Froude Number	0.97	0.97			
Flow Type	Subcritical	Subcritical		$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Velocity	5.83	5.83	ft/sec		
Q Available at Channel Design Depth	48.0	48.0	ft^3/sec	$Q = \frac{1.486}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$	(Ref. #5)
Geometry			*Units*		
Channel Top Width @D	7.0	7.0	ft	$T = b + 2zd$	(Ref. #5)
Channel Top Width @d	6.9	6.9	ft		
Bottom Width:Depth Ratio	0.5	0.5			
Wetted Perimeter	8.1	8.1	ft	$P = b + 2d\sqrt{z^2 + 1}$	(Ref. #5)
Hydraulic Radius	1.0	1.0			
Flow Area	7.7	7.7	ft^2	$A = bd + zd^2$	(Ref. #5)
Flow Depth	**1.96**	**1.96**	ft		
Freeboard					
Stable flow?	No	No		$0.7S_c < S < 1.3S_c$	(Ref. #5)
*Minimum Required Freeboard	0.0	0.0			
*Freeboard	0.0	0.0		$F = 0.75Vd \geq 0.5$	(Ref. #6)
Minimum required Channel Depth	**2.0**	**2.0**	ft		
Design Channel Depth	**2.0**	**2.0**	ft		
Lining					
Shear Stress at Flow Depth	2.45	2.45	lb/ft^2	$\tau_d = 62.4dS$	(Ref. #5)
Maximum Permissible Shear Stress	10.00	10.00	lb/ft^2		
Channel Velocity	N/A	N/A	ft/s		
	N/A	N/A	ft/s		
Is Lining Sufficient?	Yes	Yes			
Lining Type	Other	Other			
D_{50}	N/A	N/A	in		
Lining Product/Retardance Class	Rock Lined Channels	Rock Lined Channels			

D'APPOLONIA

By:	MJD	Date: 07/01/16	Subject:	Northern Tract Quarry	Sheet No.: 37 of 37
Chkd. By:	AMR	Date: 10/22/16		Collection Ditch Design	Proj. No.: 152596A

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REFERENCES

1) Soil Survey of Adams County, United States Department of Agriculture, Soil Conservation Service, September 1983.

2) Urban Hydrology for Small Watersheds, 2nd Edition, Technical Release Number 55 (TR-55), United States Department of Agriculture, Soil Conservation Service, June 1986.

3) NOAA, Point Precipitation Frequency Estimates

4) Design of Erosion Protection Mats, Cowherd, et. al., Bowser-Morner Associates, Inc.

5) Erosion and Sediment Pollution Control Program Manual, Pennsylvania Department of Environmental Protection - Office of Water Management, March 2012.

6) Engineering Manual for Mining Operations, Pennsylvania Department of Environmental Protection - Bureaus of Mining and Reclamation and District Mining Operations, 1999.

7) Standard Specifications for Highway Bridges - 17th Edition, American Association of State Highway and Transportation Officials, 2002.

8) Engineering and Design Manual - Coal Refuse Disposal Facilities, Mine Safety and Health Administration

9) North American Green Erosion Control Materials Design Software - Version 5.0 North American Green, Inc., 2004.

10) Design of Roadside Channels with flexible linings, US Department of Transportation, Federal Highway Administration, September 2005.

VARIABLES

T	= channel top width at the water surface (ft)
P	= wetted perimeter (ft)
R	= hydraulic radius = A/P (ft)
A	= cross-sectional area of the channel (sqft)
n	= Manning's "n"
d	= flow depth
D	= channel depth
V	= velocity
Q	= flow rate
τ_d	= maximum shear stress in straight section
τ_b	= maximum shear stress in a bend
τ_a	= allowable shear stress
$V_{allowable}$	= allowable velocity
D_{50}	= 50th percentile diameter
S_c	= critical slope (ft/ft)
D_m	= mean depth of flow = A/T
Rc	= Radius of channel bend

ATTACHMENT 1

Precipitation Frequency Estimates

NOAA Atlas 14, Volume 2, Version 3
Location name: Fairfield, Pennsylvania, US*
Latitude: 39.7678°, Longitude: -77.4403°
Elevation: 1240 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.356 (0.319-0.398)	0.427 (0.382-0.477)	0.512 (0.457-0.571)	0.578 (0.516-0.644)	0.670 (0.594-0.745)	0.741 (0.654-0.822)	0.818 (0.717-0.906)	0.899 (0.784-0.996)	1.01 (0.875-1.12)	1.11 (0.948-1.23)
10-min	0.555 (0.498-0.621)	0.670 (0.599-0.748)	0.799 (0.714-0.892)	0.897 (0.801-0.999)	1.03 (0.914-1.14)	1.13 (1.00-1.26)	1.24 (1.09-1.38)	1.35 (1.18-1.50)	1.51 (1.30-1.67)	1.63 (1.40-1.81)
15-min	0.682 (0.612-0.763)	0.822 (0.735-0.918)	0.987 (0.882-1.10)	1.11 (0.990-1.24)	1.28 (1.13-1.42)	1.41 (1.24-1.56)	1.55 (1.36-1.72)	1.69 (1.47-1.87)	1.89 (1.63-2.09)	2.04 (1.75-2.26)
30-min	0.907 (0.814-1.01)	1.10 (0.988-1.23)	1.36 (1.21-1.52)	1.55 (1.38-1.73)	1.82 (1.61-2.02)	2.03 (1.79-2.25)	2.25 (1.98-2.50)	2.49 (2.17-2.75)	2.83 (2.44-3.13)	3.10 (2.65-3.43)
60-min	1.11 (0.998-1.24)	1.36 (1.22-1.52)	1.71 (1.53-1.91)	1.98 (1.77-2.21)	2.37 (2.10-2.63)	2.69 (2.37-2.98)	3.03 (2.66-3.36)	3.39 (2.96-3.76)	3.93 (3.39-4.35)	4.38 (3.75-4.84)
2-hr	1.29 (1.16-1.46)	1.58 (1.41-1.77)	2.00 (1.78-2.24)	2.34 (2.08-2.62)	2.85 (2.52-3.18)	3.29 (2.89-3.67)	3.79 (3.30-4.21)	4.35 (3.76-4.83)	5.23 (4.47-5.79)	6.00 (5.09-6.65)
3-hr	1.44 (1.29-1.64)	1.75 (1.56-1.99)	2.20 (1.96-2.50)	2.57 (2.28-2.91)	3.13 (2.76-3.54)	3.62 (3.17-4.08)	4.18 (3.63-4.69)	4.81 (4.14-5.39)	5.79 (4.93-6.48)	6.66 (5.61-7.46)
6-hr	1.84 (1.65-2.10)	2.23 (1.99-2.54)	2.78 (2.48-3.17)	3.25 (2.88-3.69)	3.95 (3.47-4.47)	4.57 (3.99-5.16)	5.29 (4.58-5.95)	6.10 (5.24-6.86)	7.37 (6.24-8.27)	8.51 (7.13-9.55)
12-hr	2.31 (2.05-2.64)	2.80 (2.48-3.19)	3.48 (3.08-3.96)	4.07 (3.58-4.63)	4.98 (4.35-5.63)	5.80 (5.03-6.55)	6.75 (5.79-7.59)	7.85 (6.66-8.81)	9.59 (8.01-10.7)	11.2 (9.21-12.5)
24-hr	2.71 (2.47-3.00)	3.25 (2.96-3.61)	4.05 (3.68-4.49)	4.75 (4.30-5.26)	5.85 (5.25-6.44)	6.85 (6.11-7.52)	8.03 (7.09-8.77)	9.41 (8.23-10.2)	11.6 (10.0-12.6)	13.7 (11.6-14.8)
2-day	3.14 (2.85-3.51)	3.77 (3.42-4.22)	4.68 (4.24-5.24)	5.49 (4.95-6.12)	6.75 (6.04-7.50)	7.90 (7.02-8.75)	9.25 (8.16-10.2)	10.8 (9.46-11.9)	13.4 (11.5-14.7)	15.7 (13.3-17.3)
3-day	3.34 (3.04-3.73)	4.01 (3.65-4.47)	4.96 (4.50-5.53)	5.80 (5.23-6.45)	7.10 (6.37-7.87)	8.29 (7.38-9.16)	9.66 (8.54-10.7)	11.3 (9.88-12.4)	13.9 (12.0-15.2)	16.3 (13.8-17.8)
4-day	3.55 (3.23-3.95)	4.25 (3.87-4.73)	5.24 (4.76-5.83)	6.10 (5.52-6.77)	7.45 (6.69-8.24)	8.67 (7.74-9.56)	10.1 (8.93-11.1)	11.7 (10.3-12.9)	14.4 (12.4-15.8)	16.8 (14.3-18.4)
7-day	4.13 (3.79-4.55)	4.93 (4.52-5.44)	6.03 (5.52-6.65)	6.98 (6.37-7.68)	8.44 (7.65-9.27)	9.75 (8.79-10.7)	11.3 (10.1-12.3)	13.0 (11.5-14.2)	15.7 (13.8-17.2)	18.2 (15.7-19.9)
10-day	4.73 (4.36-5.20)	5.64 (5.19-6.19)	6.81 (6.25-7.47)	7.81 (7.15-8.55)	9.32 (8.49-10.2)	10.7 (9.66-11.6)	12.2 (11.0-13.3)	13.9 (12.4-15.1)	16.5 (14.6-18.0)	18.9 (16.5-20.6)
20-day	6.38 (5.97-6.87)	7.54 (7.04-8.10)	8.85 (8.26-9.51)	9.94 (9.26-10.7)	11.5 (10.7-12.4)	12.9 (11.9-13.8)	14.4 (13.3-15.4)	16.1 (14.7-17.2)	18.6 (16.9-20.0)	20.8 (18.7-22.3)
30-day	7.88 (7.43-8.41)	9.26 (8.72-9.87)	10.7 (10.1-11.4)	11.9 (11.2-12.6)	13.6 (12.7-14.5)	15.0 (14.1-16.0)	16.6 (15.4-17.6)	18.3 (16.9-19.4)	20.8 (19.1-22.1)	22.9 (20.9-24.4)
45-day	9.87 (9.32-10.5)	11.5 (10.9-12.2)	13.1 (12.4-13.9)	14.4 (13.6-15.3)	16.2 (15.3-17.2)	17.7 (16.7-18.8)	19.3 (18.1-20.4)	21.0 (19.6-22.3)	23.4 (21.8-24.9)	25.4 (23.5-27.0)
60-day	11.7 (11.1-12.4)	13.7 (13.0-14.5)	15.4 (14.6-16.3)	16.8 (16.0-17.8)	18.8 (17.8-19.9)	20.4 (19.3-21.6)	22.1 (20.8-23.4)	24.0 (22.5-25.3)	26.5 (24.7-28.0)	28.6 (26.6-30.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

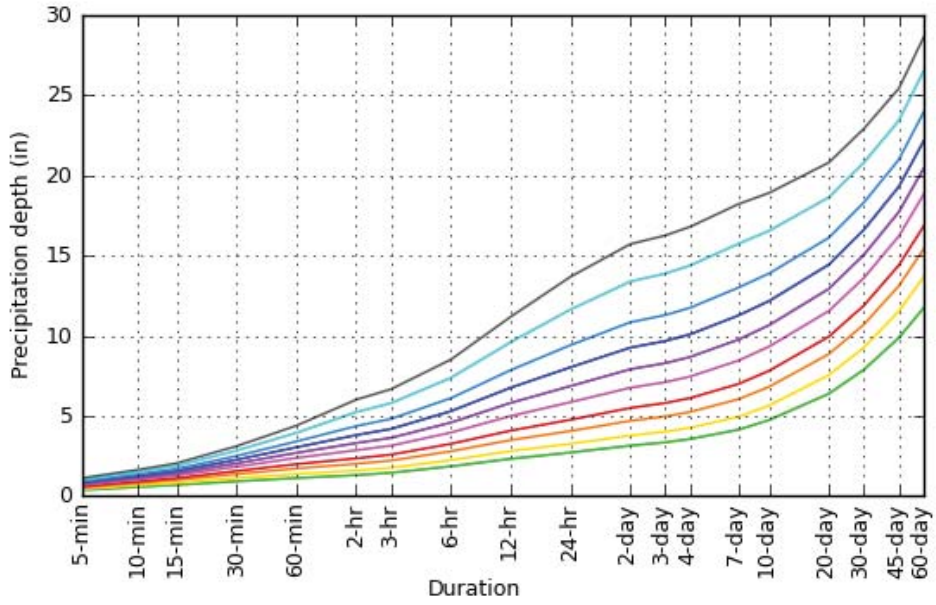
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

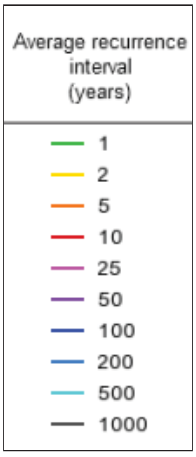
Please refer to NOAA Atlas 14 document for more information.

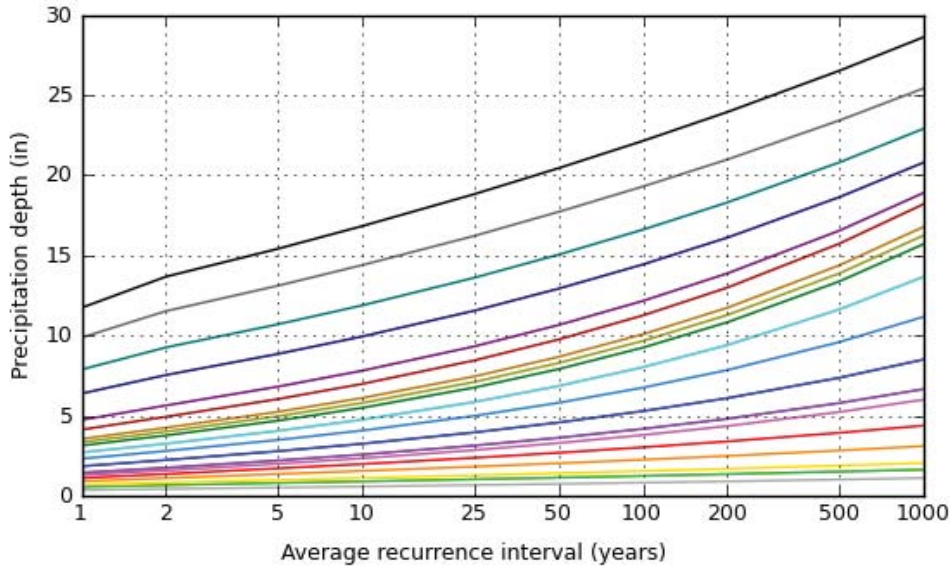
Back to Top

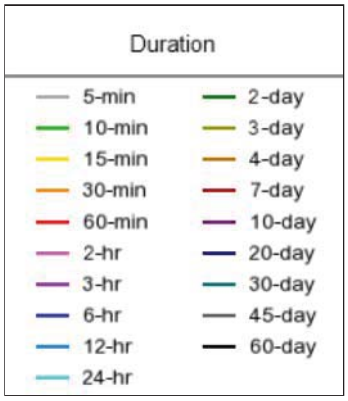
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 39.7678°, Longitude: -77.4403°







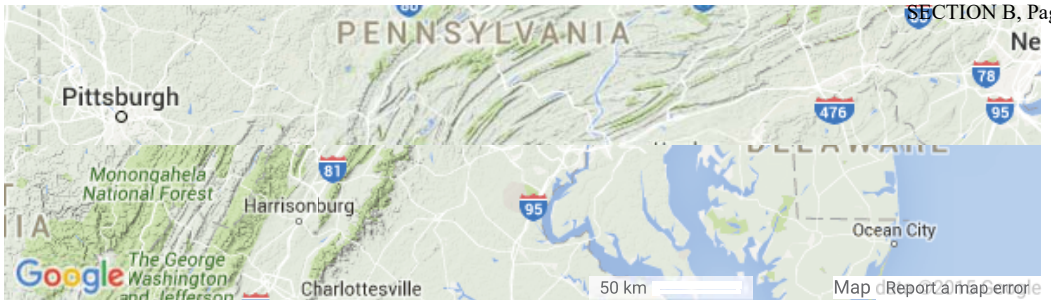


NOAA Atlas 14, Volume 2, Version 3 Created (GMT): Wed Dec 16 18:57:04 2015

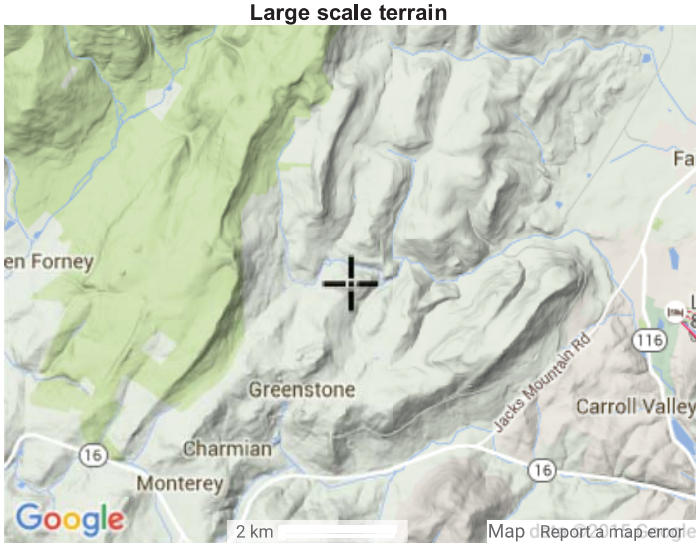
Back to Top

Maps & aerials

Small scale terrain

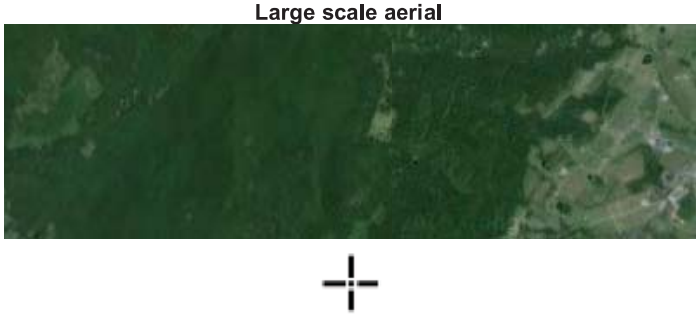


Large scale terrain



Large scale map

Large scale aerial



Back to Top

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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
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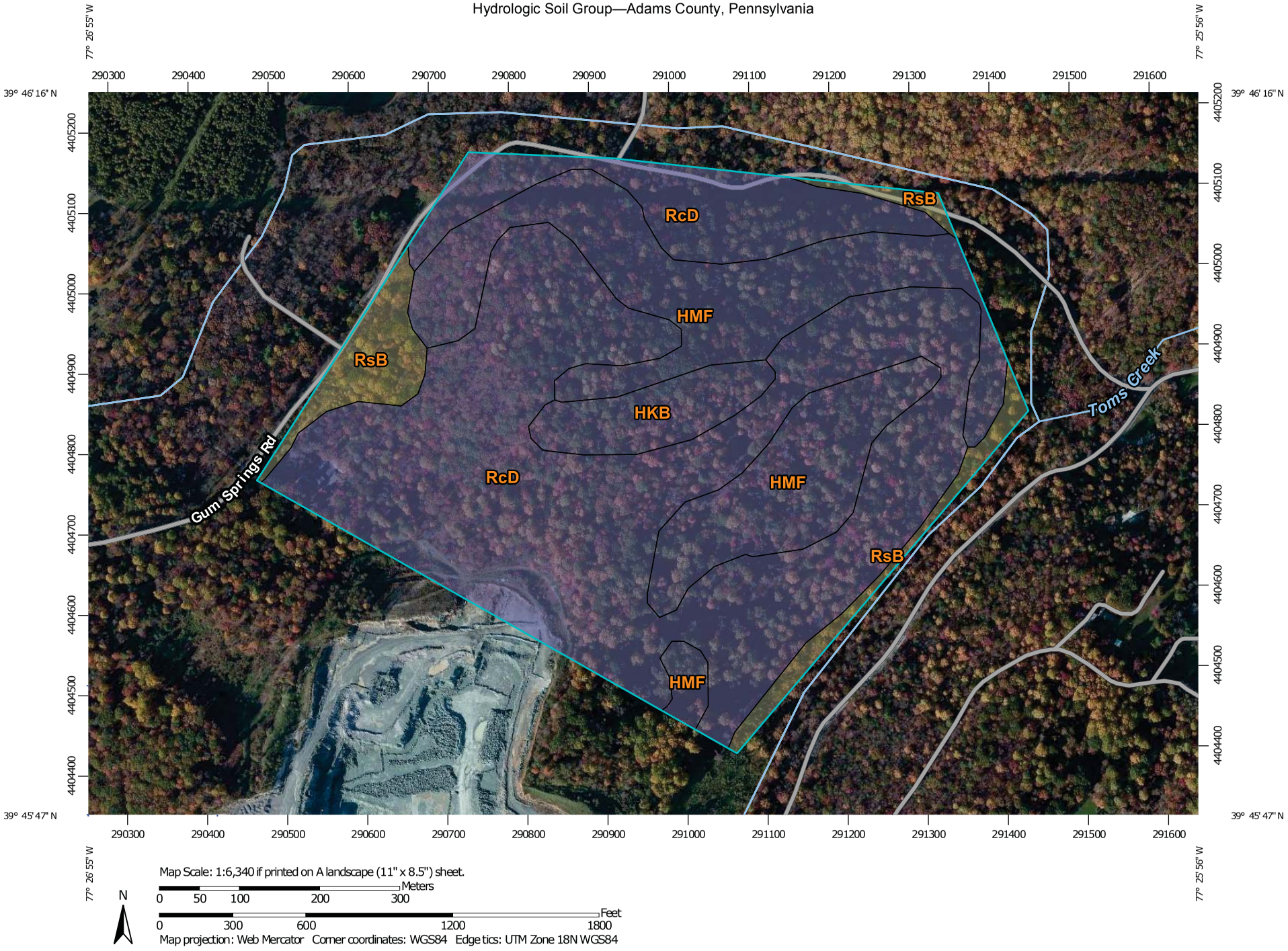
Disclaimer

ATTACHMENT 2

Web Soil Survey

Hydrologic Soil Group—Adams County, Pennsylvania



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Adams County, Pennsylvania
Survey Area Data: Version 11, Nov 16, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 14, 2011—Nov 6, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Adams County, Pennsylvania (PA001)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
HKB	Highfield, Catoctin, and Myersville soils, 0 to 8 percent slopes, very stony	B	5.1	4.5%
HMF	Highfield and Catoctin channery silt loams, 25 to 70 percent slopes, very stony	B	31.0	27.6%
RcD	Ravenrock-Highfield-Rock outcrop complex, 15 to 25 percent slopes	B	69.1	61.4%
RsB	Rohrersville silt loam, 0 to 15 percent slopes, very stony	C/D	7.3	6.5%
Totals for Area of Interest			**112.6**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

ATTACHMENT 3

Storm and Sanitary Analysis Outputs

ATTACHMENT 3

Storm and Sanitary Analysis Outputs

Project Description

File Name ..... Northern Tract Ditch Design.SPF

Project Options

Flow Units ..... CFS
Elevation Type ..... Elevation
Hydrology Method ..... SCS TR-55
Time of Concentration (TOC) Method ..... SCS TR-55
Link Routing Method ..... Hydrodynamic
Enable Overflow Ponding at Nodes ..... YES
Skip Steady State Analysis Time Periods ..... NO

Analysis Options

Start Analysis On ..... Jan 13, 2016 00:00:00
End Analysis On ..... Jan 15, 2016 00:00:00
Start Reporting On ..... Jan 13, 2016 00:00:00
Antecedent Dry Days ..... 0 days
Runoff (Dry Weather) Time Step ..... 0 01:00:00 days hh:mm:ss
Runoff (Wet Weather) Time Step ..... 0 00:05:00 days hh:mm:ss
Reporting Time Step ..... 0 00:01:00 days hh:mm:ss
Routing Time Step ..... 30 seconds

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	Rain Gage-01	Time Series	100-year	Cumulative	inches	Pennsylvania	Adams	100	8.03	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	CD-1	11.33	86.00	8.03	6.36	72.06	100.95	0 00:07:41
2	CD-10	4.40	86.00	8.03	6.36	27.98	42.28	0 00:05:00
3	CD-2	33.97	86.00	8.03	6.36	216.05	280.66	0 00:10:41
4	CD-3	4.50	86.00	8.03	6.36	28.62	43.21	0 00:05:00
5	CD-4	7.92	86.00	8.03	6.36	50.37	76.09	0 00:05:00
6	CD-5	6.85	86.00	8.03	6.36	43.57	65.76	0 00:05:00
7	CD-6	8.43	86.00	8.03	6.36	53.61	80.35	0 00:05:18
8	CD-7	1.75	86.00	8.03	6.36	11.13	16.78	0 00:05:00
9	CD-8	1.60	86.00	8.03	6.36	10.18	15.36	0 00:05:00
10	CD-9	4.20	86.00	8.03	6.36	26.71	40.32	0 00:05:00

Subbasin Hydrology

Subbasin : CD-1

Input Data

Area (ac)	11.33
Weighted Curve Number	86.00
Rain Gage ID	Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	11.33	-	86.00
Composite Area & Weighted CN	11.33		86.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	11.2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.41	0.00	0.00
Computed Flow Time (min) :	4.08	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	706	0.00	0.00
Slope (%) :	9.3	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.92	0.00	0.00
Computed Flow Time (min) :	2.39	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	435	0.00	0.00
Channel Slope (%) :	2.0	0.00	0.00
Cross Section Area (ft²) :	11.3	0.00	0.00
Wetted Perimeter (ft) :	11.4	0.00	0.00
Velocity (ft/sec) :	5.99	0.00	0.00
Computed Flow Time (min) :	1.21	0.00	0.00

Total TOC (min) 7.69

Subbasin Runoff Results

Total Rainfall (in)	8.03
Total Runoff (in)	6.36
Peak Runoff (cfs)	100.95
Weighted Curve Number	86.00
Time of Concentration (days hh:mm:ss)	0 00:07:41

Subbasin : CD-2

Input Data

Area (ac) 33.97
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	33.97	-	86.00
Composite Area & Weighted CN	33.97		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	8.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.36	0.00	0.00
Computed Flow Time (min) :	4.65	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	795	0.00	0.00
Slope (%) :	12.0	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.59	0.00	0.00
Computed Flow Time (min) :	2.37	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	1523	0.00	0.00
Channel Slope (%) :	2.0	0.00	0.00
Cross Section Area (ft²) :	16.6	0.00	0.00
Wetted Perimeter (ft) :	13.5	0.00	0.00
Velocity (ft/sec) :	6.91	0.00	0.00
Computed Flow Time (min) :	3.67	0.00	0.00

Total TOC (min) 10.69

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 280.66
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:10:41

Subbasin : CD-3

Input Data

Area (ac) 4.50
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	4.50	-	86.00
Composite Area & Weighted CN	4.50		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	23.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.55	0.00	0.00
Computed Flow Time (min) :	3.06	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	26	0.00	0.00
Slope (%) :	48	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	11.18	0.00	0.00
Computed Flow Time (min) :	0.04	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	1090	0.00	0.00
Channel Slope (%) :	10	0.00	0.00
Cross Section Area (ft²) :	5.1	0.00	0.00
Wetted Perimeter (ft) :	7.5	0.00	0.00
Velocity (ft/sec) :	10.41	0.00	0.00
Computed Flow Time (min) :	1.75	0.00	0.00

Total TOC (min) 4.84

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 43.21
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:04:50

Subbasin : CD-4

Input Data

Area (ac) 7.92
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	7.92	-	86.00
Composite Area & Weighted CN	7.92		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	23.4	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.55	0.00	0.00
Computed Flow Time (min) :	3.04	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	230	0.00	0.00
Slope (%) :	28.7	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	8.64	0.00	0.00
Computed Flow Time (min) :	0.44	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	515	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	12.2	0.00	0.00
Wetted Perimeter (ft) :	11.8	0.00	0.00
Velocity (ft/sec) :	6.16	0.00	0.00
Computed Flow Time (min) :	1.39	0.00	0.00

Total TOC (min) 4.88

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 76.09
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:04:53

Subbasin : CD-5

Input Data

Area (ac) 6.85
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	6.85	-	86.00
Composite Area & Weighted CN	6.85		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	37	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.66	0.00	0.00
Computed Flow Time (min) :	2.53	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	50	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	11.41	0.00	0.00
Computed Flow Time (min) :	0.15	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	745	0.00	0.00
Channel Slope (%) :	2.5	0.00	0.00
Cross Section Area (ft²) :	11.3	0.00	0.00
Wetted Perimeter (ft) :	11.4	0.00	0.00
Velocity (ft/sec) :	6.69	0.00	0.00
Computed Flow Time (min) :	1.86	0.00	0.00

Total TOC (min) 4.53

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 65.76
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:04:32

Subbasin : CD-6

Input Data

Area (ac) 8.43
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	8.43	-	86.00
Composite Area & Weighted CN	8.43		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	26.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.57	0.00	0.00
Computed Flow Time (min) :	2.91	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	58	0.00	0.00
Slope (%) :	34.1	0.00	0.00
Surface Type :	Unpaved	ıre & untill	Unpaved
Velocity (ft/sec) :	9.42	0.00	0.00
Computed Flow Time (min) :	0.10	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	.035	.035
Flow Length (ft) :	784	295	53
Channel Slope (%) :	3	10	6
Cross Section Area (ft²) :	10.8	6.9	8.4
Wetted Perimeter (ft) :	10.7	8.8	9.5
Velocity (ft/sec) :	7.42	11.45	9.61
Computed Flow Time (min) :	1.76	0.43	0.09

Total TOC (min) 5.30

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 80.35
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:05:18

Subbasin : CD-7

Input Data

Area (ac) 1.75
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	1.70	-	86.00
Composite Area & Weighted CN	1.70		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	29.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.60	0.00	0.00
Computed Flow Time (min) :	2.77	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	155	10	0.00
Slope (%) :	45	100	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	10.82	16.13	0.00
Computed Flow Time (min) :	0.24	0.01	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	134	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	2	0.00	0.00
Wetted Perimeter (ft) :	2.23	0.00	0.00
Velocity (ft/sec) :	5.60	0.00	0.00
Computed Flow Time (min) :	0.40	0.00	0.00

Total TOC (min) 3.42

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 16.78
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:03:25

Subbasin : CD-8

Input Data

Area (ac) 1.60
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	1.60	-	86.00
Composite Area & Weighted CN	1.60		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	27	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.58	0.00	0.00
Computed Flow Time (min) :	2.87	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	259	0.00	0.00
Slope (%) :	31	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	8.98	0.00	0.00
Computed Flow Time (min) :	0.48	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	219	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	2	0.00	0.00
Wetted Perimeter (ft) :	2.23	0.00	0.00
Velocity (ft/sec) :	5.60	0.00	0.00
Computed Flow Time (min) :	0.65	0.00	0.00

Total TOC (min) 4.00

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 15.36
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:04:00

Subbasin : CD-9

Input Data

Area (ac) 4.20
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	4.20	-	86.00
Composite Area & Weighted CN	4.20		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	35.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.64	0.00	0.00
Computed Flow Time (min) :	2.59	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	450	0.00	0.00
Slope (%) :	23.5	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	7.82	0.00	0.00
Computed Flow Time (min) :	0.96	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.035	0.00	0.00
Flow Length (ft) :	83	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	7.1	0.00	0.00
Wetted Perimeter (ft) :	7.7	0.00	0.00
Velocity (ft/sec) :	5.70	0.00	0.00
Computed Flow Time (min) :	0.24	0.00	0.00

Total TOC (min) 3.79

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 40.32
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:03:47

Subbasin : CD-10

Input Data

Area (ac) 4.40
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	4.40	-	86.00
Composite Area & Weighted CN	4.40		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	33.7	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.63	0.00	0.00
Computed Flow Time (min) :	2.63	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	226	0.00	0.00
Slope (%) :	42.8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	10.56	0.00	0.00
Computed Flow Time (min) :	0.36	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.035	0.00	0.00
Flow Length (ft) :	186	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	7.4	0.00	0.00
Wetted Perimeter (ft) :	7.9	0.00	0.00
Velocity (ft/sec) :	5.76	0.00	0.00
Computed Flow Time (min) :	0.54	0.00	0.00

Total TOC (min) 3.52

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 42.28
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:03:31

ATTACHMENT 4

North American Green Software Output

Tensar International Corporation
5401 St. Wendel-Cynthiana Road
Poseyville, Indiana 47633
Tel. 800.772.2040
Fax 812.867.0247
www.nagreen.com

Erosion Control Materials Design Software
Version 5.0

Project Name: SGI
Project Number: 84066
Channel Name: CD-1

Discharge	100
Peak Flow Period	24
Channel Slope	0.02
Channel Bottom Width	5
Left Side Slope	2
Right Side Slope	2
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Silt Loam

P550 - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
P550 Unvegetated	Straight	100 cfs	8.86 ft/s	1.43 ft	0.024	3.25 lbs/ft2	1.79 lbs/ft2	1.82	STABLE	E
P550 Reinforced Vegetation	Straight	100 cfs	5.94 ft/s	1.91 ft	0.041	12 lbs/ft2	2.38 lbs/ft2	5.04	STABLE	E
Underlying Substrate	Straight	100 cfs	5.94 ft/s	1.91 ft	--	3.25 lbs/ft2	0.123 lbs/ft2	26.38	STABLE	--

Tensar International Corporation
5401 St. Wendel-Cynthiana Road
Poseyville, Indiana 47633
Tel. 800.772.2040
Fax 812.867.0247
www.nagreen.com

Erosion Control Materials Design Software
Version 5.0

Project Name: SGI
Project Number: 84066
Channel Name: CD-2

Discharge	285
Peak Flow Period	24
Channel Slope	0.02
Channel Bottom Width	5
Left Side Slope	2
Right Side Slope	2
Low Flow Liner	
Retardance Class	C
Vegtation Type	Mix (Sod & Bunch)
Vegetation Density	Fair 50-75%
Soil Type	Silt Loam

P550 - Class C - Mix (Sod & Bunch) - Fair 50-75%

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
P550 Unvegetated	Straight	285 cfs	16.8 ft/s	1.92 ft	0.015	3.25 lbs/ft2	2.4 lbs/ft2	1.36	STABLE	E
P550 Reinforced Vegetation	Straight	285 cfs	8.85 ft/s	2.95 ft	0.035	12 lbs/ft2	3.69 lbs/ft2	3.26	STABLE	E
Underlying Substrate	Straight	285 cfs	8.85 ft/s	2.95 ft	--	3.25 lbs/ft2	0.206 lbs/ft2	15.75	STABLE	--

ATTACHMENT 5

Watershed Maps

Thursday, December 28, 2017 10:17:57 AM

N:\2015\152596 - SGI\Northern Tract\Ditch Design\Watershed Map - Phase 1.dwg

COLUMBIA GASLINE

TOMS CREEK

MAINTAINED BUFFER

LOWER GUM SPRINGS ROAD

PERMIT BOUNDARY

DITCH DRAINAGE HIGH POINT EL 1165.64

DITCH CD-1

DITCH CD-2

OPERATIONAL BUFFER

DITCH CD-1 WATERSHED AREA: 11.33 AC

DITCH CD-2 WATERSHED AREA: 33.97 AC

GUM SPRINGS ROAD

EMORY LANE

IRON SPRINGS ROAD

UNNAMED TRIBUTARY TO TOMS CREEK

PETES LANE

WETLAND (TYP.)

WETLAND A

WETLAND C

WETLAND D

WETLAND E

CHANNEL 01

CHANNEL 02

Water

As mapped

SCALE
200 0 200 400 FEET

NOTES / REVISIONS

REV.	REVISION DESCRIPTION	MADE BY	CHKD BY	DATE
4				
3				
2				
1				

ISSUED FOR | DATE

SEAL:

D'APPOLONIA
701 RODI ROAD, FLOOR 2
PITTSBURGH, PENNSYLVANIA 15235-4559
(412) 856-9440 FAX (412) 856-9535

SGI

PROJECT NUMBER: 152595
FILE NAME: Watershed Map - Phase 1.dwg

DRAWN BY: MJD | DATE: 12/18/2017
CHECKED BY: CHKD BY | DATE: DATE

SPECIALTY GRANULES LLC

CHARMIAN SITE

PHASE 1
WATERSHED MAP

SCALE: AS SHOWN | DRAWING NO. 1 | REV 0

Thursday, December 28, 2017 10:34:50 AM

N:\2015\152596 - SGI\Northern Tract\Ditch Design\Watershed Map - Phase 2.dwg

CULVERT C-2
COLUMBIA GASLINE
NT POND NO. 1
DTICH CD-8
DTICH CD-7
CULVERT C-1
DITCH CD-8 WATERSHED AREA: 1.59 AC
DITCH CD-7 WATERSHED AREA: 1.71 AC
DITCH CD-3 WATERSHED AREA: 4.42 AC
DITCH CD-5 WATERSHED AREA: 7.92 AC
DITCH CD-4
DITCH CD-3
MAINTAINED BUFFER
PERMIT BOUNDARY
OPERATIONAL BUFFER
LOWER GUM SPRINGS ROAD
GUM SPRINGS ROAD
TOMS CREEK
EMORY LANE
IRON SPRINGS ROAD
PETES LANE
UNNAMED TRIBUTARY TO TOMS CREEK
WETLAND (TYP.)
WETLAND A
WETLAND C
WETLAND D
WETLAND E
CHANNEL 01
CHANNEL 02
COPPER MINE ENTRANCE
T-305
Water
07A16
60B16
95B16
16A16
97B16
15A16
MW-7
PZ-1
PZ-5
MW-03R
MW-05D
MW-05S
MW-05R
MW-08D
MW-08S
MW-09D
MW-09R
MW-100
MW-110
MW-14D
MW-14S
4th 1140
5th 1090
6th 1040
7th 990
9th 890
10th 840
3rd 1190
2nd 1240
SCALE
200 0 200 400 FEET

NOTES / REVISIONS

REV.	REVISION DESCRIPTION	MADE BY	CHKD BY	DATE
4				
3				
2				
1				

ISSUED FOR | DATE

SEAL:

D'APPOLONIA
701 RODI ROAD, FLOOR 2
PITTSBURGH, PENNSYLVANIA 15235-4559
(412) 856-9440 FAX (412) 856-9535

SGI

PROJECT NUMBER: 152596
FILE NAME: Watershed Map - Phase 2.dwg

DRAWN BY: MJD | DATE: 12/18/2017
CHECKED BY: CHKD BY | DATE: DATE

SPECIALTY GRANULES LLC

CHARMIAN SITE

PHASE 2
WATERSHED MAP

SCALE: AS SHOWN | DRAWING NO. 1 | REV 0

PERMIT BOUNDARY

OPERATIONAL BUFFER

MAINTAINED BUFFER

PRESERVE MONITORING WELL MW-11D

PRESERVE MONITORING WELL MW-8S/8D

COLUMBIA GASLINE

CULVERT C-3

CULVERT C-4

DITCH CD-8

DITCH CD-9

DITCH CD-10

NT POND NO. 2

DITCH CD-9 WATERSHED AREA: 4.11 AC

DITCH CD-6 WATERSHED AREA: 8.43 AC

DITCH CD-8 WATERSHED AREA: 6.85 AC

TOMS CREEK

LOWER GUM SPRINGS ROAD

GUM SPRINGS ROAD

EMORY LANE

IRON SPRINGS ROAD

PETES LANE

UNNAMED TRIBUTARY TO TOMS CREEK

COPPER MINE ENTRANCE

WETLAND A

WETLAND B

WETLAND C

WETLAND D

WETLAND E

CHANNEL 01

CHANNEL 02

SCALE

200 0 200 400 FEET

NOTES / REVISIONS

REV.	REVISION DESCRIPTION	MADE BY	CHKD BY	DATE
4				
3				
2				
1				

ISSUED FOR | DATE

SEAL:

D'APPOLONIA
701 RODI ROAD, FLOOR 2
PITTSBURGH, PENNSYLVANIA 15235-4559
(412) 856-9440 FAX (412) 856-9535

SGI

PROJECT NUMBER: 152596

FILE NAME: Watershed Map - Phase 3.dwg

DRAWN BY: MJD | DATE: 12/18/2017

CHECKED BY: CHKD BY | DATE: DATE

SPECIALTY GRANULES LLC

CHARMIAN SITE

PHASE 3
WATERSHED MAP

SCALE: AS SHOWN | DRAWING NO. 1 | REV 0

SECTION C

DITCH RIGID LINING DESIGN

D'APPOLONIA

By: MJD	Date: 10/18/16	Subject:	Ditch Rigid Lining Design	Sheet No.:	1 of 5
Chkd. By: AMR	Date: 10/26/2016		Northern Tract Quarry	Proj. No.:	152596A

N:\2015\152596 - SGI\Northern Tract\Ditch Design\[Ditch Rigid Lining Design_R0.xls]Calcs

COLLECTION DITCH RIGID LINING DESIGN
NORTHERN TRACT QUARRY, CHARMIAN SITE
SPECIALTY GRANULES, INC.
ADAMS COUNTY, PENNSYLVANIA

PURPOSE

The purpose of these calculations is to design the rigid lining to be installed in various ditches at the Northern Tract Quarry located in Adams County, Pennsylvania. Fabric-formed concrete (Fabriform Unimat) lining, incorporated with steel anchors as applicable, will be used. Design formulas were provided from Fabriform's technical data and specification sheets.

DESIGN FORMULAS

Tractive Stress:

$\tau_b = \gamma_w * R * S$ where, (Ref. #1)

γ_w = Unit weight of water = 62.4 lb/ft^3

R = hydraulic radius of channel flowing at design depth

S = channel bed slope

Resisting Force of Revetment:

$$\tau_{r,b} = \frac{t(\gamma_R - \gamma_w)}{\sqrt{1+S_o^2}}(\tan\delta - S_o)\left(\frac{d}{y}\right) + A_S\phi\frac{fs}{A_R}$$ where, (Ref. #1)

Shear Resistance — Anchor Resistance

t = thickness of revetment = 6 inches

γ_R = unit weight of revetment = 130 pcf

δ = internal friction angle at subgrade/revetment interface

S_o = channel bed slope

A_S = area of steel anchor reinforcement

Φ = capacity reduction for shear = 0.85

f_s = yield stress of anchor support

A_R = area of revetment supported

d = depth of protected ditch

y = depth of water in ditch

D'APPOLONIA

By: MJD Date: 10/18/16 Subject: Ditch Rigid Lining Design Sheet No.: 2 of 5
Chkd. By: AMR Date: 10/26/2016 Northern Tract Quarry Proj. No.: 152596A
N:\2015\152596 - SGI\Northern Tract\Ditch Design\[Ditch Rigid Lining Design_R0.xls]Calcs

LINING STABILITY ANALYSIS

Channel Designation	$R^{(1)}$ (ft)	S (S = S_o) (ft/ft)	$\delta^{(2)}$ (Degrees)	D_{anchor} (inches)	A_S (in^2)	f_s (psi)	Max. Anchor Spacing (ft)	
							Longitudinal	Transverse
CD-3	0.70	0.10	19	0	0.000	0	20	5
CD-4	0.70	0.10	19	0	0.000	0	20	1
CD-5	0.70	0.10	19	0	0.000	0	20	1
CD-6	0.80	0.10	19	0	0.000	0	20	1

Channel Designation	y, Flow Depth (ft)	d, Ditch Depth (ft)	Bottom Width (ft)	Lining Width (ft)	T_b (lb/ft^2)	$T_{r,b}$ (lb/ft^2)	Req'd Factor of Safety	Factor of Safety
CD-3	1.00	3	3	16.4	4.4	24.7	1.5	5.6
CD-4	1.00	3	5	18.4	4.4	24.7	1.5	5.6
CD-5	0.95	3	5	18.4	4.4	25.9	1.5	5.9
CD-6	1.20	3	3.5	16.9	5.0	20.5	1.5	4.1

Notes:

1. The hydraulic radius (R = A/P) of each ditch is presented in the associated ditch design calculation.
2. It is assumed that the fabric-formed concrete lined ditches will be constructed on a subgrade consisting of silty, sandy clay. The subgrade will be compacted and graded to a relatively uniform surface.
3. The side slopes for each ditch are 2 horizontal to 1 vertical (2H:1V).

D'APPOLONIA

By:	MJD	Date: 10/18/16	Subject: Ditch Rigid Lining Design	Sheet No.:	3 of 5
Chkd. By:	AMR	Date: 10/26/2016	Northern Tract Quarry	Proj. No.:	152596A

N:\2015\152596 - SGI\Northern Tract\Ditch Design\[Ditch Rigid Lining Design_R0.xls]Calcs

SOIL PROPERTIES

The design soil properties were based upon geotechnical boring logs, adopt the following material properties:

Cohesion, c =	125	psf
Internal Friction Angle, Φ =	28	degrees
Unit Weight, γ =	130	pcf

D'APPOLONIA

By: MJD	Date: 10/18/16	Subject:	Ditch Rigid Lining Design	Sheet No.:	4 of 5
Chkd. By: AMR	Date: 10/26/2016		Northern Tract Quarry	Proj. No.:	152596A

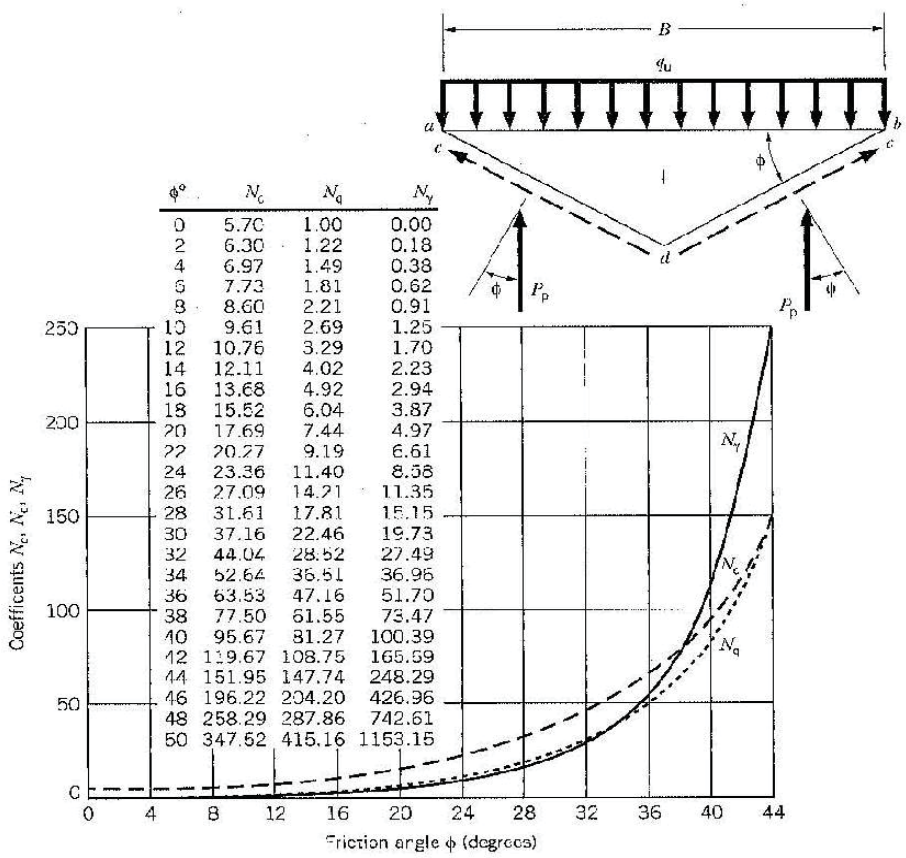
N:\2015\152596 - SGI\Northern Tract\Ditch Design\[Ditch Rigid Lining Design_R0.xls]Calcs

ALLOWABLE BEARING CAPACITY OF SOIL

Considering Terzaghi's Bearing Capacity Theory:

$q_u = cN_c + \gamma DN_q + 0.5\gamma BN_\gamma$ where,

c = soil cohesion =	125	psf
N_c = bearing capacity factor =	32.4	Considering Φ = 28º
γ = unit weight of soil =	130	pcf
D = depth of foundation embedment =	0	feet
N_q = bearing capacity factor =	18.6	Considering Φ = 28º
B = footing width =	2.5	inches
N_γ = bearing capacity factor =	15.7	Considering Φ = 28º
q_u =	4,263	psf



ϕ°	N_c	N_q	N_γ
0	5.70	1.00	0.00
2	6.30	1.22	0.18
4	6.97	1.49	0.38
6	7.73	1.81	0.62
8	8.60	2.21	0.91
10	9.61	2.69	1.25
12	10.76	3.29	1.70
14	12.11	4.02	2.23
16	13.68	4.92	2.94
18	15.52	6.04	3.87
20	17.69	7.44	4.97
22	20.27	9.19	6.61
24	23.36	11.40	8.58
26	27.09	14.21	11.35
28	31.61	17.81	15.15
30	37.16	22.46	19.73
32	44.04	28.52	27.49
34	52.64	36.51	36.96
36	63.53	47.16	51.70
38	77.50	61.55	73.47
40	95.67	81.27	100.39
42	119.67	108.75	165.59
44	151.95	147.74	248.29
46	196.22	204.20	426.96
48	258.29	287.86	742.61
50	347.52	415.16	1153.15

Table 1 - Excerpted From Reference 2

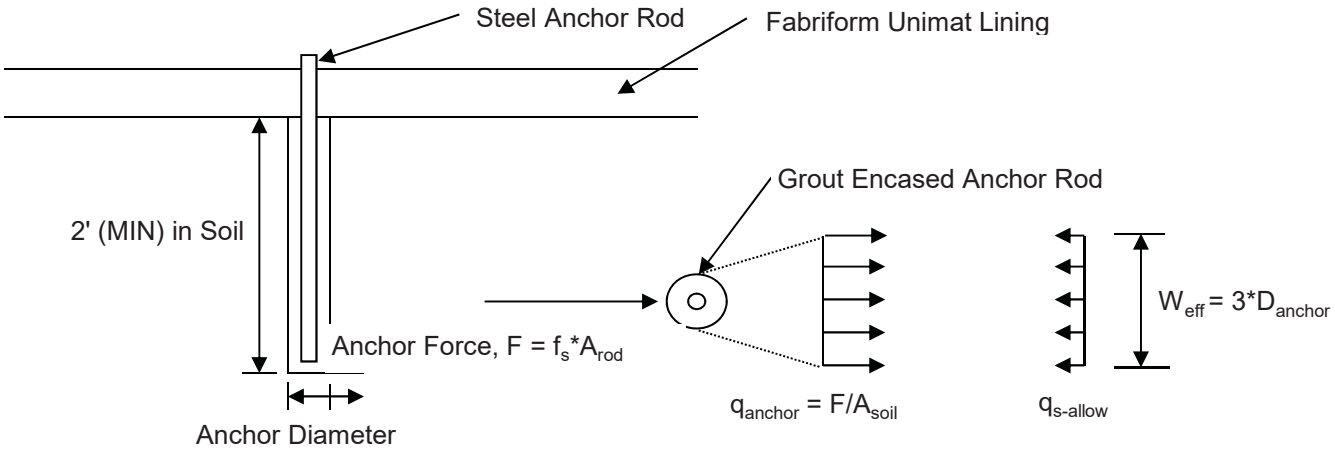
D'APPOLONIA

By:	MJD	Date: 10/18/16	Subject: Ditch Rigid Lining Design	Sheet No.:	5 of 5
Chkd. By:	AMR	Date: 10/26/2016	Northern Tract Quarry	Proj. No.:	152596A

N:\2015\152596 - SGI\Northern Tract\Ditch Design\[Ditch Rigid Lining Design_R0.xls]Calcs

FABRIC-FORMED CONCRETE LINING ANCHOR DESIGN

The following calculation will check the bearing capacity of the fabric-formed concrete lining anchor rods embedded in soil subgrade. (i.e. The bearing resistance of the soil against the horizontal pressure of the anchor rod.)



SECTION **PLAN**

Yield Stress of Anchor, f_s =	20,000	psi
Anchor Rod Bar Diameter, D_{rod} =	0.5	inches
Anchor Rod Area, A_{rod} =	0.196	in^2 (cross-sectional area)
Anchor Base Diameter, D_{anchor} =	2.5	inches (base including steel anchor and surrounding grout)
Effective Width of Resisting Soil, W_{eff} =	0.625	feet (3 times anchor width per AASHTO 3.11.5.6)
Length of Anchor, L_{anchor} =	2	feet
Area of Resisting Soil, A_{soil} =	1.25	ft^2
Max. Anchor Rod Force, F =	3,927	lb
Soil Pressure Due to Anchor, q_{anchor} =	3,142	psf
Allowable Bearing Capacity of Soil, $q_{s\text{-}allow}$ =	4,263	psf
Factor of Safety Against Soil Failure =	1.4	

Anchor induced soil pressure less than allowable bearing capacity. OK

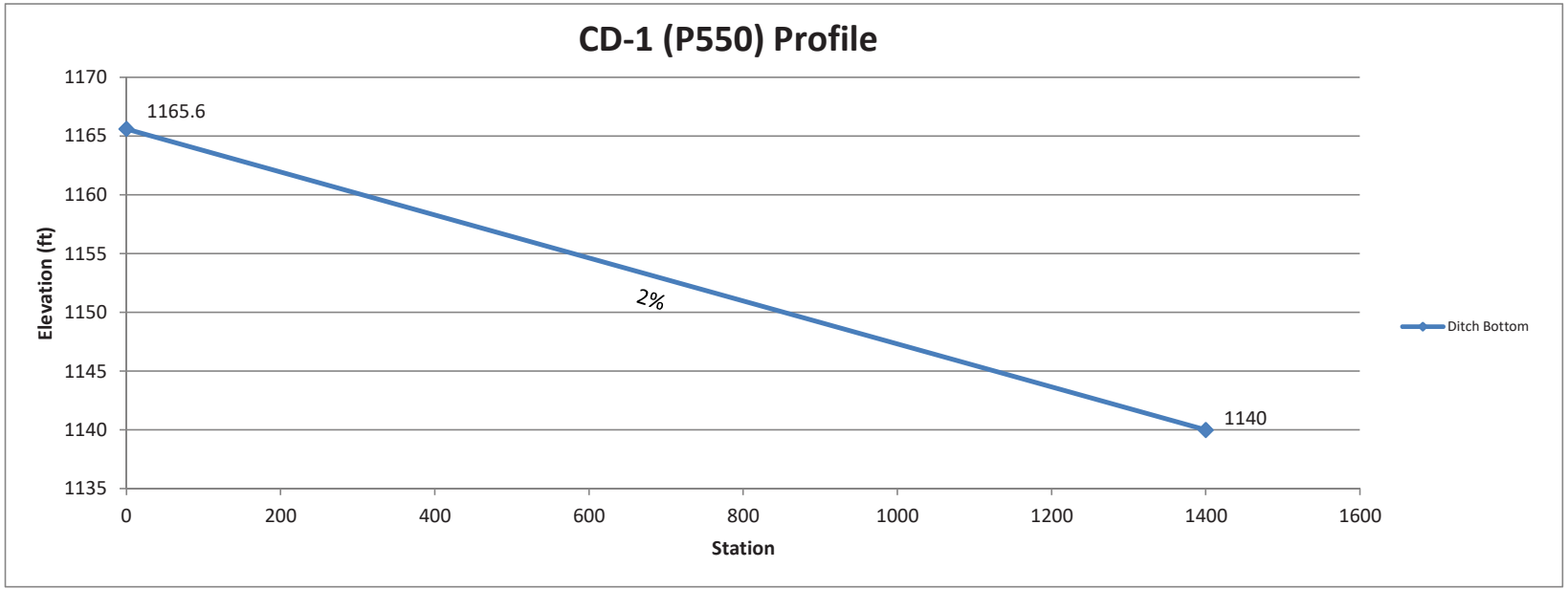
SECTION D

COLLECTION AND DIVERSION DITCH FORM 12.1

Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Design-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-1 (P550)	*Refer to Ditch Profile		11.3	100	10	86	100	0.02	0.1	P550 Vegetated	0.0409	5	2/2	1.91	16.83	12.64	5.94	100	2.00	13.00	109.4
CD-1 (P550)	*Refer to Ditch Profile		11.3	100	10	86	100	0.02	0.1	P550 Vegetated	0.0409	5	2/2	1.91	16.83	12.64	5.94	100	2.00	13.00	109.4

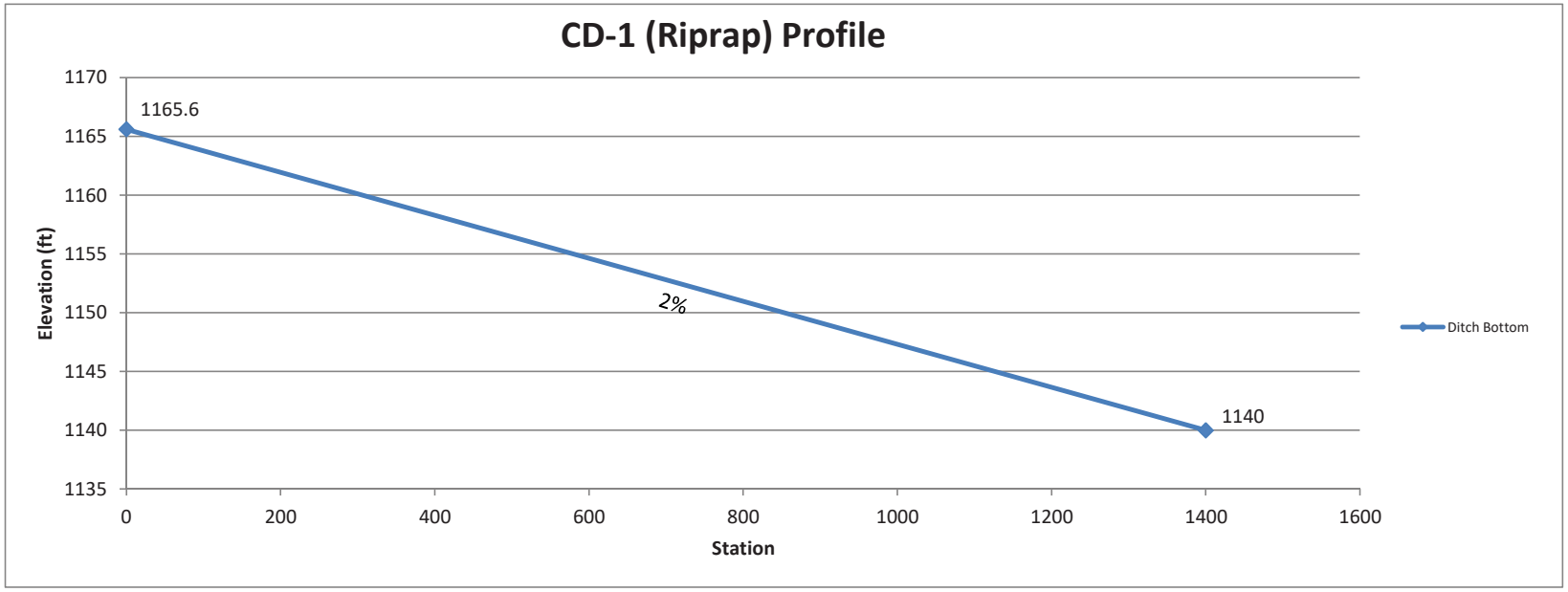


*DITCH DESIGN CALCS WERE BASED ON MIN/MAX SLOPES. ACTUAL DITCH SLOPES MAY VARY WITHIN THIS RANGE AS SHOWN ON DITCH PROFILE.

Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-1 (Riprap)	*Refer to Ditch Profile		11.3	100	10	86	100	0.02	0.1	Riprap R-4	0.0418	5	2/2	1.93	17.11	12.72	5.84	100	2.00	13.00	106.9
CD-1 (Riprap)	*Refer to Ditch Profile		11.3	100	10	86	100	0.02	0.1	Riprap R-4	0.0418	5	2/2	1.93	17.11	12.72	5.84	100	2.00	13.00	106.9

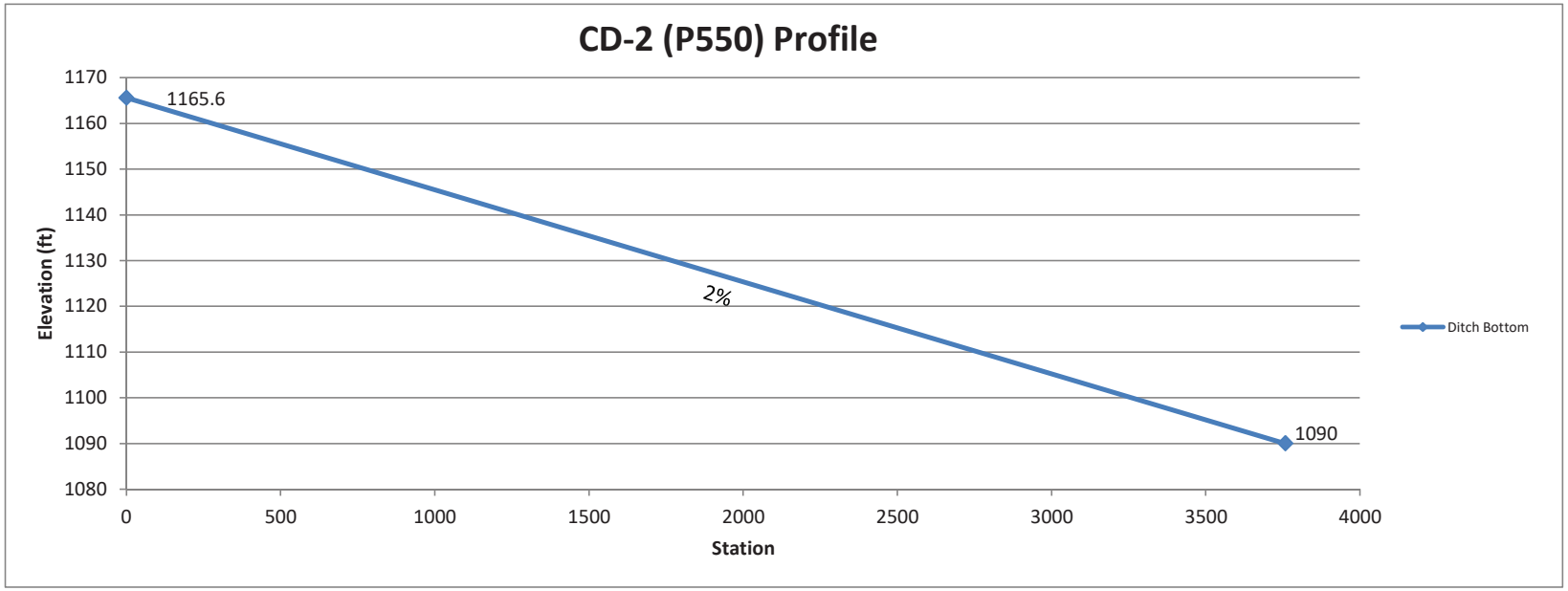


*DITCH DESIGN CALCS WERE BASED ON MIN/MAX SLOPES. ACTUAL DITCH SLOPES MAY VARY WITHIN THIS RANGE AS SHOWN ON DITCH PROFILE.

Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

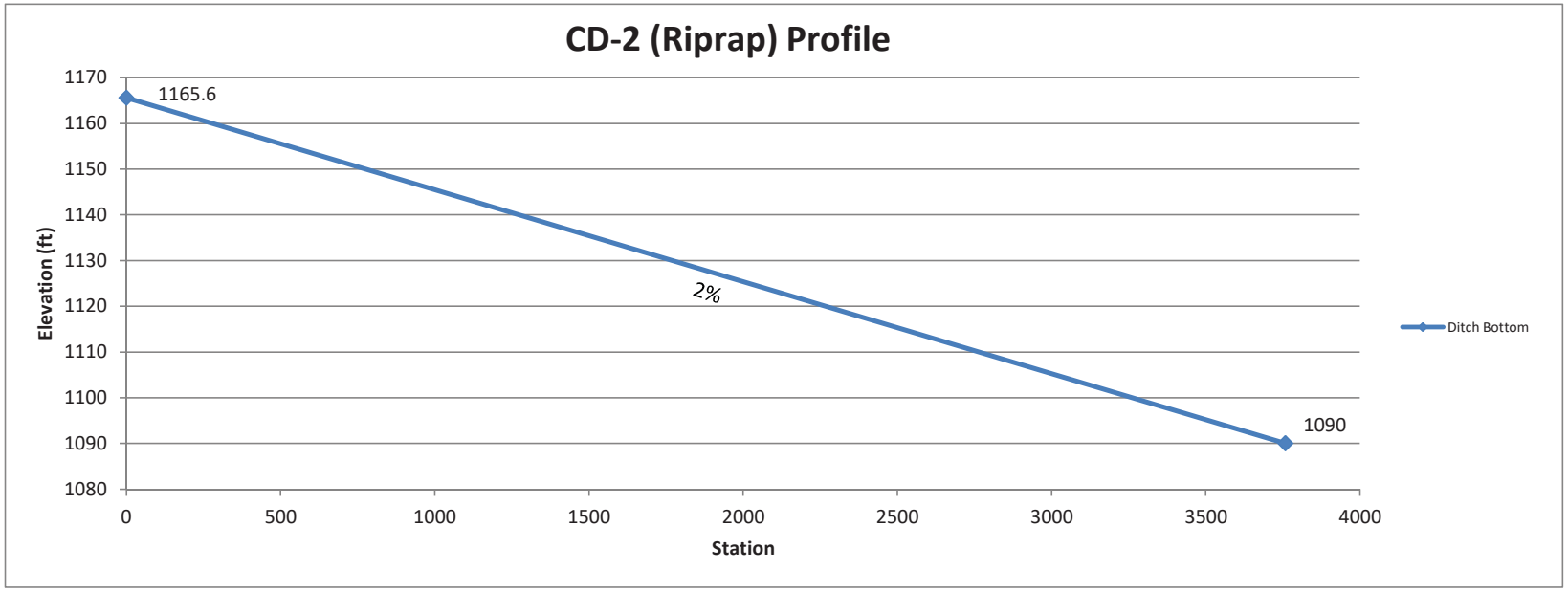
Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-2 (P550)	*Refer to Ditch Profile		34.0	100	10	86	285	0.02	0.6	P550 Vegetated	0.0346	5	2/2	2.95	32.00	16.80	8.85	285	3.50	19.00	418.3
CD-2 (P550)	*Refer to Ditch Profile		34.0	100	10	86	285	0.02	0.6	P550 Vegetated	0.0346	5	2/2	2.95	32.00	16.80	8.85	285	3.50	19.00	418.3



*DITCH DESIGN CALCS WERE BASED ON MIN/MAX SLOPES. ACTUAL DITCH SLOPES MAY VARY WITHIN THIS RANGE AS SHOWN ON DITCH PROFILE.

Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)			Site:	Charmian Site			Company:	D'Appolonia Engineering			Permit Number:									
Prepared By:	MJD			Telephone Number:	412-856-9440			Date:	7/1/2016			Sheet:									
Channel Cross-Section Type:	Triangular or Trapezoidal																				
Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start / End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-2 (Riprap)	*Refer to Ditch Profile		34.0	100	10	86	285	0.02	0.4	Riprap R-4	0.0388	5	2/2	3.11	34.94	17.45	8.16	285	3.50	19.00	373.2
CD-2 (Riprap)	*Refer to Ditch Profile		34.0	100	10	86	285	0.02	0.4	Riprap R-4	0.0388	5	2/2	3.11	34.94	17.45	8.16	285	3.50	19.00	373.2



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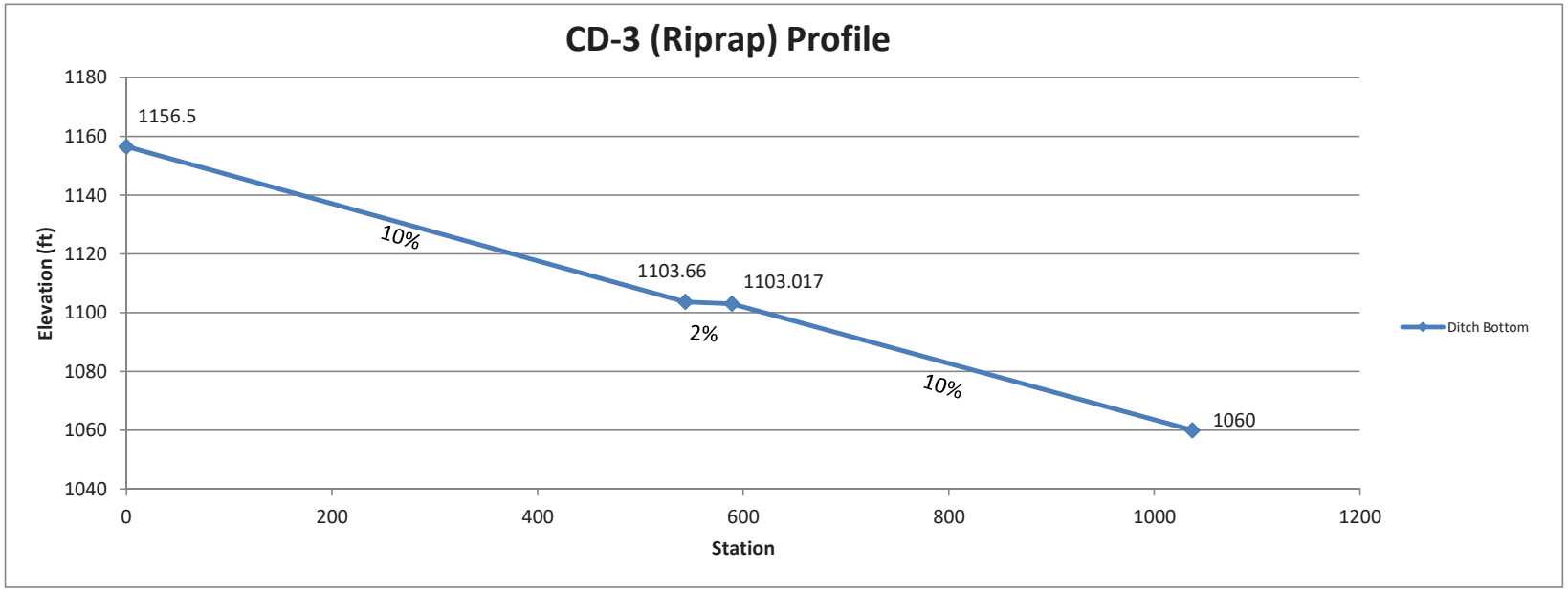
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-3 (Riprap)	*Refer to Ditch Profile		4.5	100	36	86	50	0.02	1.4	Riprap R-4	0.0432	3	2/2	1.64	10.30	9.56	4.85	50	3.00	15.00	186.2
CD-3 (Riprap)	*Refer to Ditch Profile		4.5	100	36	86	50	0.1	1.9	Riprap R-4	0.0470	3	2/2	1.15	6.07	7.59	8.24	50	3.00	15.00	383.0



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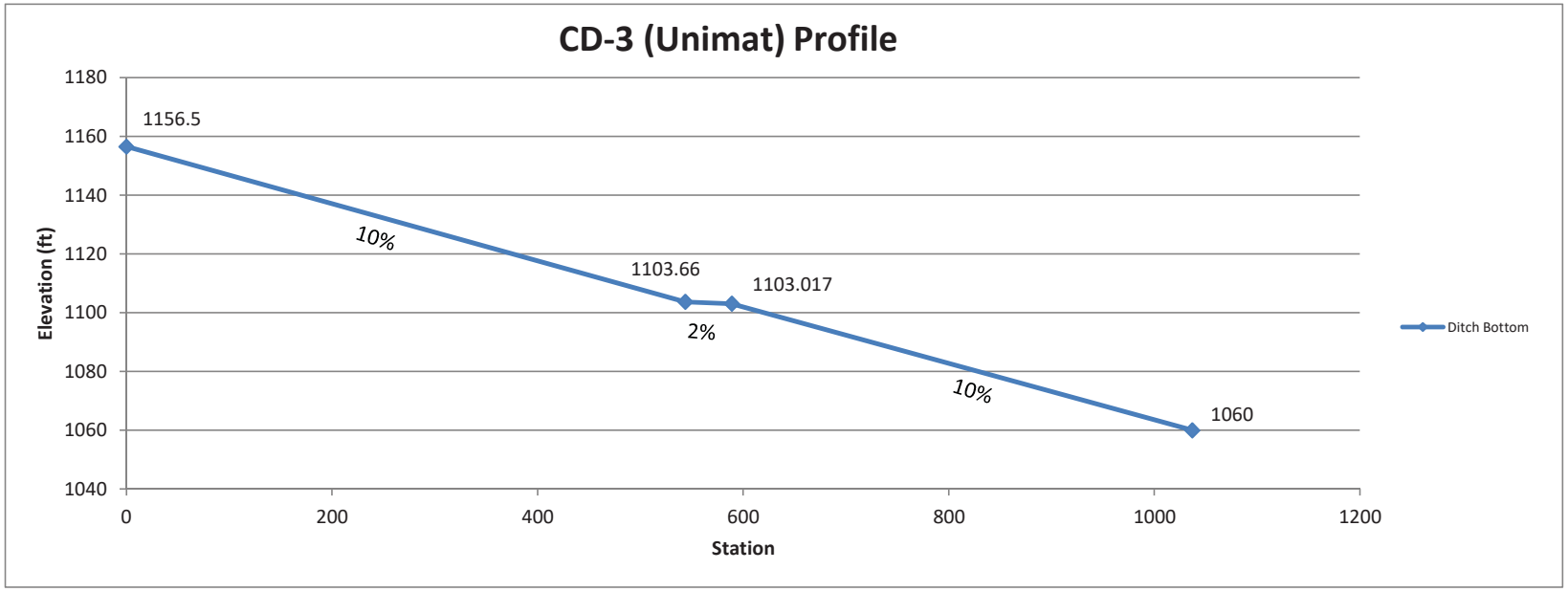
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-3 (Unimat)	*Refer to Ditch Profile		4.5	100	36	86	50	0.02	1.5	Rigid Lined Channels	0.0350	3	2/2	1.48	8.82	8.92	5.67	50	3.00	15.00	229.8
CD-3 (Unimat)	*Refer to Ditch Profile		4.5	100	36	86	50	0.1	2.0	Rigid Lined Channels	0.0350	3	2/2	0.99	4.90	6.94	10.20	50	3.00	15.00	513.8



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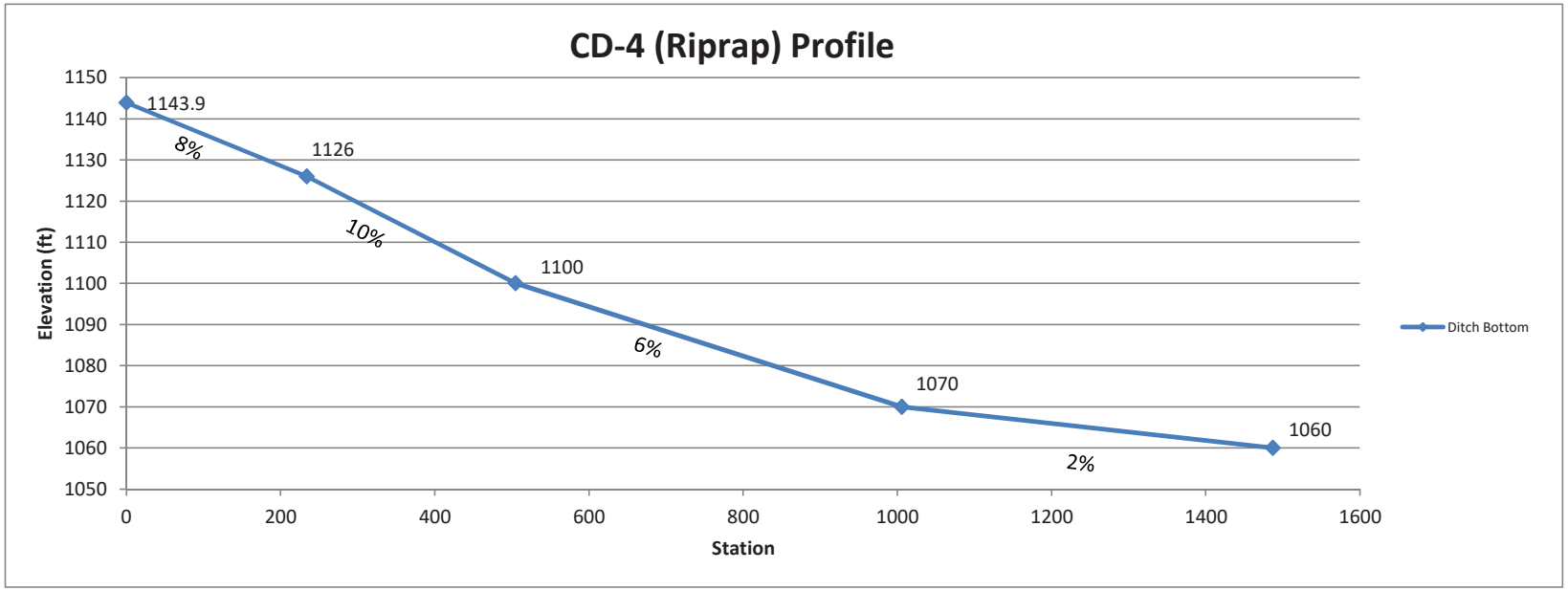
Form 12.1
Diversion/Collection Ditch Data Sheet

Title: Northern Tract Quarry Specialty Granules LLC (SGI)	Site: Charmian Site	Company: D'Appolonia Engineering	Permit Number:
Prepared By: MJD	Telephone Number: 412-856-9440	Date: 7/1/2016	Sheet:
Channel Cross-Section Type: Triangular or Trapezoidal			

Channel Design-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-4 (Riprap)	*Refer to Ditch Profile		7.9	100	25	86	77	0.02	1.3	Riprap R-4	0.0428	5	2/2	1.71	14.39	11.84	5.35	77	3.00	17.00	242.6
CD-4 (Riprap)	*Refer to Ditch Profile		7.9	100	25	86	77	0.1	1.8	Riprap R-4	0.0467	5	2/2	1.17	8.60	9.68	8.96	77	3.00	17.00	497.4



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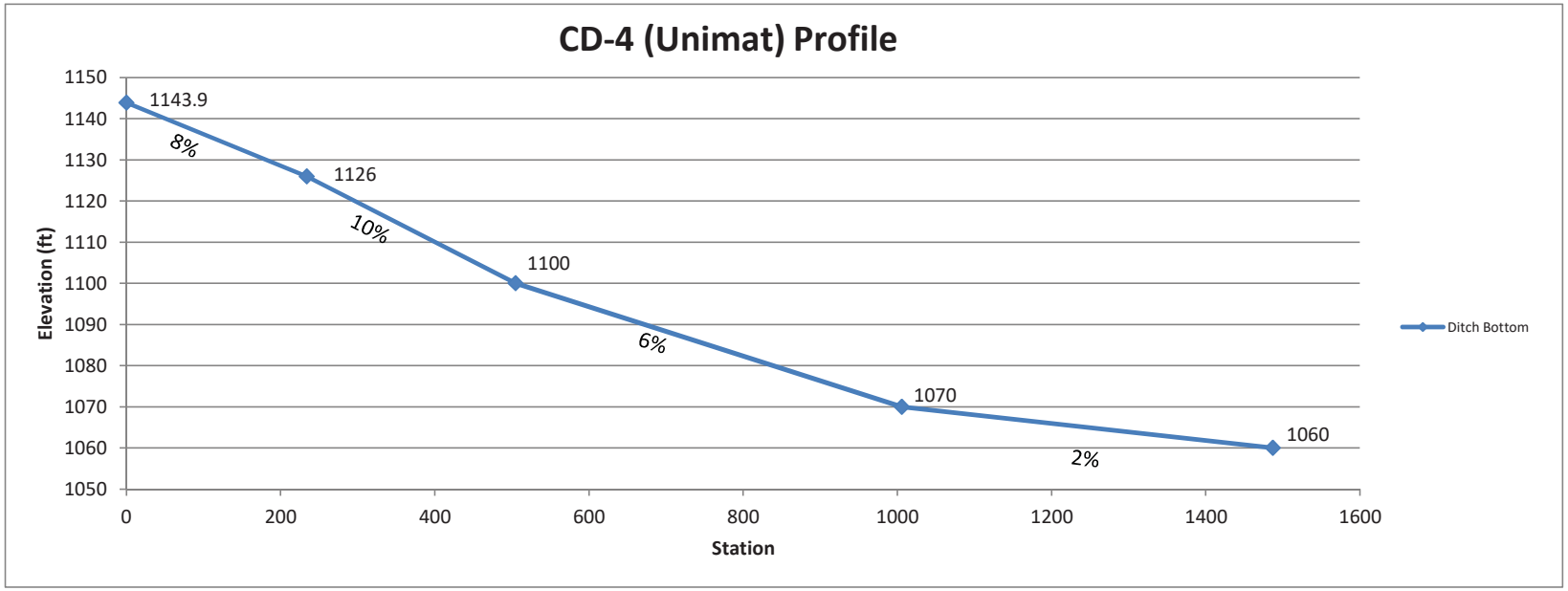
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-4 (Unimat)	*Refer to Ditch Profile		7.9	100	25	86	77	0.02	1.5	Rigid Lined Channels	0.0350	5	2/2	1.54	12.44	11.16	6.19	77	3.00	17.00	296.8
CD-4 (Unimat)	*Refer to Ditch Profile		7.9	100	25	86	77	0.1	2.0	Rigid Lined Channels	0.0350	5	2/2	1.00	7.01	9.01	10.98	77	3.00	17.00	663.7



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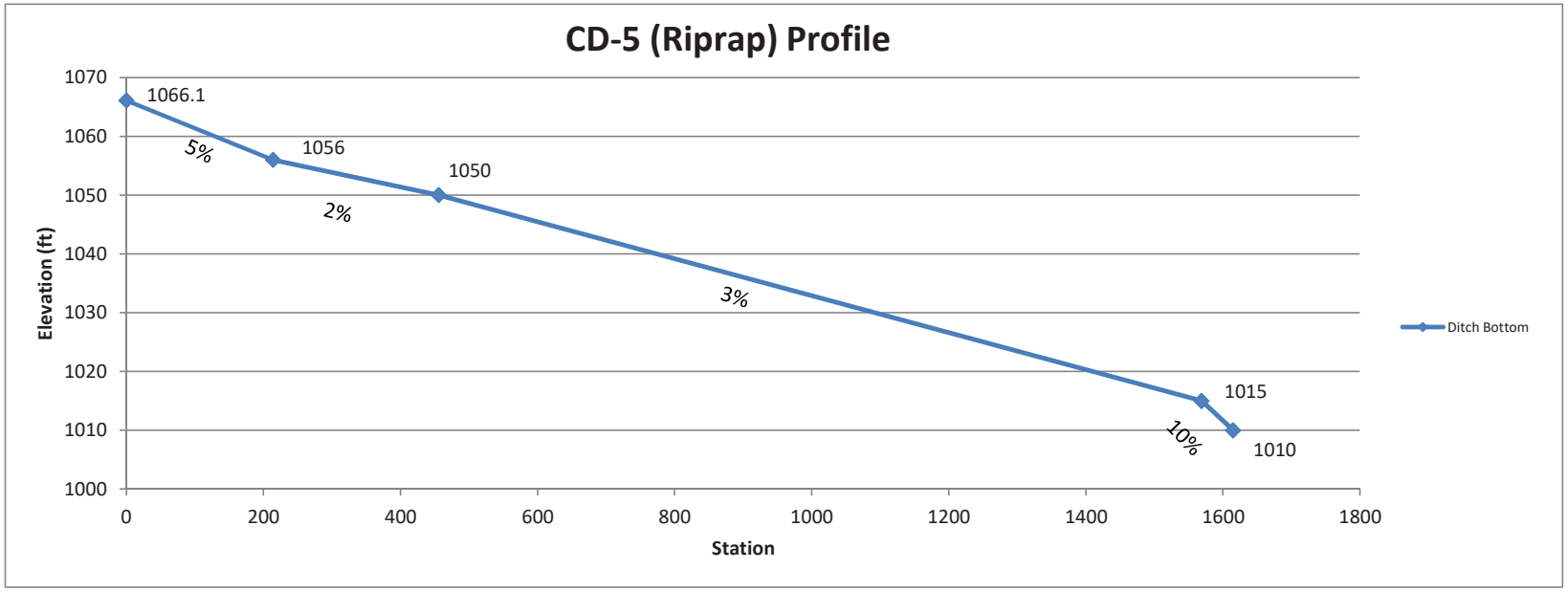
Form 12.1
Diversion/Collection Ditch Data Sheet

Title: Northern Tract Quarry Specialty Granules LLC (SGI)	Site: Charmian Site	Company: D'Appolonia Engineering	Permit Number:
Prepared By: MJD	Telephone Number: 412-856-9440	Date: 7/1/2016	Sheet:
Channel Cross-Section Type: Triangular or Trapezoidal			

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-5 (Riprap)	*Refer to Ditch Profile		6.9	100	40	86	70	0.02	1.4	Riprap R-4	0.0432	5	2/2	1.64	13.52	11.54	5.18	70	3.00	17.00	240.4
CD-5 (Riprap)	*Refer to Ditch Profile		6.9	100	40	86	70	0.1	1.9	Riprap R-4	0.0473	5	2/2	1.12	8.10	9.48	8.64	70	3.00	17.00	491.5



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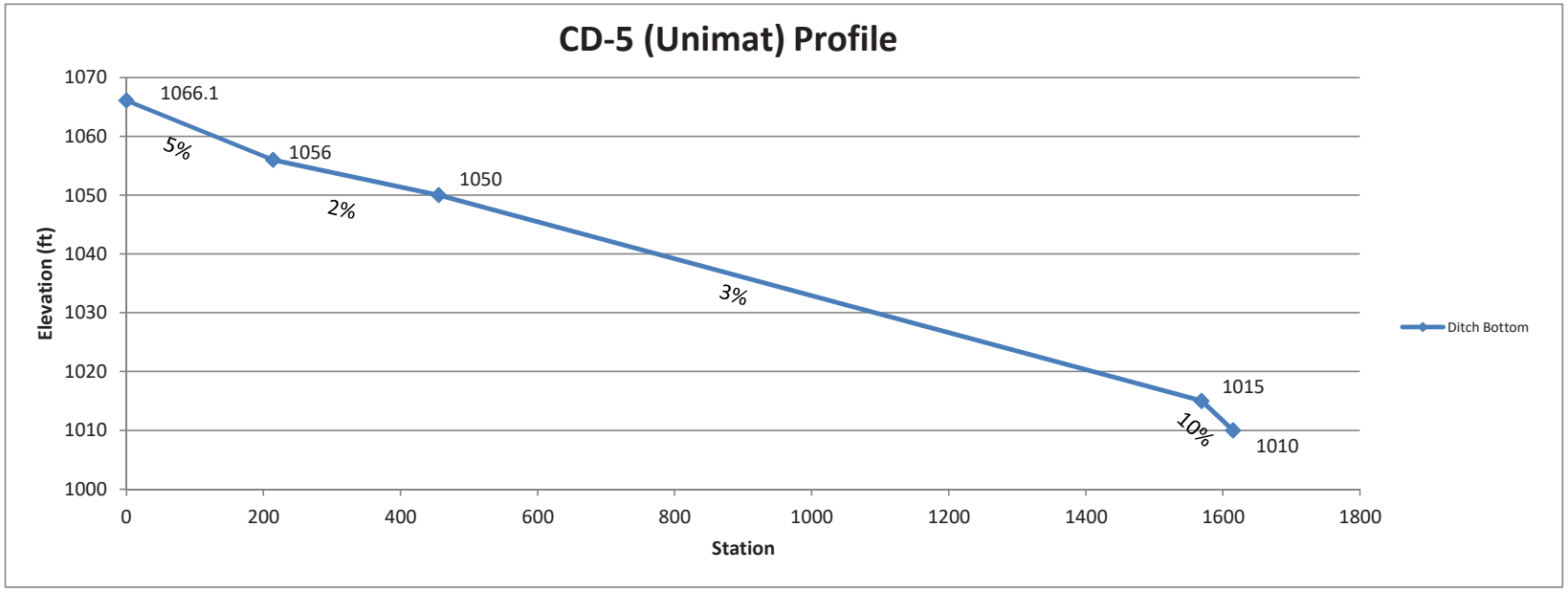
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start / End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-5 (Unimat)	*Refer to Ditch Profile		6.9	100	40	86	70	0.02	1.5	Rigid Lined Channels	0.0350	5	2/2	1.46	11.61	10.86	6.03	70	3.00	17.00	296.8
CD-5 (Unimat)	*Refer to Ditch Profile		6.9	100	40	86	70	0.1	2.0	Rigid Lined Channels	0.0350	5	2/2	0.95	6.56	8.80	10.67	70	3.00	17.00	663.7



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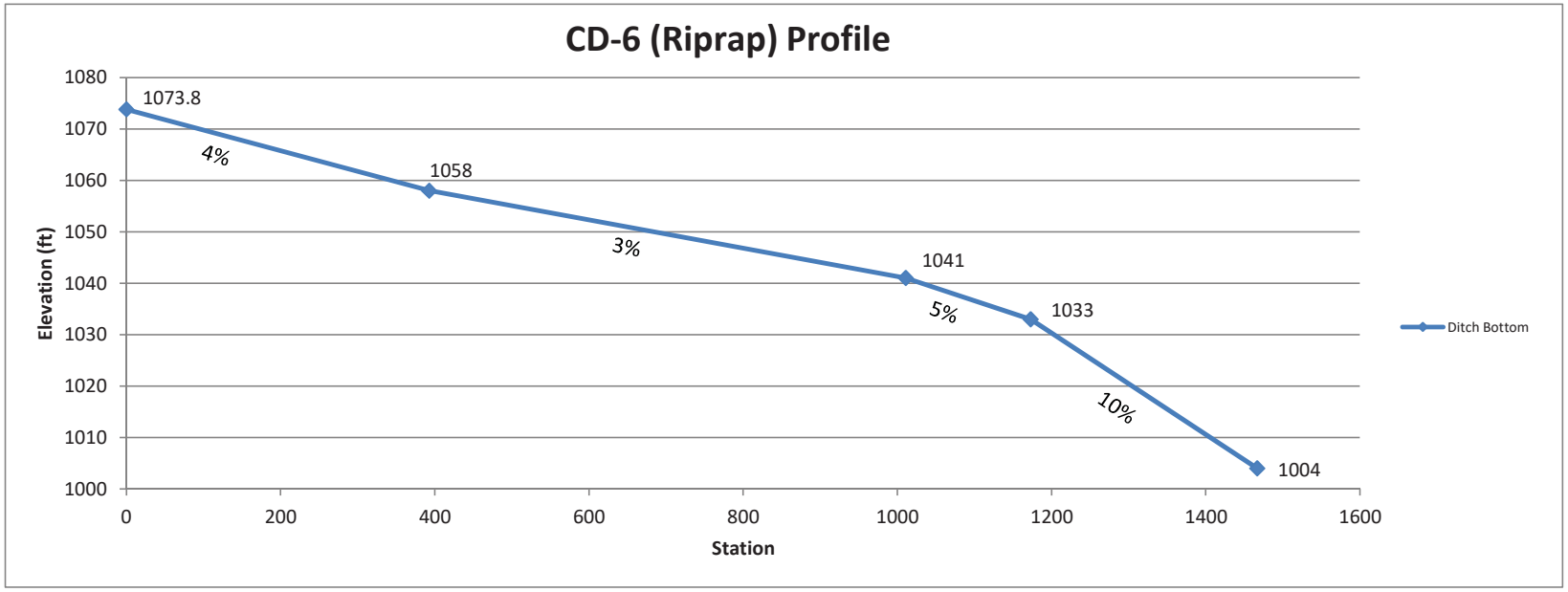
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules LLC (SGI)			Site:	Charmian Site			Company:	D'Appolonia Engineering				Permit Number:								
Prepared By:	MJD			Telephone Number:	412-856-9440			Date:	7/1/2016				Sheet:								
Channel Cross-Section Type:	Triangular or Trapezoidal																				
Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-6 (Riprap)	*Refer to Ditch Profile		8.4	100	30	86	80	0.03	1.1	Riprap R-5	0.0490	3.5	2/2	1.90	13.84	11.09	5.78	80	3.00	15.50	215.5
CD-6 (Riprap)	*Refer to Ditch Profile		8.4	100	30	86	80	0.1	1.5	Riprap R-5	0.0526	3.5	2/2	1.46	9.37	9.34	8.54	80	3.00	15.50	366.5



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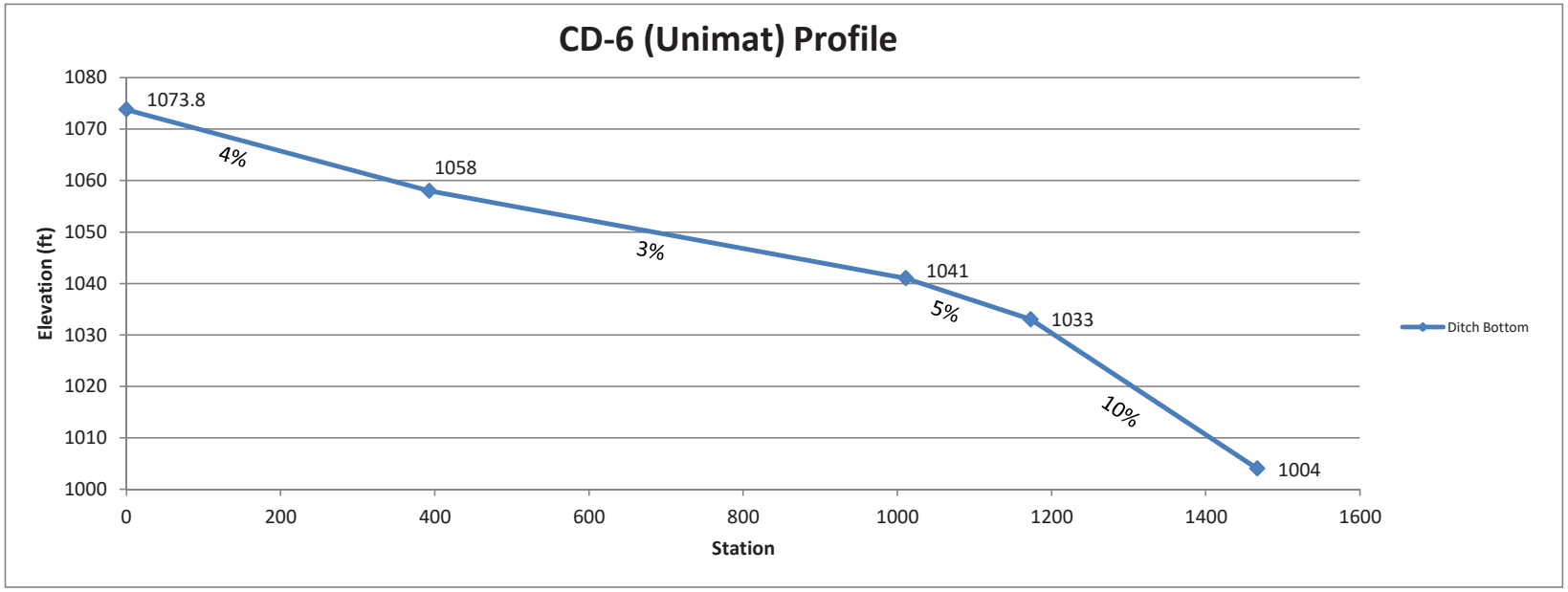
Prepared By:	MJD	Telephone Number:	412-856-9440	Date:	7/1/2016	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-6 (Unimat)	*Refer to Ditch Profile		8.4	100	30	86	80	0.03	1.4	Rigid Lined Channels	0.0350	3.5	2/2	1.61	10.80	9.93	7.40	80	3.00	15.50	301.7
CD-6 (Unimat)	*Refer to Ditch Profile		8.4	100	30	86	80	0.1	1.8	Rigid Lined Channels	0.0350	3.5	2/2	1.19	6.97	8.24	11.48	80	3.00	15.50	550.9



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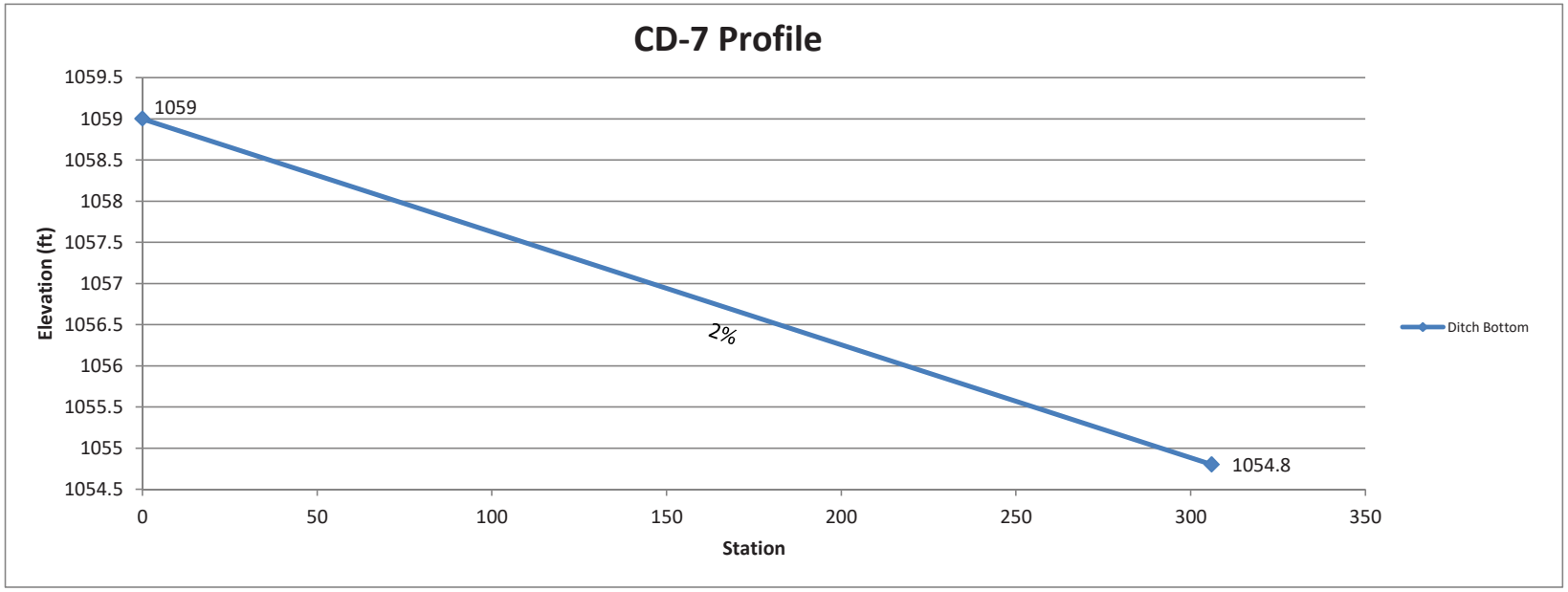
Prepared By: MJD	Telephone Number: 412-856-9440	Date: 7/1/2016	Sheet:
Channel Cross-Section Type: Triangular or Trapezoidal			

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-7	Refer to Ditch Profile		1.8	100	50	86	16.8	0.02	0.0	Rock Lined Channels	0.0350	2	2/1	1.05	3.74	5.14	4.49	16.8	1.00	5.00	14.7
CD-7	Refer to Ditch Profile		1.8	100	50	86	16.8	0.02	0.0	Rock Lined Channels	0.0350	2	2/1	1.05	3.74	5.14	4.49	16.8	1.00	5.00	14.7



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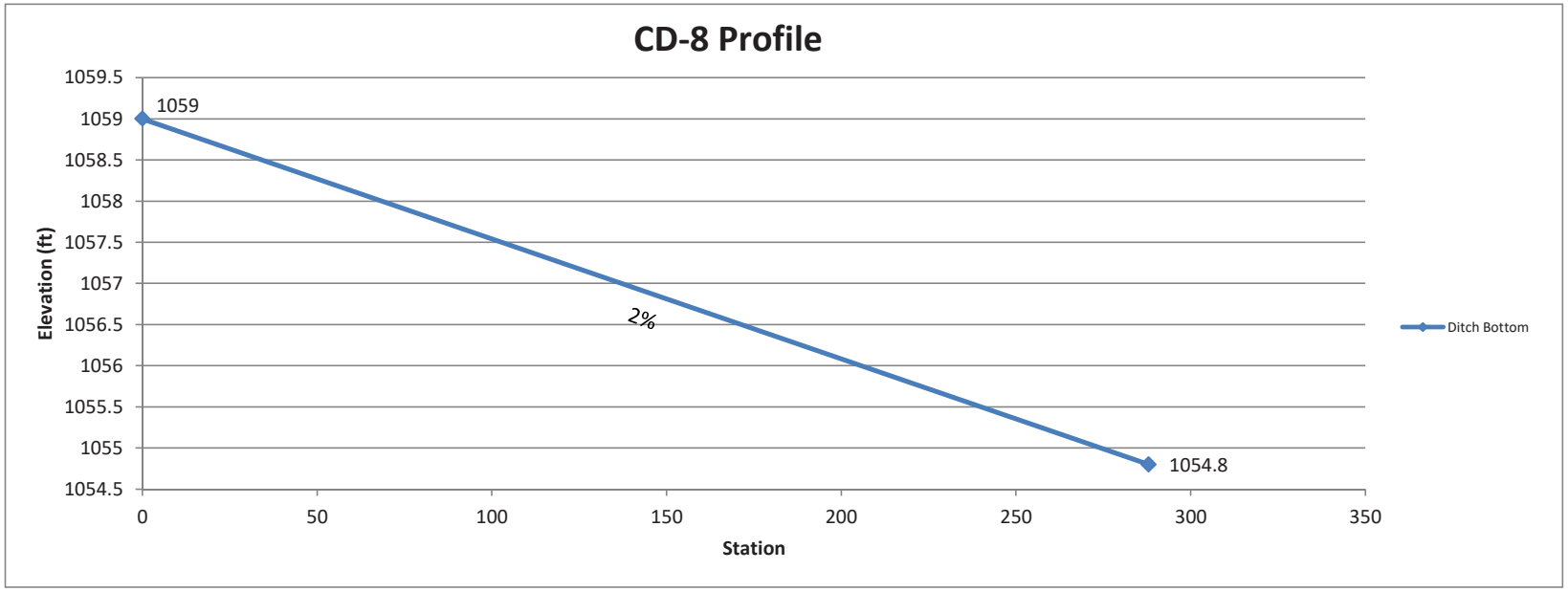
Prepared By: MJD	Telephone Number: 412-856-9440	Date: 7/1/2016	Sheet:
Channel Cross-Section Type: Triangular or Trapezoidal			

Channel Design-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation End												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-8	Refer to Ditch Profile		1.6	100	30	86	15.5	0.02	0.0	Rock Lined Channels	0.0350	2	2/1	1.00	3.52	5.01	4.40	15.5	1.00	5.00	14.7
CD-8	Refer to Ditch Profile		1.6	100	30	86	15.5	0.02	0.0	Rock Lined Channels	0.0350	2	2/1	1.00	3.52	5.01	4.40	15.5	1.00	5.00	14.7



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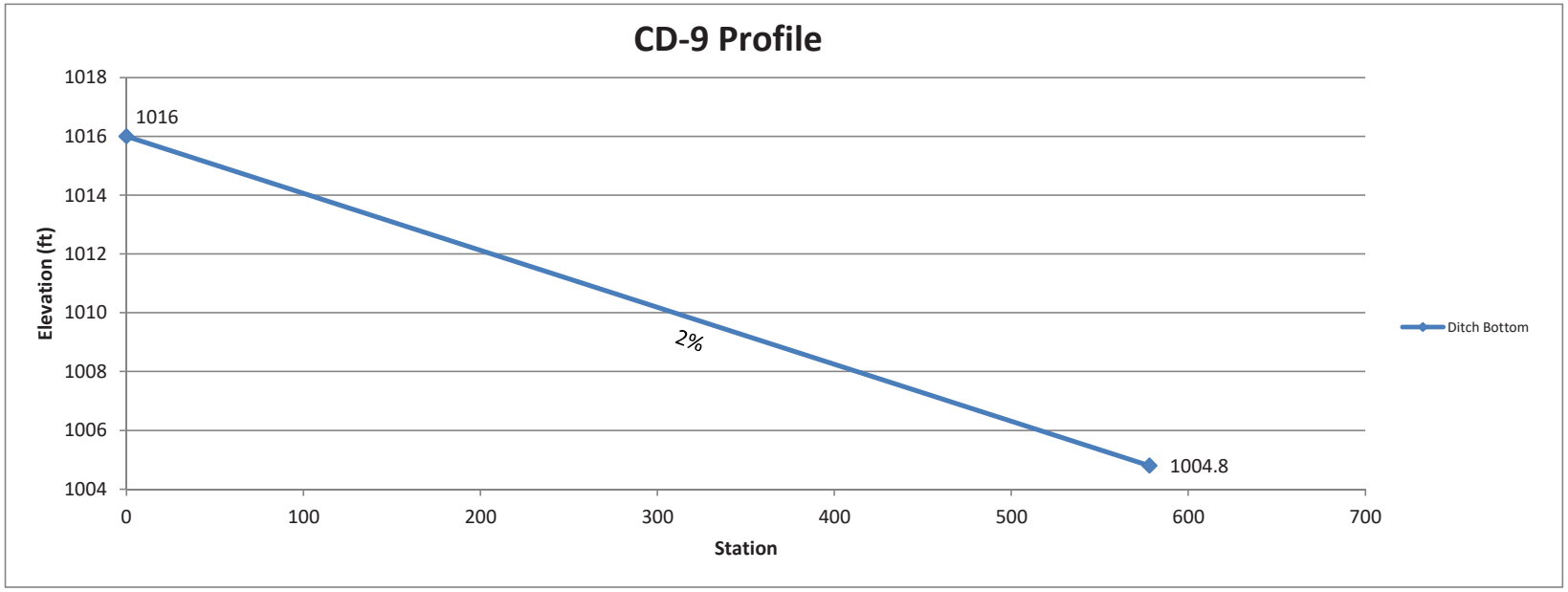
Form 12.1
Diversion/Collection Ditch Data Sheet

Title: Northern Tract Quarry Specialty Granules LLC (SGI)	Site: Charmian Site	Company: D'Appolonia Engineering	Permit Number:
Prepared By: MJD	Telephone Number: 412-856-9440	Date: 7/1/2016	Sheet:
Channel Cross-Section Type: Triangular or Trapezoidal			

Channel Desig-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start / End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-9	Refer to Ditch Profile		4.1	100	29	86	42	0.02	0.1	Rock Lined Channels	0.0350	1	2/1	1.90	7.33	6.71	5.73	42	2.00	7.00	48.0
CD-9	Refer to Ditch Profile		4.1	100	29	86	42	0.02	0.1	Rock Lined Channels	0.0350	1	2/1	1.90	7.33	6.71	5.73	42	2.00	7.00	48.0



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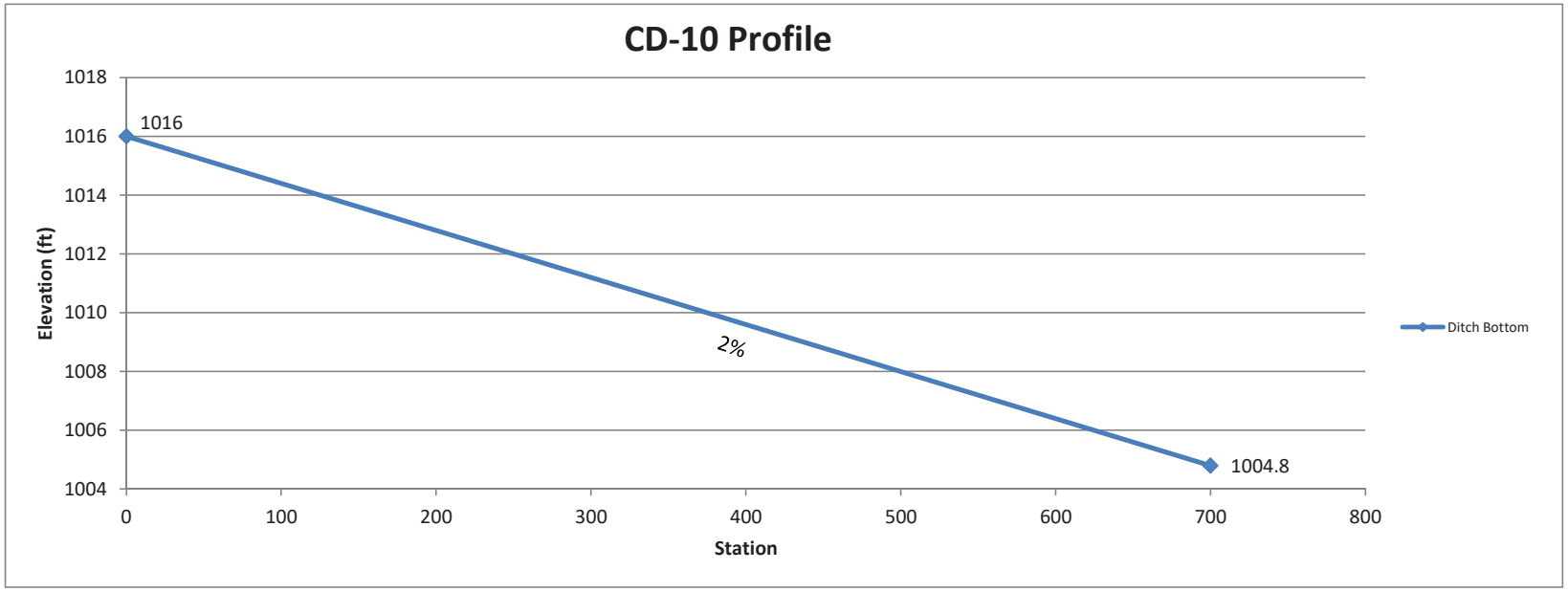
Form 12.1
Diversion/Collection Ditch Data Sheet

Title: Northern Tract Quarry Specialty Granules LLC (SGI)	Site: Charmian Site	Company: D'Appolonia Engineering	Permit Number:
Prepared By: MJD	Telephone Number: 412-856-9440	Date: 7/1/2016	Sheet:
Channel Cross-Section Type: Triangular or Trapezoidal			

Channel Design-nation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start / End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	(ft/ft)	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
CD-10	Refer to Ditch Profile		4.4	100	40	86	45	0.02	0.0	Rock Lined Channels	0.0350	1	2/1	1.96	7.72	6.88	5.83	45	2.00	7.00	48.0
CD-10	Refer to Ditch Profile		4.4	100	40	86	45	0.02	0.0	Rock Lined Channels	0.0350	1	2/1	1.96	7.72	6.88	5.83	45	2.00	7.00	48.0



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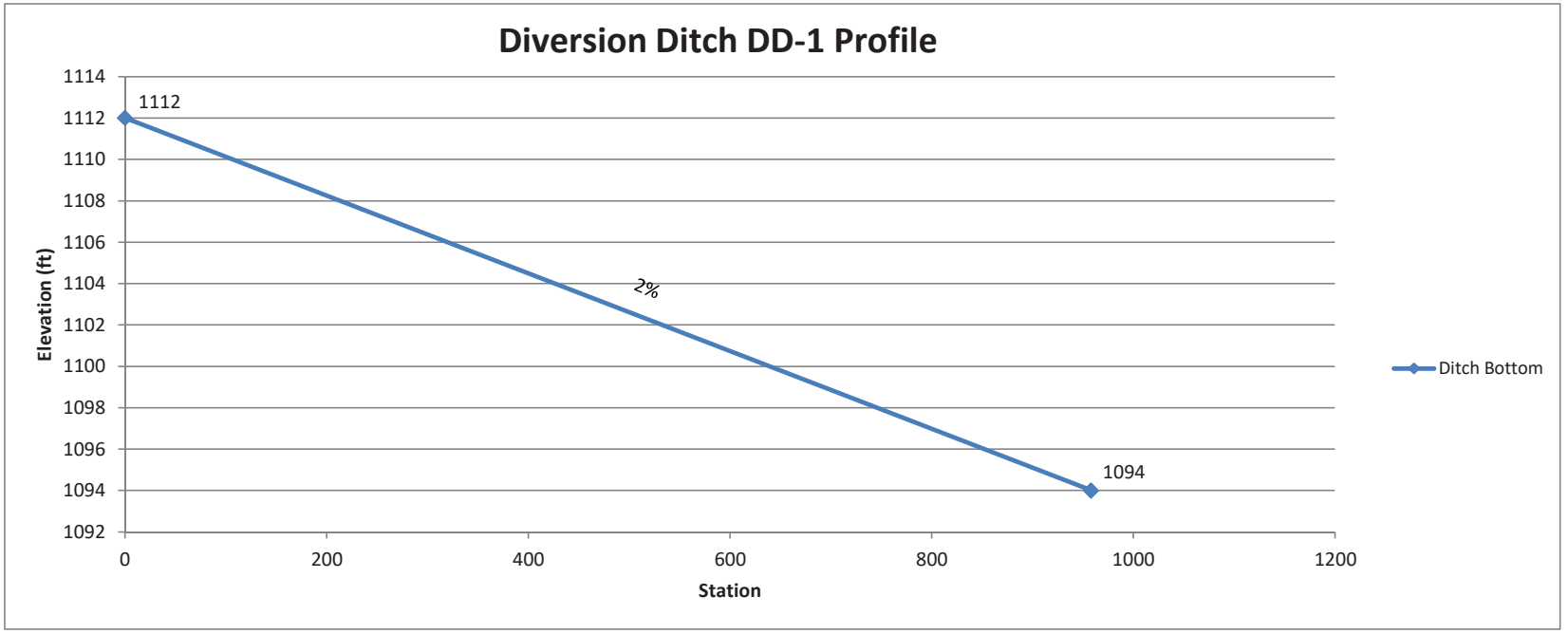
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules Inc. (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	DBB	Telephone Number:	412-856-9440	Date:	2/3/2017	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Designation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	ft/ft	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
Diversion Ditch DD-1	Refer to Ditch Profile		4.0	2.75 cfs/acre	36	86	11	0.02	1.2	P300 Unvegetated	0.0315	2	2/2	0.76	2.65	5.04	4.15	11	2.00	10.00	84.8
Diversion Ditch DD-1	Refer to Ditch Profile		4.0	2.75 cfs/acre	36	86	11	0.02	1.2	P300 Unvegetated	0.0315	2	2/2	0.76	2.65	5.04	4.15	11	2.00	10.00	84.8



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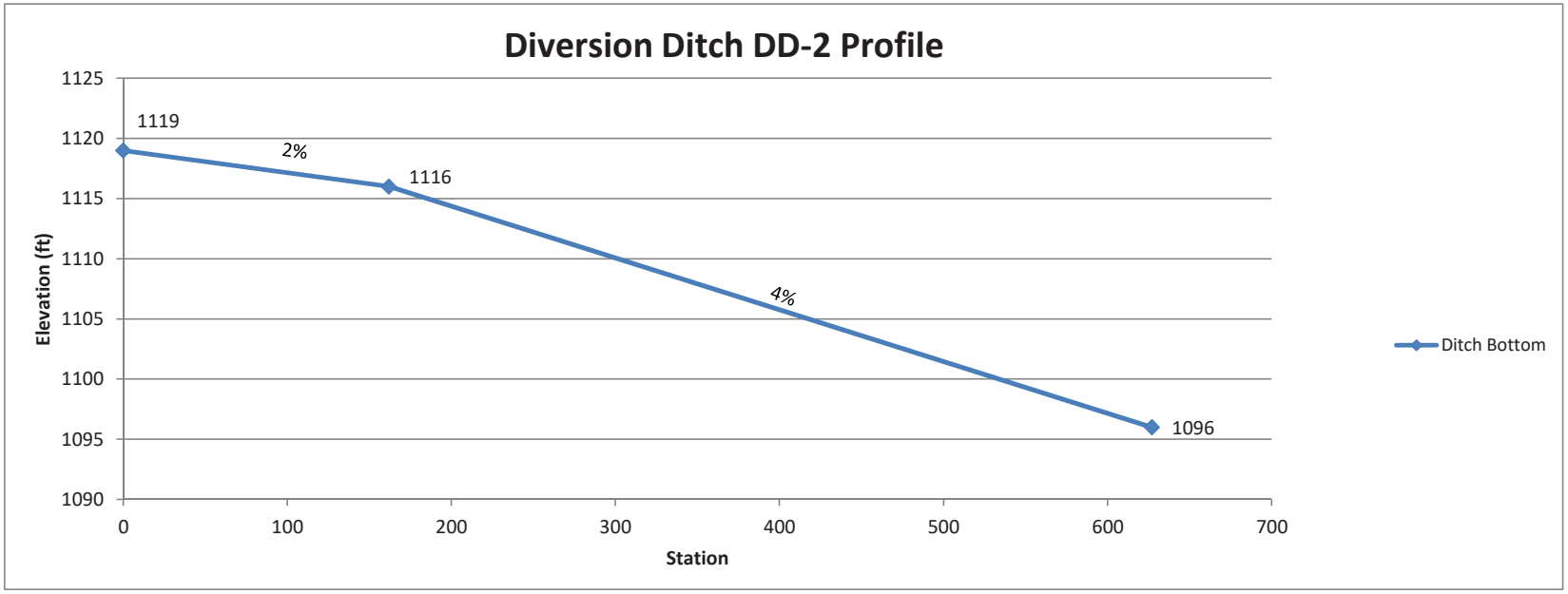
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules Inc. (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	DBB	Telephone Number:	412-856-9440	Date:	2/3/2017	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Designation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	ft/ft	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
Diversion Ditch DD-2	Refer to Ditch Profile		4.0	2.75 cfs/acre	25	86	11	0.02	1.2	P300 Unvegetated	0.0315	2	2/2	0.76	2.65	5.04	4.15	11	2.00	10.00	84.8
Diversion Ditch DD-2	Refer to Ditch Profile		4.0	2.75 cfs/acre	25	86	11	0.04	1.1	P300 Unvegetated	0.0654	2	2/2	0.91	3.50	5.64	3.15	11	2.00	10.00	57.8



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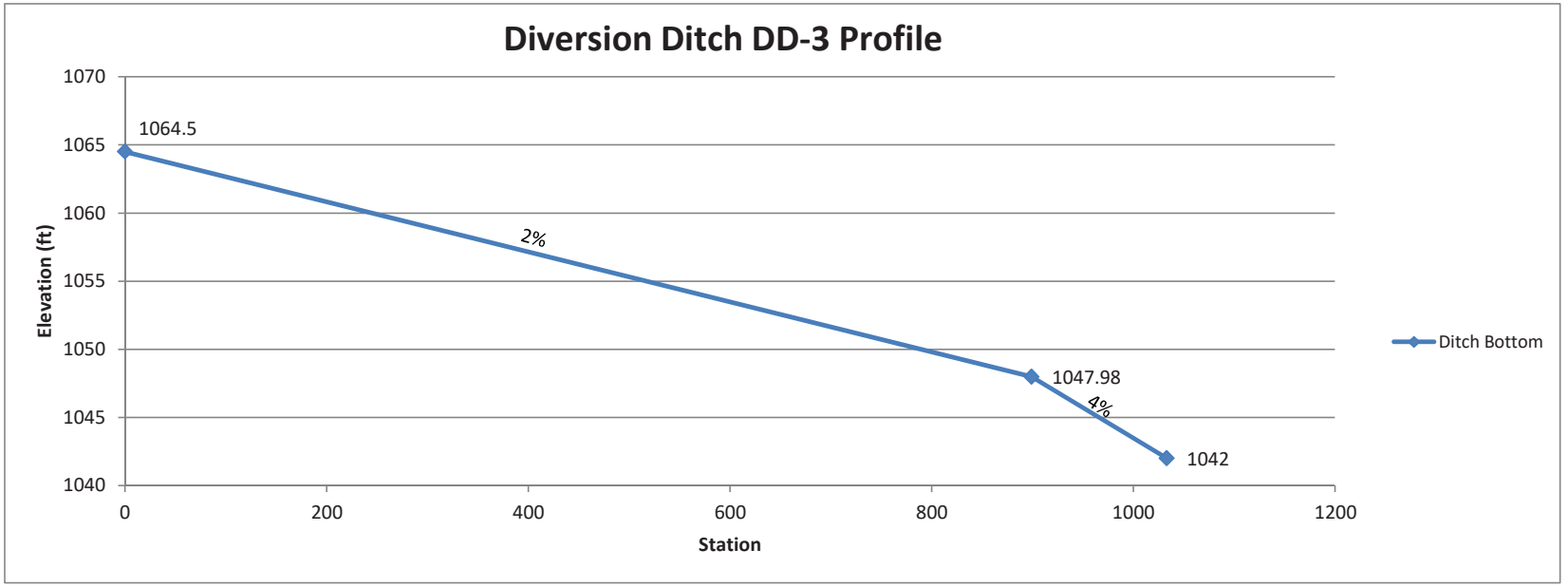
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules Inc. (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	DBB	Telephone Number:	412-856-9440	Date:	2/3/2017	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Designation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start End	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
			(Acres)	(Yrs.)	(%)		(cfs)	ft/ft	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
Diversion Ditch DD-3	Refer to Ditch Profile		5.0	2.75 cfs/acre	40	86	13.75	0.02	1.3	P300 Unvegetated	0.0324	3.5	2/2	0.68	3.33	6.22	4.14	13.75	2.00	11.50	110.0
Diversion Ditch DD-3	Refer to Ditch Profile		5.0	2.75 cfs/acre	40	86	13.75	0.04	1.5	P300 Unvegetated	0.0276	3.5	2/2	0.52	2.35	5.58	5.88	13.75	2.00	11.50	182.4



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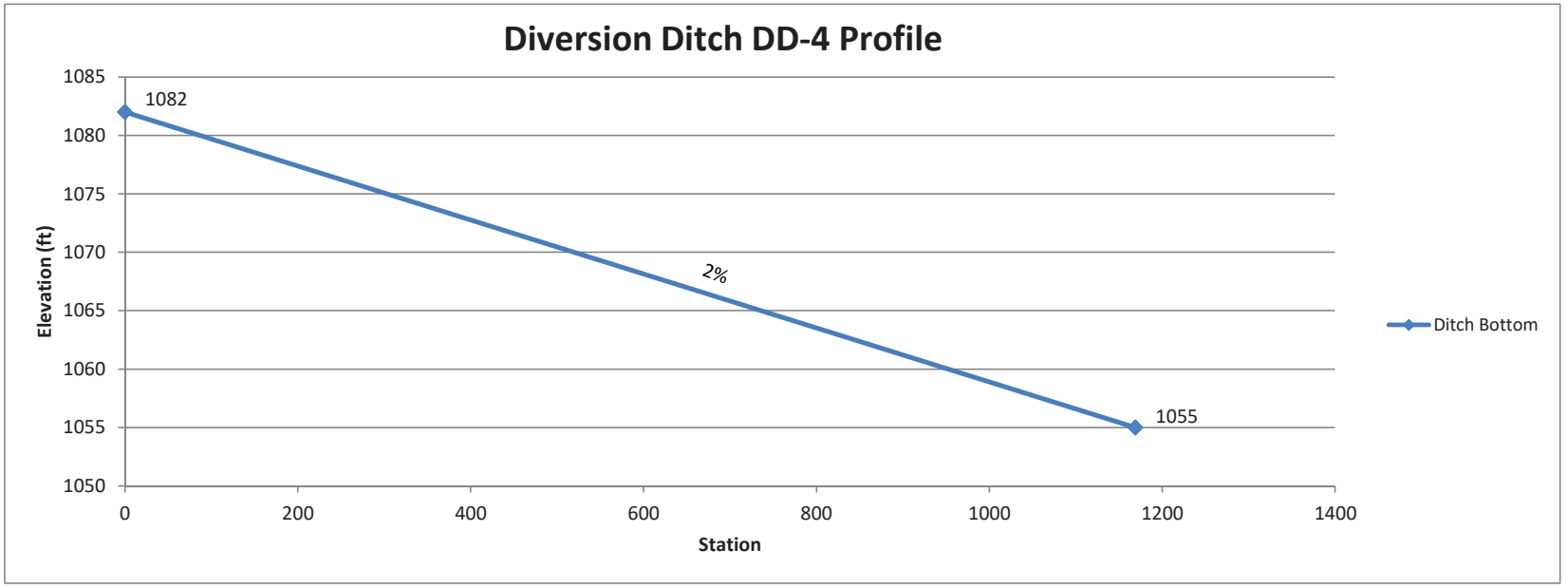
Form 12.1
Diversion/Collection Ditch Data Sheet

Title:	Northern Tract Quarry Specialty Granules Inc. (SGI)	Site:	Charmian Site	Company:	D'Appolonia Engineering	Permit Number:	
Prepared By:	DBB	Telephone Number:	412-856-9440	Date:	2/3/2017	Sheet:	
Channel Cross-Section Type:	Triangular or Trapezoidal						

Channel Designation	Station		Drainage Area	Design Storm	Average Watershed Slope	Curve Number	Peak Discharge Q	Channel Bed Slope	Free-board	Channel Lining (Specify Average Rock Size)	Man-ning's 'n'	Channel Bottom Width	Channel Side Slopes	Flow Characteristics for Channel Flowing at Design Depth					Flow Characteristics for Channel Flowing Full		
	Start	Elevation												Flow Depth	Flow Area	Top Flow Width	Flow Velocity	Q Design	Flow Depth	Top Flow Width	Q Avail-able
	End		(Acres)	(Yrs.)	(%)		(cfs)	ft/ft	(ft)	(inches)		(ft)	L/R(H:1V)	(ft)	(ft2)	(ft)	(ft/s)	(cfs)	(ft)	(ft)	(cfs)
Diversion Ditch DD-4	Refer to Ditch Profile		5.0	2.75 cfs/acre	30	86	13.75	0.02	1.3	P300 Unvegetated	0.0324	3.5	2/2	0.68	3.33	6.22	4.14	13.75	2.00	11.50	110.0
Diversion Ditch DD-4	Refer to Ditch Profile		5.0	2.75 cfs/acre	30	86	13.75	0.02	1.3	P300 Unvegetated	0.0324	3.5	2/2	0.68	3.33	6.22	4.14	13.75	2.00	11.50	110.0



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SECTION E

CULVERT - HYDRAULIC DESIGN

D'APPOLONIA

By:	MJD	Date:	06/09/16	Subject:	Northern Tract Quarry	Sheet No.:	1 of 3
Chkd. By:	AMR	Date:	10/19/16		Culvert Hydraulic Design	Proj. No.:	152596A

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CULVERT HYDRAULIC DESIGN
NORTHERN TRACT QUARRY (PHASE 2 & PHASE 3)
CHARMAIN SITE, SPECIALTY GRANULES, LLC.
ADAMS COUNTY, PENNSYLVANIA

PURPOSE

The purpose of these calculations is to design the culverts that will convey runoff from the collection ditches, under the access roads and into N.T. Pond 1 and N.T. Pond 2 during the initial development of the Northern Tract Quarry. The culverts will convey the SCS 100-year storm event. The culverts are designed to have dual-walled, smooth interior, high density polyethylene (HDPE) pipes with a minimum 1-foot cover.

PEAK DISCHARGE

The peak discharges from the ditch design will be used for the culvert design. The peak flows were determined using Autodesk Storm & Sanitary Analysis 2016. The outputs are provided in Attachment 2.

CD-3 Peak Discharge:	50.0	cfs
CD-4 Peak Discharge:	77.0	cfs
CD-5 Peak Discharge:	70.0	cfs
CD-6 Peak Discharge:	80.0	cfs

CULVERT BARREL PIPE HYDRAULIC DESIGN (INLET CONTROL)

The Nomograph Calculator for FHWA HDS 5: Hydraulic Design of Highway Culverts computer program was used to determine the appropriate pipe size for the following culverts (Attachment 1).

	C-1	C-2	C-3	C-4
Peak Discharge (cfs)	25.0	38.5	35.0	40.0
Allowable Headwater Elevation	1060.0	1060.0	1010.0	1010.0
Inlet Invert Elevation	1054.8	1054.8	1004.8	1004.8
Culvert Length (ft)	63	66	75	76
Outlet Invert Elevation	1054.2	1054.1	1004.1	1004.0
Culvert Slope (ft/ft)	0.010	0.011	0.009	0.011
Pipe Diameter (inches)	30	36	36	36
Calculated Headwater, HW (ft)	2.6	3.0	2.8	3.1
Headwater Elevation	1057.4	1057.8	1007.6	1007.9

(Since there are dual pipes conveying the runoff, the peak discharge is divided between both barrels)

D'APPOLONIA

By:	MJD	Date:	06/09/16	Subject:	Northern Tract Quarry	Sheet No.:	2 of 3
Chkd. By:	AMR	Date:	10/19/16		Culvert Hydraulic Design	Proj. No.:	152596A

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CULVERT BARREL PIPE HYDRAULIC DESIGN (OUTLET CONTROL)

The following is a summary of hydraulic calculations concerning culvert outlet control.

	C-1	C-2	C-3	C-4
Peak Discharge (cfs)	25.0	38.5	35.0	40.0
Allowable Headwater Elevation	1060.0	1060.0	1010.0	1010.0
Inlet Invert Elevation	1054.8	1054.8	1004.8	1004.8
Culvert Length (ft)	63	66	75	76
Outlet Invert Elevation	1054.2	1054.1	1004.1	1004.0
Culvert Slope (ft/ft)	0.010	0.011	0.009	0.011
Pipe Diameter, d (feet)	2.5	3.0	3.0	3.0
Tailwater, TW (ft)	4.3	4.3	4.3	4.3
Critical Depth, D_c (ft)	1.7	2.0	1.9	2.1
Culvert Manning's Coefficient, n	0.012	0.012	0.012	0.012
Entrance Loss Coefficient, K_e	0.90	0.90	0.90	0.90
Normal Headlosses, H (ft)	1.0	1.1	0.9	1.2
Estimated Culvert Velocity, V (ft/s)	7.0	7.6	7.3	7.7
Bend Loss Coefficient, K_B	-----	-----	-----	-----
Bend Headlosses, H_B (ft)	-----	-----	-----	-----
Calculated Headwater, HW (ft)	5.3	5.4	5.2	5.5
Headwater Elevation	1059.5	1059.5	1009.3	1009.5

Notes:

1. See Chapter 7 and Appendix B of Reference 5 for an explanation of the hydraulic design of outlet controlled culverts. (HW = [(D_c+d or TW)/2 or TW, whichever is greater] + H + H_B
2. Refer to Attachment 1 for the FHWA Nomograph calculator output for the normal headlosses in the culvert.
3. Assume the culvert outlet inundated with 4.3 feet of tailwater measured from the outlet invert elevation to emergency spillway invert elevation (1058.5/1008.5).

D'APPOLONIA

By:	MJD	Date:	06/09/16	Subject:	Northern Tract Quarry	Sheet No.:	3 of 3
Chkd. By:	AMR	Date:	10/19/16		Culvert Hydraulic Design	Proj. No.:	152596A

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REFERENCES

1) Erosion and Sediment Pollution Control Program Manual, Pennsylvania Department of Environmental Protection - Office of Water Management, 2012.

2) Engineering Manual for Mining Operations, Pennsylvania Department of Environmental Protection - Bureaus of Mining and Reclamation and District Mining Operations, 1999.

3) Engineering and Design Manual - Coal Refuse Disposal Facilities, Mine Safety and Health Administration, May 2009

4) Nomograph Calculator for FHWA HDS 5: Hydraulic Design of Highway Culverts - Beta Version 1.5.B, Grenney, William J., Utah State University.

5) Introduction to Hydraulics and Hydrology with Applications for Stormwater Management, Gribbin, John E., Delmar - A Division of Thomson Learning, 2002.

6) Hydraulic Design Series Number 5: Hydraulic Design of Highway Culverts - Publication No. FHWA-NHI-01-020, U.S. Department of Transportation, Federal Highway Administration, 2001.

ATTACHMENT 1

Nomograph Calculator Output

CULVERT C-1

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- ○ Square Edge with Headwall
- ○ Groove End with Headwall
- ◉ Groove End Projecting

1.703	Calc	Critical Depth (ft)
7.017		Critical Velocity (ft/s)
25		Q = Discharge (cfs)
0.01		Culvert Barrel Slope (ft/ft)
2.5		Culvert diameter (ft)
2.572		Headwater (ft)

Calc

Units: ◉ English ○ Metric

Head for Pipe Culverts Flowing Full

Suggested Mannings n values for:

- ✓ **Chart 5: n = 0.012**
- ✓ **Chart 6: n = 0.024**
- ✓ **Chart 7: n = 0.0328 to 0.0302**

63.1	Length of culvert barrel (ft)
2.5	Culvert diameter (ft)
25	Q = Discharge (cfs)
0.9	Entrance loss coefficient (Ke)
0.012	Mannings (n)
0.965	Head (ft)

Calc

Units: ◉ English ○ Metric

CULVERT C-2

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- ○ Square Edge with Headwall
- ○ Groove End with Headwall
- ◉ Groove End Projecting

2.019	Calc	Critical Depth (ft)
7.608		Critical Velocity (ft/s)
38.5		Q = Discharge (cfs)
0.01		Culvert Barrel Slope (ft/ft)
3		Culvert diameter (ft)
3.037		Headwater (ft)

Calc

Units: ◉ English ○ Metric

Head for Pipe Culverts Flowing Full

Suggested Mannings n values for:

- ✓ **Chart 5: n = 0.012**
- ✓ **Chart 6: n = 0.024**
- ✓ **Chart 7: n = 0.0328 to 0.0302**

65.5	Length of culvert barrel (ft)
3	Culvert diameter (ft)
38.5	Q = Discharge (cfs)
0.9	Entrance loss coefficient (Ke)
0.012	Mannings (n)
1.061	Head (ft)

Calc

Units: ◉ English ○ Metric

CULVERT C-3

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- ○ Square Edge with Headwall
- ○ Groove End with Headwall
- ◉ Groove End Projecting

1.922	Critical Depth (ft)
7.315	Critical Velocity (ft/s)
35	Q = Discharge (cfs)
0.01	Culvert Barrel Slope (ft/ft)
3	Culvert diameter (ft)
2.849	Headwater (ft)

Calc

Units: ◉ English ○ Metric

Head for Pipe Culverts Flowing Full

Suggested Mannings n values for:

- ✓ **Chart 5: n = 0.012**
- ✓ **Chart 6: n = 0.024**
- ✓ **Chart 7: n = 0.0328 to 0.0302**

74.8	Length of culvert barrel (ft)
3	Culvert diameter (ft)
35	Q = Discharge (cfs)
0.9	Entrance loss coefficient (Ke)
0.012	Mannings (n)
0.899	Head (ft)

Calc

Units: ◉ English ○ Metric

CULVERT C-4

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- ○ Square Edge with Headwall
- ○ Groove End with Headwall
- ◉ Groove End Projecting

2.059	Calc	Critical Depth (ft)
7.734		Critical Velocity (ft/s)
40		Q = Discharge (cfs)
0.01		Culvert Barrel Slope (ft/ft)
3		Culvert diameter (ft)
3.117		Headwater (ft)

Calc

Units: ◉ English ○ Metric

Head for Pipe Culverts Flowing Full

Suggested Mannings n values for:

- ✓ **Chart 5: n = 0.012**
- ✓ **Chart 6: n = 0.024**
- ✓ **Chart 7: n = 0.0328 to 0.0302**

76	Length of culvert barrel (ft)
3	Culvert diameter (ft)
40	Q = Discharge (cfs)
0.9	Entrance loss coefficient (Ke)
0.012	Mannings (n)
1.178	Head (ft)

Calc

Units: ◉ English ○ Metric

ATTACHMENT 2

Storm and Sanitary Analysis

Project Description

File Name ..... Northern Tract Ditch Design.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Jan 13, 2016	00:00:00
End Analysis On	Jan 15, 2016	00:00:00
Start Reporting On	Jan 13, 2016	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:01:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	6
Nodes	6
Junctions	0
Outfalls	6
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	Rain Gage-01	Time Series	100-year	Cumulative	inches	Pennsylvania	Adams	100	8.03	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	CD-1	11.33	86.00	8.03	6.36	72.06	97.17	0 00:09:09
2	CD-2	33.97	86.00	8.03	6.36	216.05	272.28	0 00:12:09
3	CD-3	4.50	86.00	8.03	6.36	28.62	43.21	0 00:05:00
4	CD-4	7.92	86.00	8.03	6.36	50.37	75.82	0 00:05:09
5	CD-5	6.85	86.00	8.03	6.36	43.57	65.76	0 00:05:00
6	CD-6	8.43	86.00	8.03	6.36	53.61	80.21	0 00:05:21

Subbasin Hydrology

Subbasin : CD-1

Input Data

Area (ac) 11.33
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	11.33	-	86.00
Composite Area & Weighted CN	11.33		86.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	11.2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.41	0.00	0.00
Computed Flow Time (min) :	4.08	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	706	0.00	0.00
Slope (%) :	9.3	0.00	0.00
Surface Type :	Bare & untilled	Unpaved	Unpaved
Velocity (ft/sec) :	3.05	0.00	0.00
Computed Flow Time (min) :	3.86	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	435	0.00	0.00
Channel Slope (%) :	2.0	0.00	0.00
Cross Section Area (ft²) :	11.3	0.00	0.00
Wetted Perimeter (ft) :	11.4	0.00	0.00
Velocity (ft/sec) :	5.99	0.00	0.00
Computed Flow Time (min) :	1.21	0.00	0.00

Total TOC (min) 9.15

Subbasin Runoff Results

Total Rainfall (in)	8.03
Total Runoff (in)	6.36
Peak Runoff (cfs)	97.17
Weighted Curve Number	86.00
Time of Concentration (days hh:mm:ss)	0 00:09:09

Subbasin : CD-2

Input Data

Area (ac) 33.97
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	33.97	-	86.00
Composite Area & Weighted CN	33.97		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	8.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.36	0.00	0.00
Computed Flow Time (min) :	4.65	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	795	0.00	0.00
Slope (%) :	12.0	0.00	0.00
Surface Type :	Bare & untilled	Unpaved	Unpaved
Velocity (ft/sec) :	3.46	0.00	0.00
Computed Flow Time (min) :	3.83	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	1523	0.00	0.00
Channel Slope (%) :	2.0	0.00	0.00
Cross Section Area (ft²) :	16.6	0.00	0.00
Wetted Perimeter (ft) :	13.5	0.00	0.00
Velocity (ft/sec) :	6.91	0.00	0.00
Computed Flow Time (min) :	3.67	0.00	0.00

Total TOC (min) 12.15

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 272.28
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:12:09

Subbasin : CD-3

Input Data

Area (ac) 4.50
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	4.50	-	86.00
Composite Area & Weighted CN	4.50		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	23.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.55	0.00	0.00
Computed Flow Time (min) :	3.06	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	26	0.00	0.00
Slope (%) :	48	0.00	0.00
Surface Type :	Bare & untilled	Unpaved	Unpaved
Velocity (ft/sec) :	6.93	0.00	0.00
Computed Flow Time (min) :	0.06	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	1090	0.00	0.00
Channel Slope (%) :	10	0.00	0.00
Cross Section Area (ft²) :	5.1	0.00	0.00
Wetted Perimeter (ft) :	7.5	0.00	0.00
Velocity (ft/sec) :	10.41	0.00	0.00
Computed Flow Time (min) :	1.75	0.00	0.00

Total TOC (min) 4.86

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 43.21
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:04:52

Subbasin : CD-4

Input Data

Area (ac) 7.92
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	7.92	-	86.00
Composite Area & Weighted CN	7.92		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	23.4	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.55	0.00	0.00
Computed Flow Time (min) :	3.04	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	230	0.00	0.00
Slope (%) :	28.7	0.00	0.00
Surface Type :	Bare & untilled	Unpaved	Unpaved
Velocity (ft/sec) :	5.36	0.00	0.00
Computed Flow Time (min) :	0.72	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	515	0.00	0.00
Channel Slope (%) :	2	0.00	0.00
Cross Section Area (ft²) :	12.2	0.00	0.00
Wetted Perimeter (ft) :	11.8	0.00	0.00
Velocity (ft/sec) :	6.16	0.00	0.00
Computed Flow Time (min) :	1.39	0.00	0.00

Total TOC (min) 5.15

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 75.82
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:05:09

Subbasin : CD-5

Input Data

Area (ac) 6.85
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	6.85	-	86.00
Composite Area & Weighted CN	6.85		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	37	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.66	0.00	0.00
Computed Flow Time (min) :	2.53	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	50	0.00	0.00
Surface Type :	Bare & untilled	Unpaved	Unpaved
Velocity (ft/sec) :	7.07	0.00	0.00
Computed Flow Time (min) :	0.24	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	0.00	0.00
Flow Length (ft) :	745	0.00	0.00
Channel Slope (%) :	2.5	0.00	0.00
Cross Section Area (ft²) :	11.3	0.00	0.00
Wetted Perimeter (ft) :	11.4	0.00	0.00
Velocity (ft/sec) :	6.69	0.00	0.00
Computed Flow Time (min) :	1.86	0.00	0.00

Total TOC (min) 4.62

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 65.76
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:04:37

Subbasin : CD-6

Input Data

Area (ac) 8.43
Weighted Curve Number 86.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	8.43	-	86.00
Composite Area & Weighted CN	8.43		86.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.12	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	26.1	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.25	0.00	0.00
Velocity (ft/sec) :	0.57	0.00	0.00
Computed Flow Time (min) :	2.91	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	58	0.00	0.00
Slope (%) :	34.1	0.00	0.00
Surface Type :	Bare & untilled	re & untill	Unpaved
Velocity (ft/sec) :	5.84	0.00	0.00
Computed Flow Time (min) :	0.17	0.00	0.00

Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.035	.035	.035
Flow Length (ft) :	784	295	53
Channel Slope (%) :	3	10	6
Cross Section Area (ft²) :	10.8	6.9	8.4
Wetted Perimeter (ft) :	10.7	8.8	9.5
Velocity (ft/sec) :	7.42	11.45	9.61
Computed Flow Time (min) :	1.76	0.43	0.09

Total TOC (min) 5.36

Subbasin Runoff Results

Total Rainfall (in) 8.03
Total Runoff (in) 6.36
Peak Runoff (cfs) 80.21
Weighted Curve Number 86.00
Time of Concentration (days hh:mm:ss) 0 00:05:22

SECTION F

CULVERT - STRUCTURAL DESIGN

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	1 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

PHASE 2 & 3 CULVERT STRUCTURAL DESIGN
NORTHERN TRACT QUARRY
CHARMAIN SITE, SPECIALTY GRANULES, LLC.
ADAMS COUNTY, PENNSYLVANIA

PURPOSE

The following calculations were performed to determine the cover thickness for the proposed pipe culverts for the culverts of the Phase 2 and Phase 3 Initial Site Development for the Northern Tract Quarry. The culverts are a set of two 30-inch or 36-inch diameter, dual-wall corrugated polyethylene pipes (CPEP).

The culverts are designed to experience live loading from a Caterpillar 740 Articulated Dump Truck (Refer to Attachment #1 for truck specifications). Due to the relatively shallow burial of all the pipes, the live load for the most shallow cover depths dictates the pipe design. The live load distribution and pressure with depth for the CAT 740 were determined in accordance with the American Association of State Highway Transporation Officials (AASHTO) Bridge Design Specifications based on the fully loaded specifications and Advanced Drainage Systems, Inc. (ADS) Drainage Handbook.

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	2 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Culvert C-1

Proposed Culvert Inside Diameter	30	in
Culvert Length	63	ft
Minimum Cover in Road Area	2	ft

Culvert Type: Corrugated, Dual-walled Polyethylene Pipe
Design Vehicular Traffic: CAT 740, 40-Ton Articulated Dumptruck

STRUCTURAL ANALYSIS

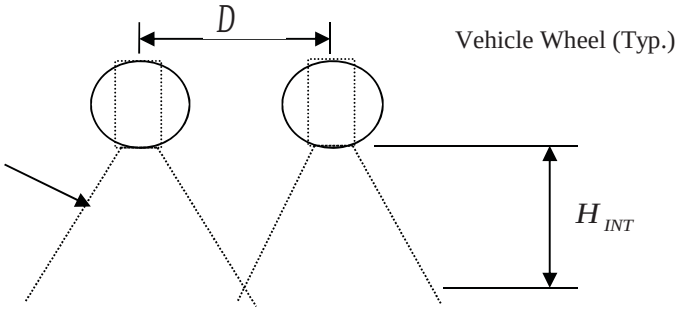
The culvert will be designed using methods prescribed in the Advanced Drainage Systems, Inc. (ADS) Drainage Handbook (Reference 1) and the American Association of State Highway and Transportation Officials (AASHTO) Load Resistance and Factor Design (LRFD) Bridge Specifications with 2015 Interim Revisions (Reference 2).

Design Case	CAT 740 Articulated Truck	
Loading Conditions	Short Term	
Minimum Cover	2.0	ft

Live Load Determination

Dimensions of the design vehicle are presented in Attachment #1. The design live load for the culvert is calculated below:

Depth of Wheel Load Interaction:



H_{INT} = depth of wheel load interaction = (D - L_T)/LLFD where,

D = minimum distance between wheels =	8.8	ft	(Front Wheel Set - Front Right to Front Left)
D = minimum distance between wheels =	6.4	ft	(Rear Wheel Set - Center Axle to Rear Axle)
LLFD = live load distribution factor =	1.15		(Per AASHTO 3.6.1.2.6)

Tire Contact Area (29.5R25 OTR Tire)

Consider a single wheel,

Gross Contact Area, A_T =	505	in^2	(Refer to Attachment #1)
Loaded Tire Width, W_T =	34.6	in	
Tire Length, L_T =	14.6	in	($L_T = A_T/W_T$)

H_{INT} (Front Wheel Set) =	6.6	ft
H_{INT} (Rear Wheel Set) =	4.5	ft

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	3 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Distribution of Wheel Loads to Culvert (AASHTO 3.6.1.2.6):

D_E = minimum depth of cover above the culvert
Distributed Length of Loaded Area, $L_D = [L_T + D_E (LLFD)]$
Distributed Width of Loaded Area, $W_D = [W_T + D_E (LLFD)]$ if $D_E \leq H_{INT}$ or $W_D = W_T + D + D_E(1.15)$ if $D_E > H_{INT}$
Distributed Loaded Area, $A_D = L_D \times W_D$

Design Live Load (AASHTO 3.6.1.3.1):

Design Wheel Load, P = m*(1+(IM/100))*p where,

Multiple Presence Factor, m = 1.2 (Based upon anticipated traffic conditions - AASHTO 3.6.1.1.2-1)
Impact Factor, IM = 33 (1.0 - 0.125D_E) ≥ 0% (AASHTO 3.6.2.2-1)
p = Wheel Load

Consider Front Wheel Set:

Front Axle Loaded Weight= 54,234 lb (Refer to Attachment #1)

		Distributed Tire Contact Area					
p (lb)	D_E (ft)	L_D (ft)	W_D (ft)	A_D (ft^2)	IM (%)	P (lb)	P/A_D (psi)
27,117	0.0	1.2	2.9	3.5	33	43,279	85.70
27,117	1.0	2.4	4.0	9.5	29	41,936	30.51
27,117	2.0	3.5	5.2	18.2	25	40,594	15.47
27,117	3.0	4.7	6.3	29.6	21	39,252	9.22
27,117	4.0	5.8	7.5	43.5	17	37,910	6.05

*Front wheels do not interact at the depths considered

Consider Rear Wheel Set:

Rear Axle Loaded Weight= 53,683 lb (Refer to Attachment #1)

		Distributed Tire Contact Area					
p (lb)	D_E (ft)	L_D (ft)	W_D (ft)	A_D (ft^2)	IM (%)	P (lb)	P/A_D (psi)
26,842	0.0	1.2	2.9	3.5	33	42,839	84.83
26,842	1.0	2.4	4.0	9.5	29	41,510	30.20
26,842	2.0	3.5	5.2	18.2	25	40,182	15.31
26,842	3.0	4.7	6.3	29.6	21	38,853	9.13
26,842	4.0	5.8	7.5	43.5	17	37,524	5.99

*Rear wheels do not interact at the depths considered

Therefore, the front wheel set loads will control the culvert design.

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	4 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Dead Load Determination

P_{sp} = geostatic load = $[\gamma_s(H + 0.11OD/12)]/144$ where,

H = burial depth

γs = unit weight of soil

OD = outside diameter of pipe culvert (See Table 2-1)

VAF = vertical arching factor = $0.76-0.71[(S_h-1.17)/(S_h+2.92)]$ where,

S_h = hoop stiffness factor = $\Phi_s M_s R/(EA)$ where,

Φ_s = capacity modification factor for soil = 0.9

M_s = secant constrained modulus of soil (See Tables 2-7)

R = effective radius of pipe = ID/2+c where,

ID = inside diameter of pipe

c = distance from ID to neutral axis of pipe (See Table 2-1)

E = modulus of elasticity of polyethylene (Table 2-5)

110,000 psi for short term conditions

22,000 psi for long term conditions

A = section area (See Table 2-1)

$W_{sp} = P_{sp}(VAF)$

$P_w = \gamma_w H_g/144$ where,

γ_w = unit weight of water = 62.4 pcf

H_g = height of groundwater above pipe

Design Case	Truck Load, Min Cover
Design Conditions	Short Term
H (ft)	2.0
γ_s (pcf)	125
OD (in)	35.1
P_{sp} (psi)	2.015
ID (in)	30
c (in)	0.891
R (in)	15.891
M_s (psi)	2607
E (psi)	110,000
A (in^2/in)	0.371
S_h	0.914
VAF	0.807
W_{sp} (psi)	**1.627**
H_g (ft)	0.0
P_w (psi)	**0.000**

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	5 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Calculated Wall Thrust

T_L = Calculated Wall Thrust = $[n_{EV}(\gamma_{EV}W_{sp}+1.3\gamma_{WA}P_w)+n_{LL}\gamma_{LL}P_lC_l](OD/2)$ where,

W_{sp} = soil arch load

n_{EV} = load modifier for earth fill (See Table 2-13)

γ_{EV} = load factor for vertical earth pressure (See Table 2-11)

γ_{WA} = load factor for water load (See Table 2-11)

n_{LL} = load modifier for live load (See Table 2-13)

γ_{LL} = load factor for live load (See Table 2-11)

P_l = live load transferred to pipe

C_l = live load distribution coefficient =$Lw/OD \leq 1.0$ where,

L_w = live load distribution width at the pipe crown (See Table 2-10)

OD = outside diameter of pipe (See Table 2-1)

P_w = hydrostatic pressure at the springline of the pipe

	Strength Limit 1	Strength Limit II	Service Limit 1
W_{sp} (psi)	1.627	1.627	1.627
n_{EV}	1.05	1.05	1.05
γ_{EV}	1.95	1.95	1
γ_{WA}	1	1	1
n_{LL}	1	1	1
γ_{LL}	1.75	1.35	1
P_l (psi)	15.467	15.467	15.467
C_l	1	1	1
L_w (in)	57.1	57.1	57.1
OD (in)	35.1	35.1	35.1
P_w (psi)	0.000	0.000	0.000
T_L (lb/in)	**534**	**425**	**301**

Tensile Resistance to Wall Thrust

T_{cr} (tension) = tensile resistance to thrust = $(F_y)(A)(\Phi_p)$ where,

F_y = tensile strength of polyethylene = (Table 2-5)

3,000 psi for short term conditions

900 psi for long term conditions

A = section area (See Table 2-1)

Φ_p = capacity modification factor for pipe = 1.0

Design Case	Truck Load, Min Cover
Design Conditions	Short Term
F_y (psi)	3,000
A (in^2/in)	0.371
T_{cr} (tension) (lb/in)	**1,113**

> Calculated Wall Thrust OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	6 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Compressive Resistance to Wall Thrust

T_{cr} (compression) = compressive resistance to thrust = $(F_y)(A_{eff})(\Phi_p)$ where,

A_{eff} = effective wall area = A_s - [$\sum(1-p_i)w_i t_i/w$] where,

A_s = wall area (See Table 2-1)

w_i =length of each individual profile element

t_i = thickness of each individual profile element

w = profile pitch (Table 2-11)

p_i = effective width factor = $(1-0.22/\lambda)/\lambda \leq 1$ where,

λ = slenderness factor = $w_i/t_i(\varepsilon/k)^{0.5} > 0.673$

w_i = length of each individual profile element

t_i = thickness of each individual profile element

k = edge support coefficient = 4.0

ε = strain in element

	Element	Crest	Web	Valley	Liner
	t_i (in)	0.127	0.165	0.257	0.110
	w_i (in)	1.345	2.046	0.844	2.850
Strength Limit 1	λ	0.673	0.709	0.673	1.481
	p_i	1.000	0.973	1.000	0.575
	$(1-p_i)w_i t_i$	0.000	0.009	0.000	0.133
Strength Limit II	λ	0.673	0.673	0.673	1.322
	p_i	1.000	1.000	1.000	0.631
	$(1-p_i)w_i t_i$	0.000	0.000	0.000	0.116
Service Limit 1	λ	0.673	0.673	0.673	1.113
	p_i	1.000	1.000	1.000	0.721
	$(1-p_i)w_i t_i$	0.000	0.000	0.000	0.088

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit 1	Strength Limit II	Service Limit 1
w (in)	4.02	4.02	4.02
T_L (lb/in)	533.5	424.9	301.4
A_s (in^2/in)	0.371	0.371	0.371
E (psi)	110,000	110,000	110,000
ε (in/in)	0.013	0.010	0.007
A_{eff} (in^2/in)	0.336	0.342	0.349
F_y (psi)	3,000	3,000	3,000
T_{cr} (comp.) (lb/in)	**1,007**	**1,027**	**1,048**

Tcr > Calculated Wall Thrust OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	7 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Critical Buckling Stress

f_{CR} = critical buckling stress = $9.24\ (R/A_{eff})[(B'R_w\Phi_sM_sEI)/0.149R^3]^{0.5}$ where,

M_s = secant constrained soil modulus

R = effective radius of pipe = ID/2 + c where,

ID = inside diameter of pipe

c = distance from inside diameter to neutral axis

E = modulus of elasticity of polyethylene

110,000 psi for short term conditions

22,000 psi for long term conditions

A_{eff} = effective area

I = moment of inertia (See Table 2-1)

R_w = water buoyancy factor = $1 - 0.33h_g/H$ where,

h_g = height of groundwater above pipe crown

H = burial depth

Φs = resistance factor for soil stiffness (See Table 2-9)

B' = nonuniform stress distribution factor = $1/(1 + 4e^{-0.065H})$

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit 1	Strength Limit II	Service Limit 1
M_s (psi)	2,607	2,607	2,607
ID (in)	30	30	30
c (in)	0.891	0.891	0.891
R (in)	15.891	15.891	15.891
E (psi)	110,000	110,000	110,000
A_{eff} (in^2/in)	0.336	0.342	0.349
I (in^4/in)	0.276	0.276	0.276
h_g (ft)	0.0	0.0	0.0
H (ft)	2.0	2.0	2.0
R_w	1.000	1.000	1.000
Φs	0.9	0.9	0.9
B'	0.222	0.222	0.222
f_{CR} (psi)	**71,103**	**69,727**	**68,324**

fcr > Fy Use Fy for compressive resistance to thrust calculation

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	8 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Bending Strain

Δ = deflection of pipe = $\Delta_c D_m - (T_L D_m)/(A_{eff} E \gamma_p)$ where,

T_L = factored wall thrust

Δc = deflection of pipe induced by construction = 0.05 in/in

γ_p =load factor for vertical earth pressure

A_{eff} = effective area

E = long term modulus of elasticity = 22,000 psi

D_m = mean pipe diameter = ID + 2c where,

ID = inside diameter of pipe

c = distance from inside diameter to neutral axis

	Strength Limit 1	Strength Limit II	Service Limit 1
T_L	534	425	301
γ_p	0.9	0.9	1.0
A_{eff} (in^2/in)	0.336	0.342	0.349
ID (in)	30	30	30
c (in)	0.891	0.891	0.891
D_m (in)	31.782	31.782	31.782
Δ (in)	**-0.963**	**-0.404**	**0.342**

ε_{bu} = factored bending strain = $\gamma_B D_f (c/R)(\Delta/D_m)$ where,

D_f = shape factor (See Table 2-5) = 4.4

Δ = deflection

γ_B = load factor for combined strain = 1.5

R = effective radius of pipe = ID/2 + c where,

ID = inside diameter of pipe

c = distance from inside diameter to neutral axis

D_m = mean pipe diameter = ID + 2c where,

	Strength Limit 1	Strength Limit II	Service Limit 1
Δ (in)	-0.963	-0.404	0.342
R (in)	15.891	15.891	15.891
ID (in)	30	30	30
c (in)	0.891	0.891	0.891
D_m (in)	31.782	31.782	31.782
εbu (in/in)	**-0.011**	**-0.005**	**0.004**

Bending strain is less than 5%. OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	9 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

Combined Strain

ε_{cu} = factored compressive strain = $\varepsilon_{bu} + (T_L/A_{eff}E)(\gamma_B/\gamma_p)$ where,

ε_{bu} = factored bending strain

T_L = factored wall thrust

γ_p = load factor for vertical earth pressure

γ_B = load factor for combined strain = 1.5

A_{eff} = effective wall area

E = modulus of elasticity of polyethylene

110,000 psi for short term conditions

22,000 psi for long term conditions

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit I	Strength Limit II	Service Limit 1
ε_{bu} (in/in)	-0.011	-0.005	0.004
T_L (lb/in)	534	425	301
γ_p	0.9	0.9	1.0
γ_B	1.5	1.5	1.5
A_{eff} (in^2/in)	0.336	0.342	0.349
E (psi)	110,000	110,000	110,000
ε_{cu} (in/in)	**0.013**	**0.014**	**0.016**

ε_{cl} = limiting combined compressive strain = $1.5F_y/E$ where,

F_y = tensile strength of polyethylene = 900 psi for long term conditions

E = long term modulus of elasticity = 22,000 psi

ε_{cl} = 0.061 in/in

Factored compressive strain is less than the limiting combined compressive strain. OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	10 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-1

ε_{tu} = factored combined tension strain = $\varepsilon_{bu} - (T_L/A_{eff}E)(\gamma_B/\gamma_p)$ where,

ε_{bu} = factored bending strain

T_L = factored wall thrust

γ_p = load factor for vertical earth pressure

γ_B = load factor for combined strain = 1.5

A_{eff} = effective area

E = modulus of elasticity of polyethylene

110,000 psi for short term conditions

22,000 psi for long term conditions

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit I	Strength Limit II	Service Limit 1
ε_{bu} (in/in)	-0.011	-0.005	0.004
$T_{L\ (lb/in)}$	534	425	301
γ_p	0.9	0.9	1.0
γ_B	1.5	1.5	1.5
A_{eff} (in^2/in)	0.336	0.342	0.349
E (psi)	110,000	110,000	110,000
$\varepsilon_{tu\ (in/in)}$	**-0.035**	**-0.024**	**-0.008**

ε_{tl} = limiting combined tension strain = $\gamma_B * \varepsilon_t$ where,

γ_B = load factor for combined strain = 1.5

ε_t = allowable tension strain = 0.05 in/in

ε_{tl} = 0.075 in/in

Factored tension strain is less than the limiting combined tension strain. OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	11 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Culverts C-2, C-3, and C-4

Proposed Culvert Inside Diameter	36	in
Culvert Length	62	ft
Minimum Cover in Road Area	2	ft

Culvert Type: Corrugated, Dual-walled Polyethylene Pipe
Design Vehicular Traffic: CAT 740, 40-Ton Articulated Dumptruck

STRUCTURAL ANALYSIS

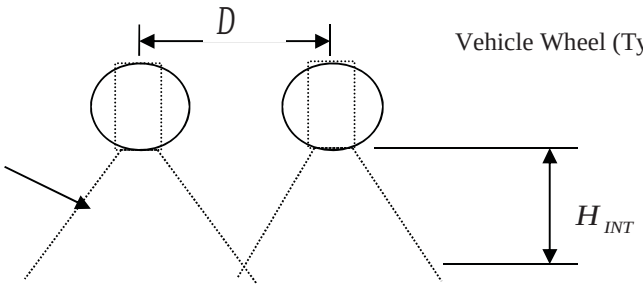
The culvert will be designed using methods prescribed in the Advanced Drainage Systems, Inc. (ADS) Drainage Handbook (Reference 1) and the American Association of State Highway and Transportation Officials (AASHTO) Load Resistance and Factor Design (LRFD) Bridge Specifications with 2015 Interim Revisions (Reference 2).

Design Case	CAT 740 Articulated Truck	
Loading Conditions	Short Term	
Minimum Cover	2.0	ft

Live Load Determination

Dimensions of the design vehicle are presented in Attachment #1. The design live load for the culvert is calculated below:

Depth of Wheel Load Interaction:



H_{INT} = depth of wheel load interaction = (D - L_T)/LLFD where,

D = minimum distance between wheels =	8.8	ft (Front Wheel Set - Front Right to Front Left)
D = minimum distance between wheels =	6.4	ft (Rear Wheel Set - Center Axle to Rear Axle)
LLFD = live load distribution factor =	1.15	(Per AASHTO 3.6.1.2.6)

Tire Contact Area (29.5R25 OTR Tire)

Consider a single wheel,

Gross Contact Area, A_T =	505	in^2	(Refer to Attachment #1)
Loaded Tire Width, W_T =	34.6	in	
Tire Length, L_T =	14.6	in	($L_T = A_T/W_T$)

H_{INT} (Front Wheel Set) =	6.6	ft
H_{INT} (Rear Wheel Set) =	4.5	ft

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	12 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Distribution of Wheel Loads to Culvert (AASHTO 3.6.1.2.6):

D_E = minimum depth of cover above the culvert
Distributed Length of Loaded Area, $L_D = [L_T + D_E (LLFD)]$
Distributed Width of Loaded Area, $W_D = [W_T + D_E (LLFD)]$ if $D_E \leq H_{INT}$ or $W_D = W_T + D + D_E(1.15)$ if $D_E > H_{INT}$
Distributed Loaded Area, $A_D = L_D \times W_D$

Design Live Load (AASHTO 3.6.1.3.1):

Design Wheel Load, $P = m*(1+(IM/100))*p$ where,

Multiple Presence Factor, m = 1.2 (Based upon anticipated traffic conditions - AASHTO 3.6.1.1.2-1)
Impact Factor, $IM = 33 (1.0 - 0.125D_E) \geq 0\%$ (AASHTO 3.6.2.2-1)
p = Wheel Load

Consider Front Wheel Set:

Front Axle Loaded Weight= 54,234 lb (Refer to Attachment #1)

p (lb)	D_E (ft)	Distributed Tire Contact Area			IM (%)	P (lb)	P/A_D (psi)
		L_D (ft)	W_D (ft)	A_D (ft^2)			
27,117	0.0	1.2	2.9	3.5	33	43,279	85.70
27,117	1.0	2.4	4.0	9.5	29	41,936	30.51
27,117	2.0	3.5	5.2	18.2	25	40,594	15.47
27,117	3.0	4.7	6.3	29.6	21	39,252	9.22
27,117	4.0	5.8	7.5	43.5	17	37,910	6.05

*Front wheels do not interact at the depths considered

Consider Rear Wheel Set:

Rear Axle Loaded Weight= 53,683 lb (Refer to Attachment #1)

p (lb)	D_E (ft)	Distributed Tire Contact Area			IM (%)	P (lb)	P/A_D (psi)
		L_D (ft)	W_D (ft)	A_D (ft^2)			
26,842	0.0	1.2	2.9	3.5	33	42,839	84.83
26,842	1.0	2.4	4.0	9.5	29	41,510	30.20
26,842	2.0	3.5	5.2	18.2	25	40,182	15.31
26,842	3.0	4.7	6.3	29.6	21	38,853	9.13
26,842	4.0	5.8	7.5	43.5	17	37,524	5.99

*Rear wheels do not interact at the depths considered

Therefore, the front wheel set loads will control the culvert design.

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	13 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Dead Load Determination

P_{sp} = geostatic load = $[\gamma_s(H + 0.11OD/12)]/144$ where,

H = burial depth

γs = unit weight of soil

OD = outside diameter of pipe culvert (See Table 2-1)

VAF = vertical arching factor = $0.76-0.71[(S_h-1.17)/(S_h+2.92)]$ where,

S_h = hoop stiffness factor = $\Phi_s M_s R/(EA)$ where,

Φ_s = capacity modification factor for soil = 0.9

M_s = secant constrained modulus of soil (See Tables 2-7)

R = effective radius of pipe = ID/2+c where,

ID = inside diameter of pipe

c = distance from ID to neutral axis of pipe (See Table 2-1)

E = modulus of elasticity of polyethylene (Table 2-5)

110,000 psi for short term conditions

22,000 psi for long term conditions

A = section area (See Table 2-1)

$W_{sp} = P_{sp}(VAF)$

$P_w = \gamma_w H_g/144$ where,

γ_w = unit weight of water = 62.4 pcf

H_g = height of groundwater above pipe

Design Case	Truck Load, Min Cover
Design Conditions	Short Term
H (ft)	2.0
γ_s (pcf)	125
OD (in)	41.1
P_{sp} (psi)	2.063
ID (in)	36
c (in)	1.069
R (in)	19.069
M_s (psi)	2620
E (psi)	110,000
A (in^2/in)	0.403
S_h	1.014
VAF	0.788
W_{sp} (psi)	**1.626**
H_g (ft)	0.0
P_w (psi)	**0.000**

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	14 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Calculated Wall Thrust

T_L = Calculated Wall Thrust = $[n_{EV}(\gamma_{EV}W_{sp}+1.3\gamma_{WA}P_w)+n_{LL}\gamma_{LL}P_lC_l](OD/2)$ where,

W_{sp} = soil arch load

n_{EV} = load modifier for earth fill (See Table 2-13)

γ_{EV} = load factor for vertical earth pressure (See Table 2-11)

γ_{WA} = load factor for water load (See Table 2-11)

n_{LL} = load modifier for live load (See Table 2-13)

γ_{LL} = load factor for live load (See Table 2-11)

P_l = live load transferred to pipe

C_l = live load distribution coefficient $=Lw/OD \leq 1.0$ where,

L_w = live load distribution width at the pipe crown (See Table 2-10)

OD = outside diameter of pipe (See Table 2-1)

P_w = hydrostatic pressure at the springline of the pipe

	Strength Limit 1	Strength Limit II	Service Limit 1
W_{sp} (psi)	1.626	1.626	1.626
n_{EV}	1.05	1.05	1.05
γ_{EV}	1.95	1.95	1
γ_{WA}	1	1	1
n_{LL}	1	1	1
γ_{LL}	1.75	1.35	1
P_l (psi)	15.467	15.467	15.467
C_l	1	1	1
L_w (in)	50.6	50.6	50.6
OD (in)	41.1	41.1	41.1
P_w (psi)	0.000	0.000	0.000
T_L (lb/in)	**625**	**498**	**353**

Tensile Resistance to Wall Thrust

T_{cr} (tension) = tensile resistance to thrust = $(F_y)(A)(\Phi_p)$ where,

F_y = tensile strength of polyethylene = (Table 2-5)

3,000 psi for short term conditions

900 psi for long term conditions

A = section area (See Table 2-1)

Φ_p = capacity modification factor for pipe = 1.0

Design Case	Truck Load, Min Cover
Design Conditions	Short Term
F_y (psi)	3,000
A (in^2/in)	0.403
T_{cr} (tension) (lb/in)	**1,209**

> Calculated Wall Thrust OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	15 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Compressive Resistance to Wall Thrust

T_{cr} (compression) = compressive resistance to thrust = $(F_y)(A_{eff})(\Phi_p)$ where,

A_{eff} = effective wall area = A_s - [$\sum(1-p_i)w_it_i/w$] where,

A_s = wall area (See Table 2-1)

w_i =length of each individual profile element

t_i = thickness of each individual profile element

w = profile pitch (Table 2-11)

p_i = effective width factor = $(1-0.22/\lambda)/\lambda \leq 1$ where,

λ = slenderness factor = $w_i/t_i(\varepsilon/k)^{0.5} > 0.673$

w_i = length of each individual profile element

t_i = thickness of each individual profile element

k = edge support coefficient = 4.0

ε = strain in element

	Element	Crest	Web	Valley	Liner
	t_i (in)	0.127	0.165	0.257	0.110
	w_i (in)	1.345	2.046	0.844	2.850
Strength Limit 1	λ	0.673	0.736	0.673	1.538
	p_i	1.000	0.953	1.000	0.557
	$(1-p_i)w_it_i$	0.000	0.016	0.000	0.139
Strength Limit II	λ	0.673	0.673	0.673	1.372
	p_i	1.000	1.000	1.000	0.612
	$(1-p_i)w_it_i$	0.000	0.000	0.000	0.122
Service Limit 1	λ	0.673	0.673	0.673	1.156
	p_i	1.000	1.000	1.000	0.700
	$(1-p_i)w_it_i$	0.000	0.000	0.000	0.094

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit 1	Strength Limit II	Service Limit 1
w (in)	4.02	4.02	4.02
T_L (lb/in)	624.6	497.5	352.9
A_s (in^2/in)	0.403	0.403	0.403
E (psi)	110,000	110,000	110,000
ε (in/in)	0.014	0.011	0.008
A_{eff} (in^2/in)	0.364	0.373	0.380
F_y (psi)	3,000	3,000	3,000
T_{cr} (comp.) (lb/in)	**1,093**	**1,118**	**1,139**

Tcr > Calculated Wall Thrust OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	16 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Critical Buckling Stress

f_{CR} = critical buckling stress = $9.24\ (R/A_{eff})[(B'R_w\Phi_sM_sEI)/0.149R^3]^{0.5}$ where,

M_s = secant constrained soil modulus

R = effective radius of pipe = ID/2 + c where,

ID = inside diameter of pipe

c = distance from inside diameter to neutral axis

E = modulus of elasticity of polyethylene

110,000 psi for short term conditions

22,000 psi for long term conditions

A_{eff} = effective area

I = moment of inertia (See Table 2-1)

R_w = water buoyancy factor = $1 - 0.33h_g/H$ where,

h_g = height of groundwater above pipe crown

H = burial depth

Φs = resistance factor for soil stiffness (See Table 2-9)

B' = nonuniform stress distribution factor = $1/(1 + 4e^{-0.065H})$

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit 1	Strength Limit II	Service Limit 1
M_s (psi)	2,620	2,620	2,620
ID (in)	36	36	36
c (in)	1.069	1.069	1.069
R (in)	19.069	19.069	19.069
E (psi)	110,000	110,000	110,000
A_{eff} (in^2/in)	0.364	0.373	0.380
I (in^4/in)	0.319	0.319	0.319
h_g (ft)	0.0	0.0	0.0
H (ft)	2.0	2.0	2.0
R_w	1.000	1.000	1.000
Φs	0.9	0.9	0.9
B'	0.222	0.222	0.222
f_{CR} (psi)	**64,399**	**62,976**	**61,829**

fcr > Fy Use Fy for compressive resistance to thrust calculation

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	17 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Bending Strain

Δ = deflection of pipe = $\Delta_c D_m - (T_L D_m)/(A_{eff} E \gamma_p)$ where,

T_L = factored wall thrust

Δc = deflection of pipe induced by construction = 0.05 in/in

γ_p =load factor for vertical earth pressure

A_{eff} = effective area

E = long term modulus of elasticity = 22,000 psi

D_m = mean pipe diameter = ID + 2c where,

ID = inside diameter of pipe

c = distance from inside diameter to neutral axis

	Strength Limit 1	Strength Limit II	Service Limit 1
T_L	625	498	353
γ_p	0.9	0.9	1.0
A_{eff} (in^2/in)	0.364	0.373	0.380
ID (in)	36	36	36
c (in)	1.069	1.069	1.069
D_m (in)	38.138	38.138	38.138
Δ (in)	**-1.394**	**-0.664**	**0.295**

ε_{bu} = factored bending strain = $\gamma_B D_f (c/R)(\Delta/D_m)$ where,

D_f = shape factor (See Table 2-5) = 4.4

Δ = deflection

γ_B = load factor for combined strain = 1.5

R = effective radius of pipe = ID/2 + c where,

ID = inside diameter of pipe

c = distance from inside diameter to neutral axis

D_m = mean pipe diameter = ID + 2c where,

	Strength Limit 1	Strength Limit II	Service Limit 1
Δ (in)	-1.394	-0.664	0.295
R (in)	19.069	19.069	19.069
ID (in)	36	36	36
c (in)	1.069	1.069	1.069
D_m (in)	38.138	38.138	38.138
εbu (in/in)	**-0.014**	**-0.006**	**0.003**

Bending strain is less than 5%. OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	18 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

Combined Strain

ε_{cu} = factored compressive strain = $\varepsilon_{bu} + (T_L/A_{eff}E)(\gamma_B/\gamma_p)$ where,

ε_{bu} = factored bending strain

T_L = factored wall thrust

γ_p = load factor for vertical earth pressure

γ_B = load factor for combined strain = 1.5

A_{eff} = effective wall area

E = modulus of elasticity of polyethylene

110,000 psi for short term conditions

22,000 psi for long term conditions

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit I	Strength Limit II	Service Limit 1
ε_{bu} (in/in)	-0.014	-0.006	0.003
T_L (lb/in)	625	498	353
γ_p	0.9	0.9	1.0
γ_B	1.5	1.5	1.5
A_{eff} (in^2/in)	0.364	0.373	0.380
E (psi)	110,000	110,000	110,000
ε_{cu} (in/in)	**0.012**	**0.014**	**0.016**

ε_{cl} = limiting combined compressive strain = $1.5F_y/E$ where,

F_y = tensile strength of polyethylene = 900 psi for long term conditions

E = long term modulus of elasticity = 22,000 psi

ε_{cl} = 0.061 in/in

Factored compressive strain is less than the limiting combined compressive strain. OK

D'APPOLONIA

By	AMR	Date	10/21/2016	Subject	Northern Tract Quarry	Sheet No.	19 of 20
Chkd. By	MJD	Date	10/26/2016		Culvert Structural Design	Proj. No.	152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]C-2, C-3, C-4

ε_{tu} = factored combined tension strain = $\varepsilon_{bu} - (T_L/A_{eff}E)(\gamma_B/\gamma_p)$ where,

ε_{bu} = factored bending strain

T_L = factored wall thrust

γ_p = load factor for vertical earth pressure

γ_B = load factor for combined strain = 1.5

A_{eff} = effective area

E = modulus of elasticity of polyethylene

110,000 psi for short term conditions

22,000 psi for long term conditions

Design Case	Truck Load, Min Cover		
Design Conditions	Short Term		
	Strength Limit I	Strength Limit II	Service Limit 1
ε_{bu} (in/in)	-0.014	-0.006	0.003
$T_{L\ (lb/in)}$	625	498	353
γ_p	0.9	0.9	1.0
γ_B	1.5	1.5	1.5
A_{eff} (in^2/in)	0.364	0.373	0.380
E (psi)	110,000	110,000	110,000
$\varepsilon_{tu\ (in/in)}$	**-0.039**	**-0.027**	**-0.010**

ε_{tl} = limiting combined tension strain = $\gamma_B * \varepsilon_t$ where,

γ_B = load factor for combined strain = 1.5

ε_t = allowable tension strain = 0.05 in/in

ε_{tl} = 0.075 in/in

Factored tension strain is less than the limiting combined tension strain. OK

D'APPOLONIA

By:	AMR	Date: 10/21/2016	Subject:	Northern Tract Quarry	Sheet No.: 20 of 20
Chkd. By:	MJD	Date: 10/26/2016		Culvert Structural Design	Proj. No.: 152596A

N:\2015\152596 - SGI\Northern Tract E&S\Culvert Design\[Northern Tract Culverts - Structural Design.xls]References

REFERENCES

1) Drainage Handbook - Structures, Advanced Drainage Systems, Inc. (ADS), 2011.

2) AASHTO LRFD Bridge Design Specifications, Customary Units, 7th Edition, 2016 Interim Revisions, American Association of State Highway and Transportation Officials (AASHTO), 2014.

3) Drainage Handbook - Structures, Hancor, Inc., 2009.

ATTACHMENT #1

CATERPILLAR®

740
Articulated Truck

Engine		
Engine Model	Cat® C15 ACERT™	
Gross Power – SAE J1995	350 kW	469 hp
Net Power – SAE J1349	338 kW	453 hp

Weights		
Rated Payload	39.5 tonnes	43.5 tons
Body Capacities		
Heaped SAE 2:1	24 m^3	31.4 yd^3

Engine

Engine Model	Cat® C15 ACERT™	
Gross Power – SAE J1995	350 kW	469 hp
Net Power – SAE J1349	338 kW	453 hp
Net Power – ISO 9249	342 kW	458 hp
Net Power – EEC 80/1269	342 kW	458 hp
Bore	137 mm	5.4 in
Stroke	171.5 mm	6.75 in
Displacement	15.2 L	926 in^3

- The power ratings apply at rated speed of 1,800 rpm when tested under the conditions for the specified standard.
- The net power advertised is the power available at the flywheel when the engine is equipped with alternator, air cleaner, muffler and fan at minimum speed.
- Net power when the fan is at maximum speed is 330 kW (442 hp) per the SAE reference conditions.
- The 740 meets EPA Tier 3/EU Stage 3a emission specifications for the U.S. and Europe through 2010.
- No engine derating required below 2438 m (8,000 ft.).

Weights

Rated Payload	39.5 tonnes	43.5 tons

Body Capacities

Heaped SAE 2:1	24 m^3	31.4 yd^3
Struck	18.5 m^3	24.2 yd^3
Tailgate Struck	19.5 m^3	25.5 yd^3
Tailgate Heaped 2:1	25.5 m^3	33.5 yd^3

Transmission

Forward 1	8.9 km/h	5.5 mph
Forward 2	12.1 km/h	7.5 mph
Forward 3	16.4 km/h	10.2 mph
Forward 4	22 km/h	13.7 mph
Forward 5	30 km/h	18.6 mph
Forward 6	40 km/h	25.1 mph
Forward 7	54.7 km/h	34 mph
Reverse 1	8.4 km/h	5.2 mph
Reverse 2	11.6 km/h	7.2 mph

Sound Levels

Interior Cab	79 dB(A)

- The operator sound exposure Leq (equivalent sound pressure level) measured according to the work cycle procedures specified in ANSI/SAE J1166 OCT 98 is 79 dB(A), for the cab offered by Caterpillar, when properly installed and maintained and tested with the doors and windows closed.
- Hearing protection may be needed when operating with an open operator station and cab (when not properly maintained or doors/windows open) for extended periods or in noisy environments.

Operating Weights

Front Axle – Empty	19 400 kg	42,770 lb
Center Axle – Empty	7200 kg	15,873 lb
Rear Axle – Empty	6500 kg	14,330 lb
Total – Empty	33 100 kg	72,973 lb
Front Axle – Rated Load	5200 kg	11,464 lb
Center Axle – Rated Load	17 150 kg	37,809 lb
Rear Axle – Rated Load	17 150 kg	37,809 lb
Total – Rated Load	39 500 kg	87,083 lb
Front Axle – Loaded	24 600 kg	54,234 lb
Center Axle – Loaded	24 350 kg	53,683 lb
Rear Axle – Loaded	23 650 kg	52,139 lb
Total – Loaded	72 600 kg	160,055 lb

Body Plate Thickness

Front	8 mm	0.31 in
Scow	16 mm	0.63 in
Side	12 mm	0.47 in
Base	16 mm	0.63 in

Service Refill Capacities

Fuel Tank	532 L	140.5 gal
Cooling System	80 L	21.1 gal
Hydraulic System	328 L	86.6 gal
Engine Crankcase	38 L	9.5 gal
Transmission	72 L	19 gal
Final Drives/ Differential	72 L	19 gal
Output Transfer Gear Box	18 L	4.8 gal

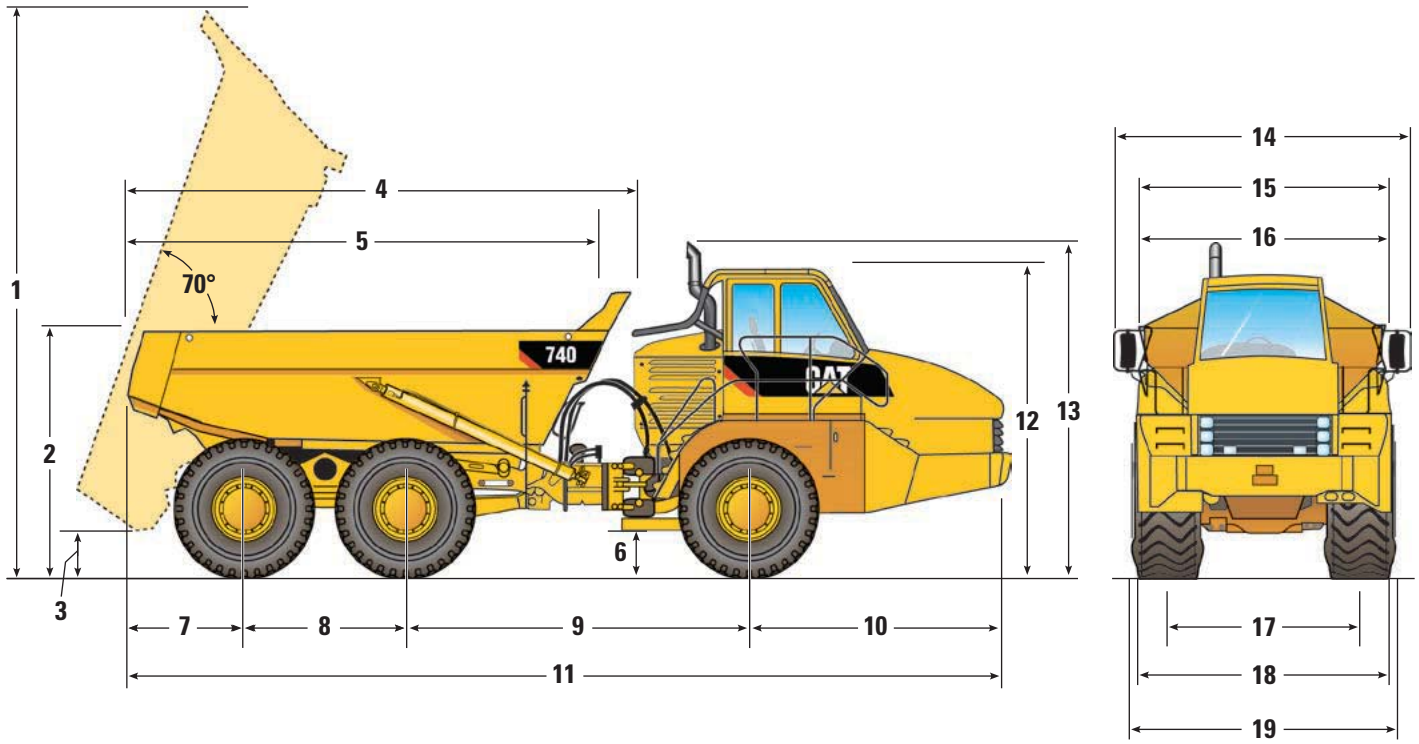
Body Hoist

Raise time	12 Seconds
Lower time	7 Seconds

Standards

Brakes	ISO 3450 – 1996
Cab/FOPS	ISO 3449 Level II – 2005
Cab/ROPS	ISO 3471 – 2008
Steering	ISO 5010 – 2007

Dimensions



	mm	ft
1	7092	23.4
2	3239	10.6
3	697	2.3
4	6288	20.6
5*	5734	18.8
6	577	1.8
7	1458	4.7
8	1966	6.4
9	4244	13.9
10	3221	10.5

	mm	ft
11	10 889	35.7
12	3745	12.3
13**	4049	13.3
14	3823	12.5
15***	3705	12.14
16	3418	11.2
17	2687	8.8
18	3430	11.2
19****	3520	11.5

*Inside of body.
**Exhaust stack can be removed for transportation.
***If equipped with a scissor tailgate.
****Max-unladen over tire bulge.

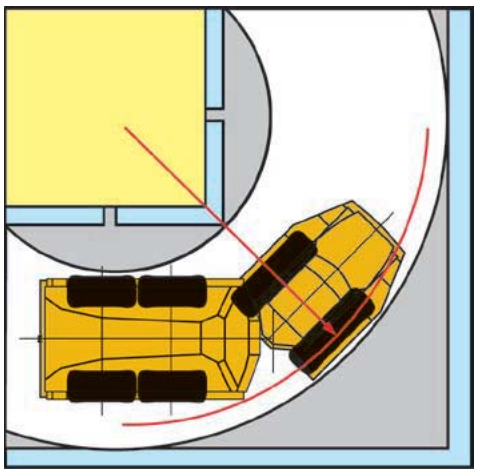
Turning Circle

Dimensions are for machines equipped with 29.5R25 tires.

Turning dimensions		
Steer angle – left/right	45°	
SAE turning radius	8138 mm	320.4 in
Clearance radius	8595 mm	338.4 in
Inside radius	4101 mm	161.5 in
Aisle width	5694 mm	224.2 in

Steering

Lock to Lock	4.6 seconds @ 60 rpm



Optimal Loader/Truck Pass Matching

Hydraulic Excavators	385C	365C	345D
Loader Capacity (Tonnes) – 50 min hr	954-1193	750-1100	665-805
Loader Capacity (Tons) – 50 min hr	1049-1314	825-1210	735-885
Passes	3-4	5	6

Wheel Loaders	988H	980H	972H	966H
Loader Capacity (Tonnes) – 50 min hr	565-790	590-650	490-565	400-535
Loader Capacity (Tons) – 50 min hr	625-870	650-717	540-625	440-590
Passes	3-4	4	5	5-6

An optimum system match gives you a major productivity advantage. The 740 is an excellent match for the Cat 385C, 365C and 345D Hydraulic Excavators; and 966H, 972H, 980H and 988H Wheel Loaders. This results in increased production and lower system costs per unit of volume moved.

WIDE BASE SIZE

DIMENSIONAL DATA

RADIAL

GP-2B
GP-4B AT
EV-3B

RL-2F

RL-2+

RL-4K (24/24)
RL-5K (24/24)

BIAS

SRB-7A

SG LUG
SG LUG DL

SHRL
SHRL DL

SHRL XT DL

HRL D/L-5C
SXT DL

SM-5A
SMO D/L-5A
SMO D/L-5B
SMO D/L-5C

**** Composite Tire for Rock(3) and Traction (2) – E/L/G-3T***
For applications in Loader(L), Earthmover(E) and Grader(G) Service.

Size	Type	Ind Code	Current In Line Location	Rim Width & Flange	INFLATED DIMENSIONS		LOADED DIMENSIONS		Revol Per		Gross Contact Area		Tire Volume		Tread Depth 32nds		PERFORMANCE CAPABILITY					
					Overall Width	Overall Diameter	Load Sect & Growth	Static Load Rad									2S		4S		6S	
					in mm	in mm	in mm	in mm	mi	km	in2	cm2	gal	ltrs	in	mm	tmph	tkph	tmph	tkph	tmph	tkph
29.5R25	**GP-2B**	**E-***	**N E A**	25.00-3.5	**30.5** 775	**73.1** 1857	**33.9** 861	**33.0** 837	**288**	179	**418**	2697	**307.7**	1164.6	**48**	38	**235**	340	**185**	270	**155**	230
	GP-2B	**L-***	**N E**		**30.5** 775	**73.1** 1857	**34.6** 879	**32.2** 817	**288**	179	**505**	3258	**307.7**	1164.6	**48**	38			**^155**	^230	**^130**	^190
	EV-3B	*IND-3*	*N E*		**30.5** 775	**73.1** 1857	**34.6** 879	**32.2** 817	**288**	179	**505**	3258	**307.7**	1164.6	**48**	38						
	RL-2+	**(E+)***	**N E A**		**30.9** 785	**74.0** 1880	**33.4** 848	**33.9** 861	**284**	176	**447**	2884	**315.1**	1192.7	**60**	48	**185**	270	**140**	200		
	RL-2+	**(L+)***	**N E**		**30.9** 785	**74.0** 1880	**34.2** 869	**32.9** 834	**284**	176	**514**	3316	**315.1**	1192.7	**60**	48			**^85**	^120	**^80**	^120
	TL-3A+	**E/L-3**	*N* **E**		**27.5** 699	**69.0** 1753	**30.2** 767	**30.3** 770	**305**	189	**484**	3121	**250.0**	946.0	**59**	47						
	GP-4B AT	**E-4**	*N* **E A**		**29.2** 742	**73.5** 1866	**33.9** 861	**32.8** 833	**284**	177	**542**	3497	**300.0**	1136.0	**72**	57	**165**	240	**130**	190	**105**	150
	GP-4B AT	**L-4**	*N* **E A**		**29.3** 744	**73.4** 1864	**34.4** 874	**32.1** 817	**286**	178	**595**	3839	**300.0**	1136.0	**72**	57						
	RL-4K 24/24	**L-4**	**N**		**30.4** 771	**75.7** 1923	**33.6** 853	**33.0** 839	**278**	173	**583**	3758	**325.0**	1230.0	**72**	57			**^90**	^130	**^85**	^120
	RL-5K 24/24	**L-5**	**N E A**		**31.7** 805	**75.6** 1920	**34.9** 887	**33.9** 861	**278**	173	**468**	3019	**273.7**	1036.1	**120**	95			**^70**	^100	**^65**	^100
	RL-2F	*E-2*	*N*		**30.7** 780	**73.1** 1857	**33.9** 861	**33.9** 861	**288**	179	**410**	2645	**307.8**	1165.1	**44**	35	**220**	320	**160**	230		
	RL-2F	*L-2*	*N*		**30.7** 780	**73.1** 1857	**34.6** 879	**32.2** 817	**288**	179	**498**	3213	**307.8**	1165.1	**44**	35			**^115**	^170	**^110**	^160
29.5-25	*SG LUG (SGL-2A)*	*E-2*	*N*	25.00-3.5	**30.7** 780	**72.8** 1849	**33.0** 838	**32.0** 813	**294**	183	**516**	3329	**245.0**	929.0	**47**	37			**125**	180		
	SHRL (HRL-3A)	**E-3**	*N* **L A**		**30.7** 780	**72.8** 1849	**33.0** 838	**32.0** 813	**294**	183	**516**	3329	**277.0**	1048.5	**52**	41			**115**	170		
	SHRL-DL (HRL DL 3A)	**L-3**	**N L A**		**30.7** 780	**73.1** 1857	**33.6** 853	**32.4** 823	**290**	180	**561**	3620	**277.0**	1048.5	**52**	41			**^65**	^100		
	SHRL XT DL	**L-4**	**N**		**31.4** 798	**74.5** 1892	**34.8** 884	**33.5** 851	**281**	175	**563**	3632	**277.0**	1048.5	**77**	61			**^60**	^90		
	SXT DL(HRL DL 5A)	**L-5**	**N**		**30.9** 785	**74.4** 1890	**34.1** 866	**34.2** 869	**279**	173	**492**	3174			**128**	101			**^55**	^80		
	HRL D/L-5C	**L-5**	**N**		**30.1** 764	**75.4** 1915	**32.1** 815	**34.2** 868	**271**	168	**500**	3226			**117**	93						
	SMO D/L-5A	**L-5S**	**N**		**30.8** 782	**74.4** 1890	**34.2** 869	**34.2** 869	**275**	171	**468**	3020			**123**	98						
	SRB-7A	*E-7*	*N*		**30.6** 777	**71.7** 1821	**32.0** 813	**32.5** 825	**290**	180	**557**	3593	**288.0**	1090.7	**27**	21			**170**	250		
	SG LUG DL	*L-2*	*N*		**30.7** 780	**72.8** 1849	**33.6** 853	**31.0** 787	**304**	189	**615**	3968	**245.3**	928.6	**47**	37			**^80**	^120		

 # Estimated Data
Italicized sizes (light type) not currently in line this location.
Sizes in bold type can be obtained in locations in bold.
Extended lead time may be needed in other locations.

In Line: **N** = North America **E** = Europe / Africa / Mid East
L = Latin America **A** = Asia / Australia

^ Indicates WCF Work Capability Factor

LOAD LIMITS AT COLD INFLATION PRESSURES

30 MPH (50 KM/H) MAXIMUM SPEED OFF-THE-ROAD HAULAGE SERVICE

	PSI	40	44	47	51	54	58	62	65	69	73	76
RADIAL	KPA	275	300	325	350	375	400	425	450	475	500	525
29.5R25	**LBS**	**18700**	**20400**	**21500**	**22700**	**24000 ***	**25400**	**26000**	**27600**	**28300**	**30000**	**30900****
	KG	8500	9250	9750	10300	10900 *	11500	11800	12500	12850	13600	14000 **

	PSI	25	29	33	36	40	44	47	51	54	58
BIAS	KPA	175	200	225	250	275	300	325	350	375	400
29.5-25	**LBS**	**17600**	**19300**	**20400**	**22000(22)**	**23400**	**24000**	**25400(28)**	**26800**	**27600**	**29100(34)**
	KG	8000	8750	9250	10000(22)	10600	10900	11500(28)	12150	12500	13200(34)

30 MPH (50 KM/H) MAXIMUM SPEED OFF-THE-ROAD ARTICULATED DUMP SERVICE

	PSI	29	33	36	40	44	47	51	54	58	62	65
RADIAL	KPA	200	225	250	275	300	325	350	375	400	425	450
29.5R25	**LBS**	**16500**	**18200**	**19800**	**20900**	**22700**	**24000***	**25400**	**26800**	**28300**	**29100**	**30900****
	KG	7500	8250	9000	9500	10300	10900*	11500	12150	12850	13200	14000**

5 MPH (10 KM/H) MAXIMUM SPEED OFF-THE-ROAD SLOW SPEED SERVICE

	PSI	58	62	65	69	73	76	80	83	87	91	94	116
RADIAL	KPA	400	425	450	475	500	525	550	575	600	625	650	800
29.5R25	**LBS**	**34200**	**35300**	**37500**	**38600**	**39700 ***	**41900**	**43000**	**44100**	**45400**	**46700**	**49400****	**56800*****
	KG	15500	16000	17000	17500	18000 *	19000	19500	20000	20600	21200	22400**	25750***

	PSI	33	36	40	44	47	51	54	58	62	65	69	73	76
BIAS	KPA	225	250	275	300	325	350	375	400	425	450	475	500	525
29.5-25	**LBS**	**26800**	**28300(16)**	**30000**	**32000**	**33100(22)**	**35300**	**36400**	**37500**	**38600(28)**	**40800**	**41900**	**43000**	**44100(34)**
	KG	12150	12850(16)	13600	14500	15000(22)	16000	16500	17000	17500(28)	18500	19000	19500	20000(34)

40 MPH (65 KM/H) MAXIMUM SPEED OFF-THE-ROAD SAND SERVICE

	PSI	11	15	18	22	25	29	33	36
BIAS	KPA	75	100	125	150	175	200	225	250
29.5-25	**LBS**	**8540**	**10200**	**11680**	**12790**	**14330**	**15210**	**16530**	**17640**
	KG	3875	4625	5300	5800	6500	6900	7500	8000

30 MPH (50 KM/H) MAXIMUM SPEED OFF-THE-ROAD SAND SERVICE

	PSI	11	15	18	22	25	29	33	36
BIAS	KPA	75	100	125	150	175	200	225	250
29.5-25	**LBS**	**10470**	**12350**	**13890**	**15650**	**17090**	**18190**	**19840**	**20940**
	KG	4750	5600	6300	7100	7750	8250	9000	9500

WIDE BASE SIZE
Tubeless Tires

DIMENSIONAL DATA

GP-2B AT-2A GP-3D GP-4D RL-2+ RL-3F

Size	Type	Ind Code	Current In Line Location	Rim Width & Flange (1)	INFLATED DIMENSIONS Overall Width in	mm	Overall Diameter in	mm	LOADED DIMENSIONS Load Sect & Growth in	mm	Static Load Rad in	mm	Revol Per mi	km	Gross Contact Area in2	cm2	Tire Volume gal	ltrs	Tread Depth 32nds in	mm	PERFORMANCE CAPABILITY# 2S tmph	tkph	4S tmph	tkph	6S tmph	tkph
650/55R25	**GP-2A**	**L-2**	**E**	17.00-2.0	**24.6**	625	**54.2**	1378	**26.5**	673	**23.4**	594	**387**	241	**330**	2130	**121.4**	459.8	**34**	27						
(25/55R25)	**GP-2B**	**L-2**	**E**																							
22/65R25	**AT-2A**	**E-2**	**N** **A**	14.00-1.5	**21.5**	546	**54.5**	1384	**23.9**	607	**24.3**	617	**385**	240	**278**	1794	**110.1**	416.6	**27**	22	**195**	280				
(555/65R25)	**AT-2A**	**L-2**	**N**		**21.5**	546	**54.5**	1384	**24.6**	625	**23.9**	607	**389**	243	**284**	1848	**110.1**	416.6	**27**	22			**^90**	^130	**^75**	^110
550/65R25	**GP-3D**	**E/L-3T**	*N* **E**	14.00-1.5	**21.4**	544	**54.4**	1362	**23.9**	607	**24.3**	617	**386**	240	**290**	1874	**100.0**	379.0	**37**	29	**115**	170	**86**	130	**58**	80
600/65/R25	**GP-3D**	**L-3T**	*N* **E**	17.00-2.0	**23.4**	594	**56.7**	1439	**26.7**	678	**25.4**	646	**369**	229	**308**	1984	**128.0**	485.4	**40**	32	**132**	190	**99**	140	**66**	100
25/65R25	*RL-3F*	*E-3*	*N* *A*	19.50-2.0	**25.5**	647	**58.5**	1486	**27.4**	696	**26.6**	676	**359**	223	**270**	1740	**161.4**	611.0	**40**	32			**125**	180		
650/65R25	**GP-3D**	**E/L-3T**	*N* **E**	19.50-2.5	**26.3**	668	**58.7**	1491	**29.5**	749	**26.2**	665	**357**	222	**355**	2290	**150.0**	568.0	**44**	35	**144**	210	**108**	160	**73**	110
750/65R25	**RL-2+**	**E-3T+**	*N* **E**	24.00-3.0	**30.2**	767	**64.1**	1628	**33.4**	848	**28.8**	732	**328**	204	**466**	3004	**219.9**	833.1	**54**	43	**155**	230	**115**	170	**75**	110
(30/65R25)	**RL-2+**	**L-3T+**	*N* **E**		**30.2**	767	**64.1**	1628	**34.0**	864	**28.4**	721	**328**	204	**450**	2903	**219.9**	833.1	**54**	43						
	GP-3D	**E/L-3T**	*N* **E**		**30.3**	769	**64.1**	1628	**33.9**	862	**28.9**	735	**328**	204	**461**	2976	**225.0**	852.0	**47**	37	**162**	240	**120**	180	**78**	110
775/65R29	**GP-4D**	**E-4**	*N* **E**	24.00-3.0	**31.2**	792	**68.9**	1749	**34.5**	876	**30.4**	772	**305**	190	**556**	3585	**250.0**	946.0	**67**	53	**169**	250	**125**	180	**105**	150
(800/65R29)	**GP-4D**	**L-4**	**E**		**31.2**	792	**68.9**	1749	**34.5**	876	**29.8**	758	**305**	190	**640**	4130	**250.0**	946.0	**67**	53						
875/65R29	**GP-4D**	**E-4**	*N* **E** **A**	27.00-3.0	**33.9**	861	**74.0**	1880	**37.0**	939	**32.7**	830	**282**	176	**552E**	3561#	**325.0**	1230.0	**72**	57	**189**	280	**150**	220	**121**	180
	GP-4D	**L-4**	*N* **E**	27.00-3.0	**33.9**	861	**74.0**	1880	**37.0**	939	**32.7**	830	**282**	176	**676E**	4362#	**325.0**	1230.0	**72**	57						

65 Series vs. Wide Base (Equivalent OD)

550/65R25 ~ 17.5R25	750/65R25 ~ 23.5R25
600/65R25 ~ NA	800/65R29 ~ 26.5R25
650/65R25 ~ 20.5R25	875/65R29 ~ 29.5R25

 # Estimated Data
Italicized sizes (light type) not currently in line this location.
Sizes in bold type can be obtained in locations in bold.
Extended lead time may be needed in other locations.

In Line: **N** = North America **E** = Europe / Africa / Mid East
L = Latin America **A** = Asia / Australia

^ Indicates WCF Work Capability Factor

SECTION G

LEVEL SPREADER DESIGN

D'APPOLONIA

By:	AMB	Date: 10/10/17	Subject: Northern Tract Quarry	Sheet No.:	1 of 3
Chkd. By:	AMR	Date: 11/15/17	Submerged Outlet Level Spreader	Proj. No.:	152596A

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TEMPORARY SUBMERGED LEVEL SPREADER DESIGN
NORTHERN TRACT QUARRY - E&S CONTROL STAGES 2 AND 5
CHARMIAN SITE, SPECIALTY GRANULES, LLC
ADAMS COUNTY, PENNSYLVANIA

PURPOSE

The purpose of these calculations is to design a temporary submerged outlet level spreader to be used during Erosion and Sedimentation Control Stages 2 and 5 for the Northern Tract Quarry. The temporary submerged outlet level spreader will receive runoff from the western portion of the site during Stage 2 and the eastern portion of the site during Stage 5 via temporary diversion ditches. The drain pipes will be designed with AASHTO Class II perforations, and surrounded by a non-woven geotextile and AASHTO No. 57 aggregate. The drain pipes will be connected to the conveyance pipes via a PennDOT Type 4 box, and will be installed in a 4 ft. wide by 4 ft. deep trench that will be backfilled with AASHTO No. 57 aggregate after the installation of the level spreader.

INFLOWS

Each level spreader will receive inflows from a separate temporary diversion ditch. The level spreaders will be designed to handle the largest of the three inflows (13.8 cfs). The temporary diversion ditch peak flows are tabulated below (Ref. #4).

Ditch Name	Peak Flow (cfs)
DD-1	11.0
DD-3	13.8
DD-4	13.8

Temporary diversion ditch DD-1 will end at the PennDOT Type 4 box.. Temporary diversion ditches DD-3 and DD-4 will end at a temporary slope pipe, which will convey the runoff to the PennDOT Type 4 boxes. The Type 4 boxes will then convey the runoff to the drain pipes.

AGGREGATE DRAIN CAPACITY

Length of Aggregate Zone =	102	ft	
Width of Aggregate Zone =	4	ft	
Area of Aggregate Zone =	408	ft^2	(Exposed aggregate area)
Coefficient of Permeability of Aggregate =	10.0	cm/s	(Typical value for AASHTO #57)
Assumed Hydraulic Gradient =	0.3	ft/ft	
Aggregate $Q_{available}$ =	44.173	cfs	
Collection Pipe Inside Diameter =	24	in	
Total $Q_{required}$ =	13.80	cfs (Ref. #6)	
Drain Capacity Adequate ?	YES		

D'APPOLONIA

By:	AMB	Date: 10/10/17	Subject:	Northern Tract Quarry	Sheet No.: 2 of 3
Chkd. By:	AMR	Date: 11/15/17		Submerged Outlet Level Spreader	Proj. No.: 152596A

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PIPE PERFORATION CAPACITY CHECK

The collection pipe for the drain will consist of a perforated, corrugated 24 inch ID High Density Polyethelene (HDPE) pipe, with AASHTO Class II perforations. These calculations will determine the required length of perforated collection pipe to convey the design discharge.

Perforated HDPE Capacity:

Flow through Perforations, $Q = CA(2gh)^{1/2}$ where,

C = Orifice Coefficient =	0.6	(Conservatively assume lowest typical value - Ref. #5)
Minimum Inlet Area, A =	2.0	in^2/ft (AASHTO Type II perforations for 24 inch ID pipe)
g = acceleration due to gravity =	32.2	ft/s^2
h = hydraulic head =	5.0	ft
Pipe Capacity, Q =	0.150	cfs/ft
Required Total Capacity =	13.80	cfs (Ref. #6)
Required Length of Perforated Pipe =	92	ft
Total Pipe Length for F.S. of 1.1 =	102	ft
Actual Length of Perforated Pipe =	102	ft
Actual F.S. =	1.1	ft

D'APPOLONIA

By:	AMB	Date: 10/10/17	Subject: Northern Tract Quarry	Sheet No.:	3 of 3
Chkd. By:	AMR	Date: 11/15/17	Submerged Outlet Level Spreader	Proj. No.:	152596A

N:\2015\152596 - SGI\Northern Tract\NT Pond Design\NT 2 Temp Slope Pipe\[Submerged Outlet Level Spreader Calc.xls]Calcs

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