OGMCOAL DNR unknown <ogmcoal@utah.gov>

Lower Robinson Creek reconstruction

Keenan Storrar <kstorrar@utah.gov> Wed, Mar 25, 2015 at 3:49 PM
To: Dan Guy <blackhawk2422@yahoo.com>, Kirk Nicholes <knicholes@altoncoal.com>, OGMCOAL DNR <ogmcoal@utah.gov>

Dan, Kirk:

Thank you for discussing the reconstruction of Lower Robinson Creek today by phone.

I have attached the spreadsheet I mentioned that highlights some of the major features needed in the final transition zone.

Please don't hesitate to call or email me if you have any followup questions.

Thank you,
Keenan Storrar
Utah Division of Oil, Gas and Mining
801-538-5345
kstorrar@utah.gov

NEH654-CH14-Rock_Chute-vs031606.xls
974K

Spreadsheet tool:	Rock Chute Design Data
Version:	(Version 4.01 - 04/23/03, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)
Contact:	
Reference:	Chapter 14, NEH-654.

Disclaimer

- **This Excel spreadsheet tool has specific uses and limits of applicability.**
- **The user assumes responsibility for the selection and application of this tool.**
- **The user should check all of the computed results for reasonableness and accuracy.**

Comments, Feedback

Users of this spreadsheet tool are requested to provide comments for

- **Suitability: range of application or limitations**
- **Ease of use**
- **Results: Are they reasonable and verified?**
- **Any other comments for improvement:**

jon.fripp@ftw.usda.gov
kerry.robinson@gnb.usda.gov
jerry.bernard@wdc.usda.gov

Rock Chute Design Data

(Version 4.01 - 04/23/03, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Spillway protection **County:** Woodbury
Designer: Jim Villa **Checked by:**
Date: 3/26/2015 **Date:**

Input Channel Geometry

Inlet Channel	Chute	Outlet Channel
Bw = 20.0 ft.	Bw = 20.0 ft.	Bw = 40.0 ft.
Side slopes = 4.0 (m:1)	Factor of safety = 1.20 (F_s)	Side slopes = 4.0 (m:1)
n-value = 0.035	Side slopes = 4.0 (m:1) → 2.0:1 max.	n-value = 0.045
Bed slope = 0.0060 ft./ft.	Bed slope (5:1) = 0.200 ft./ft. → 2.5:1 max.	Bed slope = 0.0050 ft./ft.
Freeboard = 0.5 ft.	Outlet apron depth, d = 1.0 ft.	Base flow = 0.0 cfs

Design Storm Data (Table 2, NHCP, NRCS Grade Stabilization Structure No. 410)

Drainage area = 400.0 acres Rainfall = ○ 0 - 3 in. ● 3 - 5 in. ○ 5+ in.

Apron elev. --- Inlet = 105.0 ft. --- Outlet = 99.0 ft. --- (H_{drop} = 5 ft.)

Chute capacity = Q5-year
Total capacity = Q10-year
Minimum capacity (based on a 5-year, 24-hour storm with a 3 - 5 inch rainfall)

Q_{high} = 500.0 cfs High flow storm through chute → Tw (ft.) = Program 0.20

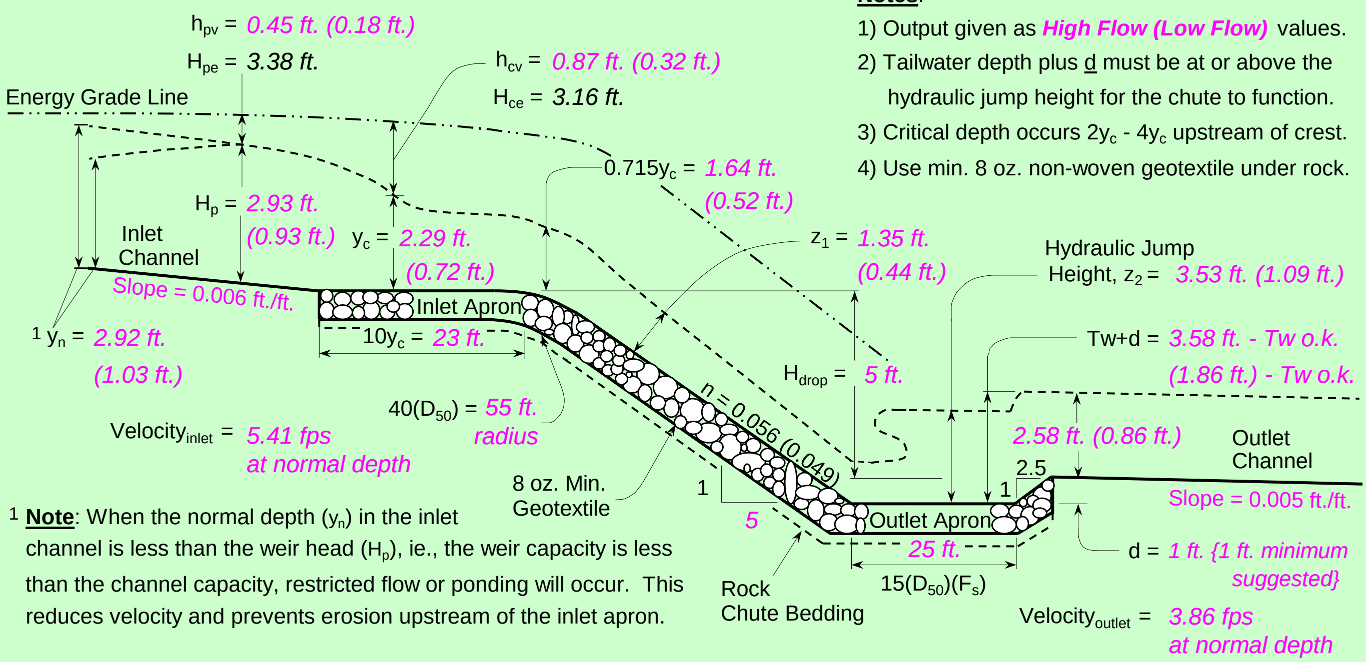
Q_{low} = 75.0 cfs Low flow storm through chute → Tw (ft.) = Program

***Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.*

***Input tailwater (Tw)**:*

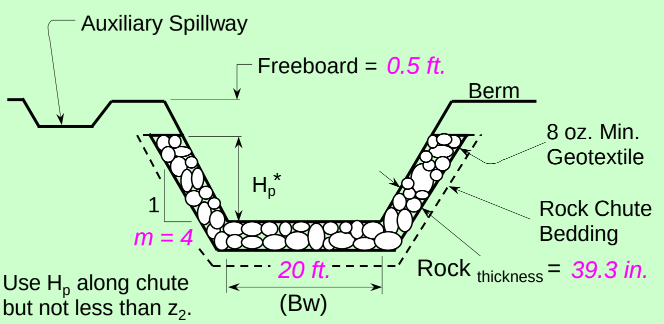
Profile and Cross Section (Output)

Notes:
1) Output given as ***High Flow (Low Flow)*** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.
4) Use min. 8 oz. non-woven geotextile under rock.



[1] **Note**: When the normal depth (y_n) in the inlet channel is less than the weir head (H_p), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

Profile Along Centerline of Chute



* Use H_p along chute but not less than z_2.

Typical Cross Section

q_t =	19.66 cfs/ft.	Equivalent unit discharge
F_S =	1.20	Factor of safety (multiplier)
z_1 =	1.35 ft.	Normal depth in chute
n-value =	0.056	Manning's roughness coefficient
$D_{50}(F_s)$ =	19.6 in. (552 lbs. - 50% round / 50% angular)	
$2(D_{50})(F_s)$ =	39.3 in.	Rock chute thickness
Tw + d =	3.58 ft.	Tailwater above outlet apron
z_2 =	3.53 ft.	Hydraulic jump height
****** The outlet***	***will***	***function adequately***

High Flow Storm Information

Rock Chute Design - Plan Sheet

(Version 4.0 - 07/10/00, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Spillway protection **County:** Woodbury
Designer: Jim Villa **Checked by:**
Date: 3/26/2015 **Date:**

Design Values

Angular D_{50} dia. =	19.6 in.
$Rock_{chute}$ thickness =	39.3 in.
Inlet apron length =	23 ft.
Outlet apron length =	25 ft.
Radius =	55 ft.

Will bedding be used? Yes ---------- Depth (in.) = 6.0

Rock Gradation Envelope

% Passing		Diameter, in. (weight, lbs.)
D_{100}	---------	29 - 39 (1852 - 4390)
D_{85}	---------	25 - 35 (1206 - 3200)
D_{50}	---------	20 - 29 (549 - 1852)
D_{10}	---------	16 - 25 (281 - 1206)

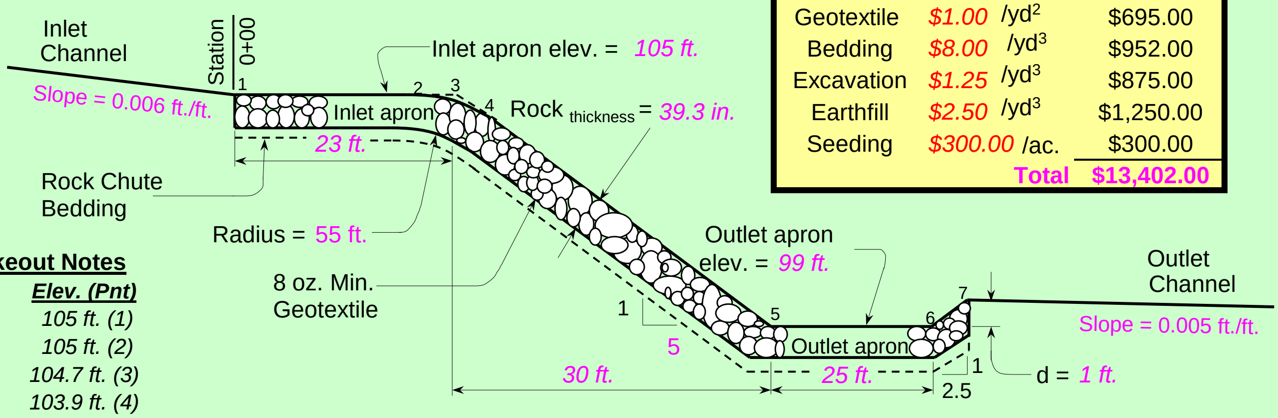
Quantities [a]

Angular Rock =	622	yd^3
Geotextile (8 oz.)[b] =	695	yd^2
Bedding (6 in.) =	119	yd^3
Excavation =	700	yd^3
Earthfill =	500	yd^3
Seeding =	1.0	acres

Notes: [a] *Rock, bedding, and geotextile quantities are determined from the x-section below (neglect radius).*
[b] *Geotextile shall be overlapped (18-in. min.) and anchored (18-in. min. along sides and 24-in. min. on the ends).*

Rock Chute Cost Estimate

Unit	Unit Cost	Cost
Rock	$15.00 /$yd^3$	$9,330.00
Geotextile	$1.00 /$yd^2$	$695.00
Bedding	$8.00 /$yd^3$	$952.00
Excavation	$1.25 /$yd^3$	$875.00
Earthfill	$2.50 /$yd^3$	$1,250.00
Seeding	$300.00 /ac.	$300.00
	Total	**$13,402.00**

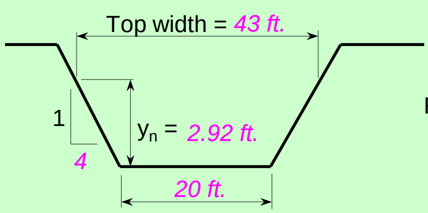


Stakeout Notes

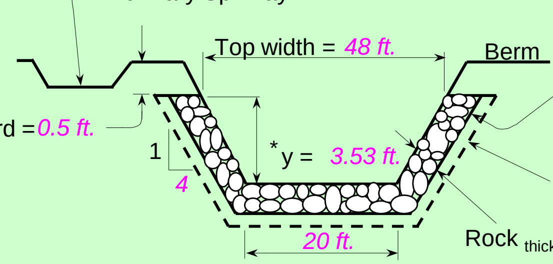
Sta.	Elev. (Pnt)
0+00	105 ft. (1)
0+17.6	105 ft. (2)
0+23	104.7 ft. (3)
0+28.3	103.9 ft. (4)
0+53	99 ft. (5)
0+78	99 ft. (6)
0+80.5	100 ft. (7)

Profile Along Centerline of Rock Chute

***Note**: The outlet will function adequately*

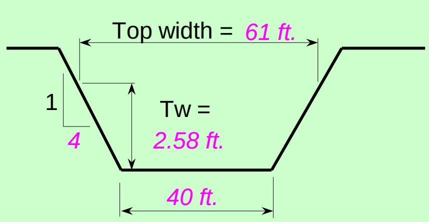


Inlet Channel Cross Section



Rock Chute Cross Section

* Use H_p throughout chute but not less than z_2.



Outlet Channel Cross Section

Profile, Cross Sections, and Quantities

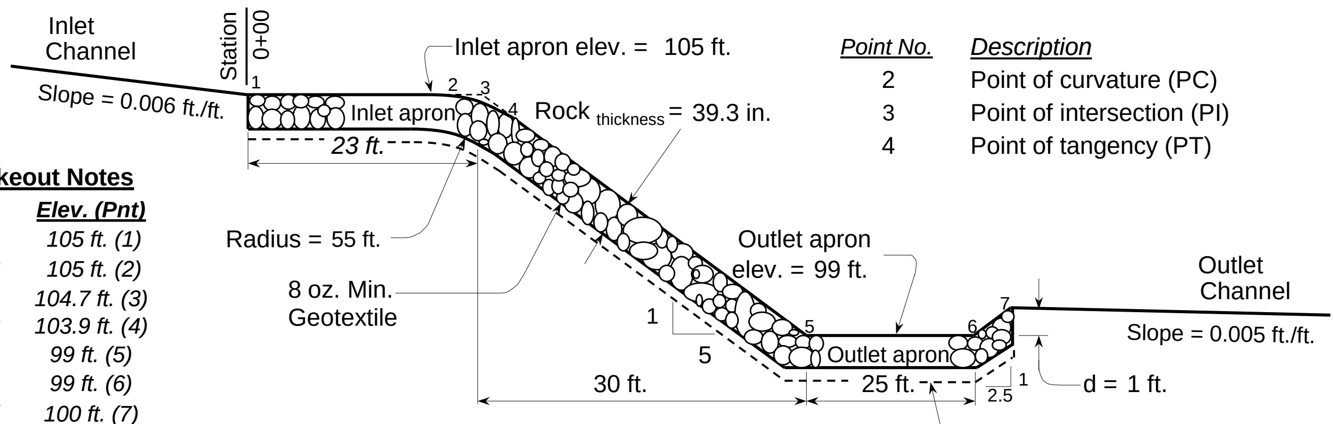
Project: Spillway protection
Location: Woodbury County

U.S. Department of Agriculture
Natural Resources Conservation Service

Designed: Jim Villa	Approved by:
Drawn: NRCS Standard Dwg.	Title:
	Title:
Traced:	Sheet No. / Drawing No.
Checked:	of

Design Values		***Rock Gradation Envelope***		***Quantities*** [a]	
Angular D_{50} dia. =	19.6 in.	*% Passing*	*Diameter, in. (weight, lbs.)*	***Angular*** Rock =	622 yd^3
$Rock_{chute}$ thickness =	39.3 in.	D_{100} ---------	29 - 39 (1852 - 4390)	Geotextile (8 oz.)[b] =	695 yd^2
Inlet apron length =	23 ft.	D_{85} ---------	25 - 35 (1206 - 3200)	Bedding (6 in.) =	119 yd^3
Outlet apron length =	25 ft.	D_{50} ---------	20 - 29 (549 - 1852)	Excavation =	700 yd^3
Radius =	55 ft.	D_{10} ---------	16 - 25 (281 - 1206)	Earthfill =	500 yd^3
Will bedding be used?	Yes	*Coefficient of Uniformity,* $(D_{60})/(D_{10}) \leq 2.0$		Seeding =	1.0 acres

Notes: [a] *Rock, bedding, and geotextile quantities are determined from x-section below (neglect radius).*
[b] *Geotextile shall be overlapped (18-in. minimum) and anchored (18-in. minimum along sides and 24-in. minimum on the ends) --- quantity not included.*

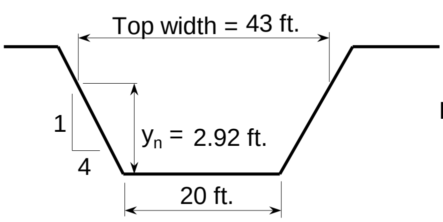


Point No.	*Description*
2	Point of curvature (PC)
3	Point of intersection (PI)
4	Point of tangency (PT)

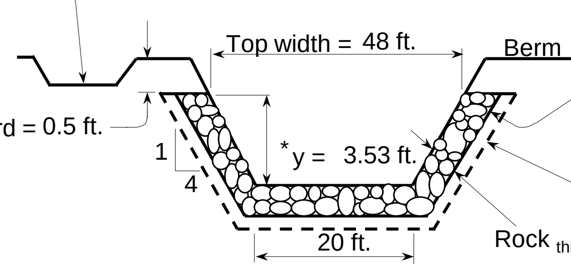
Stakeout Notes

Sta.	***Elev. (Pnt)***
0+00	*105 ft. (1)*
0+17.6	*105 ft. (2)*
0+23	*104.7 ft. (3)*
0+28.3	*103.9 ft. (4)*
0+53	*99 ft. (5)*
0+78	*99 ft. (6)*
0+80.5	*100 ft. (7)*

Profile Along Centerline of Rock Chute

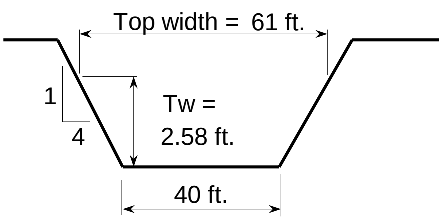


Inlet Channel Cross Section



Rock Chute Cross Section

* Use H_p throughout chute but not less than z_2.



Outlet Channel Cross Section

Profile, Cross Sections, and Quantities

Project: Spillway protection
Location: Woodbury County

U.S. Department of Agriculture
Natural Resources Conservation Service

Designed: Jim Villa	Approved by:
Drawn: NRCS Standard Dwg.	Title:
	Title:
Traced:	Sheet No. ___ of ___ / Drawing No.
Checked:	

Rock Chute Design Calculations

(Version 4.0 - 07/10/00, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Spillway protection **County:** Woodbury
Designer: Jim Villa **Checked by:** ____________
Date: 3/26/2015 **Date:** ________

I. Calculate the normal depth in the inlet channel.

High Flow			Low Flow			
y_n =	**2.92**	**ft.**	**y_n =**	**1.03**	**ft.**	(Normal depth)
Area =	92.5	ft^2	Area =	24.9	ft^2	(Flow area in channel)
Q_{high} =	500.0	cfs	Q_{low} =	75.0	cfs	(Capacity in channel)

II. Calculate the critical depth in the chute.

High Flow			Low Flow			
y_c =	**2.29**	**ft.**	**y_c =**	**0.72**	**ft.**	(Critical depth in chute)
Area =	66.8	ft^2	Area =	16.5	ft^2	(Flow area in channel)
Q_{high} =	500.0	cfs	Q_{low} =	75.0	cfs	(Capacity in channel)
H_{ce} =	3.16	ft.	H_{ce} =	1.04	ft.	(Total minimum specific energy head)
h_{cv} =	0.87	ft.	h_{cv} =	0.32	ft.	(Velocity head corresponding to y_c)
$10y_c$ =	**22.89**	**ft.**	---	---		(Required inlet apron length)
$0.715y_c$ =	**1.64**	**ft.**	**$0.715y_c$ =**	**0.52**	**ft.**	(Depth of flow over the weir crest or brink)

III. Calculate the tailwater depth in the outlet channel.

High Flow			Low Flow				
Tw =	**2.58**	**ft.**	**Tw =**	**0.86**	**ft.**	(Tailwater depth)	
Area =	129.6	ft^2	Area =	37.4	ft^2	(Flow area in channel)	
Q_{high} =	500.0	cfs	Q_{low} =	75.0	cfs	(Capacity in channel)	5.00 = H_{drop}
H_2 =	0.00	ft.	H_2 =	0.00	ft.	(Downstream head above weir crest, $H_2 = 0$, if $H_2 < 0.715*y_c$, neglect velocity head)	

IV. Calculate the head for a trapezoidal shaped broad-crested weir.

C_d = 1.00 C_{vn} = 0.581 (Discharge coefficient for rectangular & v-notch broad-crested weirs, respectively)

High Flow

H_p =	3.12	ft.	**2.93**	**ft.**	(Weir head)
Area =	101.2	ft^2	92.8	ft^2	(Flow area in channel)
V_i =	0.00	fps	**5.39**	**fps**	(Approach velocity)
h_{pv} =	0.00	ft.	0.45	ft.	(Velocity head corresponding to H_p)
Q_{high} =	500.0	cfs	500.0	cfs	(Capacity in channel)

Trial and error procedure solving simultaneously for velocity and head

Low Flow

H_p =	1.03	ft.	**0.93**	**ft.**	(Weir head)
Area =	24.9	ft^2	22.0	ft^2	(Flow area in channel)
V_i =	0.00	fps	**3.41**	**fps**	(Approach velocity)
h_{pv} =	0.00	ft.	0.18	ft.	(Velocity head corresponding to H_p)
Q_{low} =	75.0	cfs	75.0	cfs	(Capacity in channel)

Trial and error procedure solving simultaneously for velocity and head

Rock Chute Design Calculations

(Version 4.0 - 07/10/00, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Spillway protection
Designer: Jim Villa
Date: 3/26/2015

County: Woodbury
Checked by:
Date:

V. Calculate the rock chute parameters (w/o a factor of safety applied).

High Flow			Low Flow			
q_t =	1.83	cms/m	q_t =	0.32	cms/m	(Equivalent unit discharge)
D_{50} (mm) =	415.59 → ***(16.36 in.)***		D_{50} =	166.21	mm	(Median ***angular*** rock size)
n =	0.056		n =	0.049		(Manning's roughness coefficient)
z_1 =	1.35	ft.	z_1 =	0.44	ft.	(Normal depth in the chute)
A_1 =	34.4	ft^2	A_1 =	9.6	ft^2	(Area associated with normal depth)
Velocity =	14.55	fps	Velocity =	7.81	fps	(Velocity in chute slope)
z_{mean} =	1.12	ft.	z_{mean} =	0.41	ft.	(Mean depth)
F_1 =	2.43		F_1 =	2.15		(Froude number)
$L_{rock\ apron}$ =	20.45	ft.	----	----		(Length of rock outlet apron = 15*D_{50})

VI. Calculate the height of hydraulic jump height (conjugate depth).

High Flow			Low Flow			
z_2 =	**3.53**	**ft.**	**z_2 =**	**1.09**	**ft.**	(Hydraulic jump height)
Q_{high} =	500.0	cfs	Q_{low} =	75.0	cfs	(Capacity in channel)
A_2 =	120.3	ft^2	A_2 =	26.6	ft^2	(Flow area in channel)

VII. Calculate the energy lost through the jump (absorbed by the rock).

High Flow			Low Flow			
E_1 =	4.64	ft.	E_1 =	1.39	ft.	(Total energy before the jump)
E_2 =	3.80	ft.	E_2 =	1.22	ft.	(Total energy after the jump)
R_E =	18.18	%	R_E =	12.38	%	(Relative loss of energy)

Calculate Quantities for Rock Chute

-------Rock Riprap Volume-------

Area Calculations	Length @ Rock CL
h = 3.53	Inlet = 22.84
x_1 = 13.50	Outlet = 25.48
L = 14.55	Slope = 30.59
A_s = 47.67	2.5:1 Lip = 2.35
x_2 = 13.10	**Total = 81.26 ft.**
A_b = 111.04	**Rock Volume**
A_b+2*A_s = 206.38 ft^2	**621.13 yd^3**

-------Bedding Volume-------

Area Calculations	
h = 6.81	**Bedding Thickness**
x_1 = 2.06	t_1, t_2 = ***6.00*** in.
L = 28.08	
A_s = 14.04	**Length @ Bed CL**
x_2 = 2.00	**Total = 81.23 ft.**
A_b = 11.46	**Bedding Volume**
A_b+2*A_s = 39.54 ft^2	**118.97 yd^3**

-------Geotextile Quantity-------

Width	Length @ Bot. Rock
2*Slope = 56.16	**Total = 81.24 ft.**
Bottom = 20.81	**Geotextile Area**
Total = 76.96 ft.	**694.70 yd^2**

Note: 1) The radius is not considered when calculating quantities of riprap, bedding, or geotextile.
2) The geotextile quantity does not include over-overlapping (18-in. min.) or anchoring material (18-in. min. along sides, 24-in. min. on ends).

Instructions - Rock Chute Design Program

This Excel spreadsheet is included as a tool to design rock chutes for conservation practices. Median size for **angular** rock is determined along with the chute hydraulics and dimensions. This spreadsheet is based on "Design of Rock Chutes" by Robinson, Rice, and Kadavy, ASAE Vol. 41(3), pp. 621-626, 1998 (Ref. 1). One Spreadsheet version is included. Rock_Chute.xls is intended for Excel in Microsoft Office 97. The Excel file (.xls) is password protected. A ***Glossary*** is included below. All equations are available from the Iowa NRCS Design Staff by request.

Glossary

A_1 (ft^2) = Area of flow corresponding to normal depth in the chute.

A_2 (ft^2) = Area of flow corresponding to the hydraulic jump height in the chute.

Bw (ft.) = Designates the bottom width for the inlet channel, the chute, and the outlet channel sections.

d (ft.) = Lower the outlet apron a depth d to submerge the hydraulic jump (1-ft. suggested minimum).

*D_{50} (ft.) = Median **angular (cubical)** rock size (angular rock is stable at a unit discharge approximately 40% greater than that for rounded (spherical) stone of the same diameter).*

E_1 (ft.) = Total energy before the jump.

E_2 (ft.) = Total energy after the jump.

F_1 = Froude number corresponding to normal chute depth.

Freeboard = The berm (or embankment) height above the top of rock in feet.

F_s = Factor of safety (multiplier) applied to the median angular rock size, D_{50}. The designer may use Minnesota Technical Release 3 , Loose Riprap Protection, July 1989, page 17, Table 2-1 for help.

H_2 (ft.) = Downstream head above weir crest, affects weir flow if H_2 is greater than $0.715y_c$ or the brink depth (When H_2>0 submerged weir flow exists and normal depth (z_1) will not occur in the chute slope, and the program may over-estimate the D_{50} size for this condition.)

H_{ce} (ft.) = Total minimum specific energy head (sum of critical depth and velocity head).

h_{cv} (ft.) = Velocity head (V^2/2g) corresponding to velocity at critical depth.

H_{drop} (ft.) = The difference in elevation between the inlet apron and outlet channel.

H_p (ft.) = Head upstream of the weir crest required to force flow through the weir.

H_{pe} (ft.) = Total energy head (sum of H_p and the velocity head).

h_{pv} (ft.) = Velocity head (V^2/2g) corresponding to velocity at depth H_p.

m = Horizontal component of the side slope ratio (m:1).

n = Manning's roughness coefficient measured in the middle 1/3 of the chute calculated by Equation 7 in Ref. 1, and also used to designate the inlet and outlet channel roughness.

Q_{high} (cfs) = High flow storm

Q_{low} (cfs) = Low flow storm

(The user shall make sure that tailwater depths are at the hydraulic jump height or greater for high and low flow conditions.)

q_t (cfs/ft.) = Equivalent unit discharge in the rock chute.

R_E (%) = Relative loss of energy = $(1-E_2/E_1)*100$.

Tw (ft.) = Tailwater depth above the outlet channel (determined by Manning's equation or input by user).

Tw+d (ft.) = Tailwater depth above the outlet apron (must be z_2 or greater).

V_i (fps) = Approach velocity upstream of weir crest (trial and error procedure solving simultaneously for approach velocity and head).

y (ft.) = Height of riprap (vertically) along the rock chute side slope, the greater of H_p or z_2.

y_c (ft.) = Critical depth occurs $2y_c$ to $4y_c$ upstream of the rock chute crest ($0.715y_c$ occurs at the crest).

y_n (ft.) = Normal depth in the inlet channel determined by using Manning's equation (accelerated flow continues upstream of the weir crest approximately $10y_c$).

Instructions - Rock Chute Design Program

z_1 (ft.) = Normal depth in the middle 1/3 of the chute, calculated by Equation 6 in Ref. 1.
z_2 (ft.) = Conjugate depth or <u>hydraulic jump height</u> due to the transition from supercritical to subcritical flow at the base of chute slope.
z_{mean} (ft.) = Mean depth in the rock chute.

<u>Factor of Safety</u> - The factor of safety (or multiplier, F_s) is used to safeguard against possible undersizing of the rock chute's median rock size (D_{50}). ***F_s adjusts the D_{50} rock size, the rock chute thickness, and the outlet apron length***. The Iowa NRCS Design Staff also considered modifying (with F_s) the unit discharge (cfs/ft.), Q_{high}, and the bed slope (hydraulic grade line) instead of the D_{50}. Applying a F_s to the D_{50} will give a more conservative (larger) median rock size than applying the same F_s to the other above mentioned parameters. The user must decide what value of F_s to use. See Minnesota Technical Release 3 , Loose Riprap Protection, July 1989, page 17, Table 2-1.

<u>Maximum values</u> (or limits) were not considered in the spreadsheet. Only values that were outside the scope of the research were limited (chute bed slope and chute side slope). Each designer should consider what limits or maximum values they want for various parameters, such as the height of drop (H_{drop}), high flow storm (Q_{high}), bottom width (Bw), etc.

The program has 2 sheets, (Rock Chute Design Data and Rock Chute Design - Plan Sheet) that are available to the user by selecting the appropriate icon, besides the **Instructions** sheet. They are described below.

<u>1) Rock Chute Design Data</u>

The **Instructions** button (in the upper right) switches the user to this page (select the **Back to Design** button to return). The **Plan Sheet** button takes the user to the Profile, Cross Sections, and Quantities sheet (see below). The **Solve Spreadsheet** button (in the center of the sheet) must be selected after changing the design information. The **Tailwater from Program** button will enter the word "Program" in the tailwater cells (or the user may specify a tailwater by typing the value corresponding to high and low discharge). There are three main areas in the Design Data sheet: **1) Input Channel Geometry**, **2) Design Storm Data**, **3) Profile and Cross Section (Output)**. No print button is available on this sheet. The user should refer to the Rock Chute Design - Plan Sheet for print buttons. *The user should not print with the print icons (standard icons) or menus in Excel,* ***<u>not all the design information will print</u>***.

Input Channel Geometry

This is the major input area for setting channel geometry. All red, italicized values and text can be entered (or changed) by the user. The user should note the **Solve Spreadsheet** button in the center of the spreadsheet. Changing any value, with the exception of *Freeboard* under the inlet channel column, *Outlet apron depth, d,* and the *Factor of safety (multiplier)* under the chute column will blank the output values in the Profile and Cross Section area (see below). The user must select the **Solve Spreadsheet** button when finished inputting. The program sets a limit on the steepest side slope allowed in the chute (2:1) and the steepest bed slope (2.5:1). Values steeper than these will blank the output area and the program can not be solved or printed (just to the right of these cells will indicate *Too Steep)*. Also, the user should input a 1.0-foot "suggested" minimum for d (always make sure that T_w + d is greater than or equal to z_2).

Instructions - Rock Chute Design Program

Design Storm Data (Table 2, NHCP, NRCS Grade Stabilization Structure No. 410)

Here the user is prompted to input the *Drainage area* and the *Inlet and Outlet apron elevation*. The program will determine the NRCS minimum capacity (storm frequency year) for a full-flow open structure (chute and auxiliary spillway). The user must select the rainfall amount (0-3 in., 3-5 in., or 5+ in.) for a 5-year frequency, 24-hour duration storm. Input the high and low frequency storm (in cfs) flowing through the chute portion of the structure (this program does not design the auxiliary spillway). The tailwater must be adequate for both high and low flow events. The tailwater can be entered by the user or computed by the program for corresponding high and low flow storms. The **Tailwater from Program** button enters the word "Program" in the tailwater cells indicating that the spreadsheet will calculate the tailwater. The user should note that changing Q_{high} or Q_{low} will require the **Solve Spreadsheet** button to be selected.

Profile and Cross Section (Output)

No values need to be input. These results display chute hydraulics and dimensions for both high and low flow conditions. Low flow results are given in parenthesis and units are listed with the value. The user should make sure that T_w + d is greater than or equal to z_2 as indicated by T_w *o.k.* in the output. If output values give a dashed line or say "Not Solved" the user must select the **Solve Spreadsheet** button. If this doesn't work check the chute *Bed Slope* and *Side Slope* values and make sure they are not too steep. The High Flow Storm Information shows the D_{50} rock size by diameter (inches) and weight (pounds) for 50% angular and 50% round rock with a specific gravity (Gs) of 2.65. The weight comes from Minnesota Technical Release 3 (MN TR-3), Loose Riprap Protection, July 1989, page 18, Figure 2-2.

2) Rock Chute Design - Plan Sheet

This sheet gives the Profile, Cross Sections, and Quantities (along with a cost estimate) for the design. The user may input all red, italicized values and text. The design values can be changed by the user to make them more appropriate for construction *(we strongly discourage reducing the design values below what the program calculated)*. The user must enter the quantity of Excavation, Earthfill, and Seeding (if needed). Input the unit cost for each item in the cost estimate box. There are two print buttons in the upper left: **Print Documentation** will print this page as it appears on the screen (in addition to 3 pages of design information), and **Print Plan** will print a modified page that is a copy of the Plan Sheet (without the cost estimate). This page can then be pasted on the plan and includes stakeout notes for the finished rock chute grade. Use the **Back to Design** button to return to the design data sheet. The **Instructions** button (in the upper right) switches the user to this page. A uniform rock riprap size is required. Uniformly sized materials remained stable at higher flow rates than non-uniform (well graded) A coefficient of uniformity (D_{60}/D_{10}) of 2.0 or less was used to define the D_{10} size. The remainder of the values (D_{100}, D_{85}, and D_{50}) came from MN TR-3, Loose Riprap Protection, July 1989, page 21, Table 2-2.

Any questions or comments please contact:

NRCS
Iowa Design Staff
693 Federal Building
210 Walnut Street
Des Moines, IA 50309-2180