OSM VALLEY FILL STUDY

SAMPLES MINE VALLEY FILL #1
FUTURE FORESTED CONDITIONS

Appalachian
Regional
Coordinating
Center

US Army Corps
of Engineers
Pittsburgh District

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TABLE OF CONTENTS

GENERAL **1**

DESCRIPTION OF HYDROLOGIC AND HYDRAULIC MODELS **2**

Drainage Area 2
Precipitation 2
Soil Types 3
SCS Runoff Curve Numbers 3
Time of Concentration and Lag 4
Base Flow 4
Routing Reaches 4

FUTURE FORESTED CONDITIONS **6**

Drainage Area 6
Soil Types and SCS Runoff Curve Numbers 8
Time of Concentration and Lag 10
Base Flow 11
Routing Reaches 12

HYDROLOGIC AND HYDRAULIC MODEL RESULTS **13**

CONCLUSIONS **15**

RECOMMENDATIONS **16**

REFERENCES **17**

GENERAL

The intent of this study was to determine the effect on storm runoff by changes to topography, soils, land use, vegetation, etc, caused by mountain top removal / valley fill surface coal mining operations. The changes to the 10 and 100 year flows and water surface elevations were determined and compared for the premining, during mining, post mining, AOC+ (Approximate Original Contour Plus) and future forested conditions.

This report covers the results from the future forested conditions only. The results of the study for premining, during mining, post mining and AOC+ have been previously reported. They will be included in this report by reference and by inclusion in the “HYDROLOGIC AND HYDRAULIC MODEL RESULTS” section.

The Samples Mine Valley Fill SH-1, located in the headwaters of the Seng Creek watershed in Boone County, West Virginia, was selected as the study site. The determination of the effects of changes to this drainage area represents a classic ungaged watershed study. The Seng Creek watershed is ungaged and no historic hydrologic information is available.

Corps of Engineers personnel from the Pittsburgh District (Walt Leput, Mark Zaitsoff, Ray Rush, Karen Taylor, Paul Donahue), the Hydrologic Engineering Center (HEC) (Harry Dotson) and the Waterways Experiment Station (WES) (Bill Johnson), and Office of Surface Mining (OSM) personnel (Don Stump, Dan Rahnema) visited the site.

Discussions were held to determine the methods of analysis that could be used to achieve the required results. Since great changes occur to the drainage area from pre to future forested conditions, the method of analysis needed to be able to subdivide it and model the changed areas as appropriate. Those involved concurred that the HEC-HMS (Hydrologic Modeling System) and HEC-RAS (River Analysis System) models would provide the methods of analysis and results needed for the study.

A HEC-HMS (version 1.1) rainfall runoff model was used to evaluate the changes in flow magnitude. The runoff curve number (CN) method developed by the Soil Conservation Service (SCS) (now National Resource Conservation Service, NRCS) was used to determine the rainfall losses and the transformation from rainfall excess to runoff. This method has the advantage over regional parameter methods of rainfall-runoff determination of being based on observable physical properties of the watershed and of being able to model great changes in the runoff characteristics of the watershed.

A HEC-RAS (version 2.2) hydraulic model was used to provide peak flow timing and routing input to the HEC-HMS hydrologic model. Flows generated by the hydrology model were input to the hydraulic model until the input and output from both models were consistent. The HEC-RAS model was then used to determine the changes in water surface elevation.

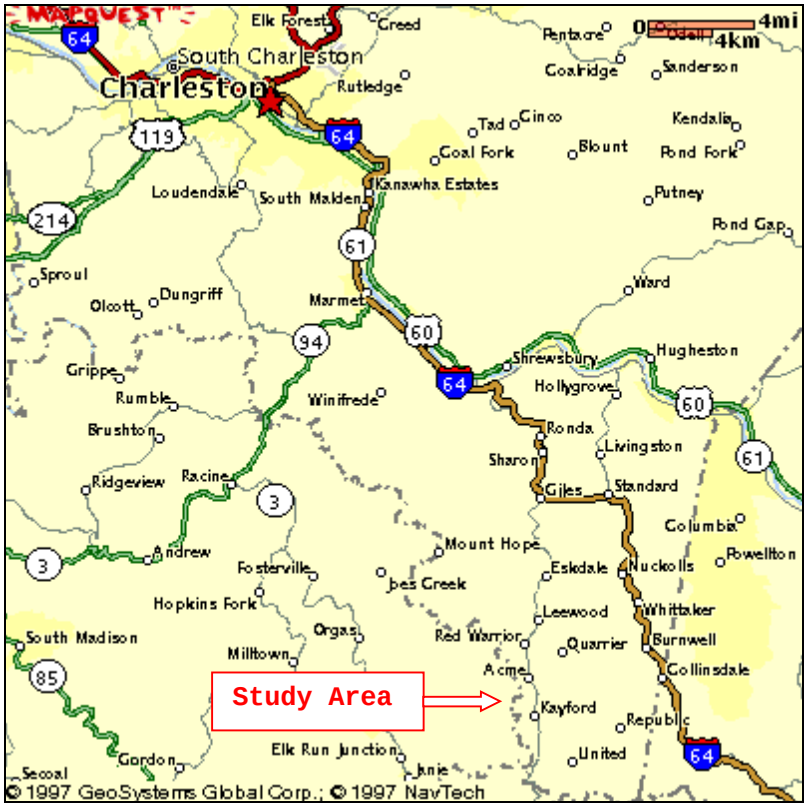
Topographic maps, aerial photographs and survey cross sections were used to formulate these hydrologic and hydraulic models.

This study was conducted under interagency agreement number 143868-IA98-1244, entitled “Model Analysis of Potential Downstream Flooding as a Result of Valley Fills and Large-Scale Surface Coal Mining Operations in Appalachia”, between the Office of Surface Mining Reclamation and Enforcement and the U.S. Army Corps of Engineers. The Samples Mine Valley Fill #1 was the first site studied. The other three were the Samples Mine Valley Fill #2, #1 and 2 combined and the Hobet Mine Westridge Valley Fill in Lincoln County, WV. Results from these other sites have been reported separately. The study was initiated 24 September 1998.

DESCRIPTION OF HYDROLOGIC AND HYDRAULIC MODELS

Drainage Area

The Samples Mine Valley Fill SH-1 is located in the headwaters of the Seng Creek (tributary to the Big Coal and Kanawha Rivers) watershed on the eastern side of Boone County on the boundaries with Kanawha and Raleigh Counties, WV. The valley fill drainage area occupies the most upstream 0.7 square miles (13%) of the 5.55 square mile Seng Creek watershed.



Precipitation

Precipitation depths were determined using the National Weather Service publications HYDRO35 and Technical Paper 40 (TP40). HYDRO 35 provides maps of rainfall depths for 5, 15 and 60 minute durations, and 2 and 100 year frequencies. Equations are provided to calculate the precipitation depths for other frequencies. TP40 provides maps of precipitation depths for 2, 3, 6, 12 and 24 hour durations, and 1 to 100 year frequencies.

The Samples Mine is located on the eastern side of Boone County, WV, and that location was used to determine the precipitation depths. The following table shows the precipitation depths determined from HYDRO 35 and TP40 for the study area:

Duration	Frequency [YR]	
	10	100
	Depth [IN]	
5 MIN	0.54	0.74
15 MIN	1.09	1.57
1 HR	1.86	2.70
2 HR	2.38	3.44
3 HR	2.68	3.76
6 HR	3.05	4.44
12 HR	3.53	5.06
24 HR	3.98	5.65

These values were used for the premining, during mining, post mining, AOC+ and future forested conditions.

Soil Types

The Boone County, WV, soil survey was used to determine the soil types located in the study area.

The Seng Creek watershed is contained within the Dekalb-Pineville-Guyandotte general soil unit. The soils within this unit are described as “very steep, well drained soils that formed mainly in material weathered from sandstone; on mountainous uplands”. The various soil types within this unit are the Cedarcreek-Rock outcrop (CgF), Dekalb-Pineville-Guyandotte association (DPF), Itmann channery loam (ImE), Kaymine-Rock outcrop complex (KrF), and Lily-Dekalb complex (LdE). The soil survey provides information on the detailed make up of the soil types, giving such information as component soil types, impervious area, etc.

The soil type subareas were traced onto the USGS topographic or regraded drainage maps for the premining, postmining, AOC+, and future forested conditions or the aerial photographs for the during mining condition; the areas of each soil type within the runoff subareas were determined by planimetering.

SCS Runoff Curve Numbers

The SCS runoff curve number (CN) method was used to convert precipitation depth into runoff excess. The curve number method is based on observable physical properties (soil and cover) of the runoff subareas.

A hydrologic soil group (HSG) characterizes the soil properties. The soil survey provides information on the detailed make up of the various soil types, making it possible to classify their component soils into HSG A (low runoff potential and high infiltration rates) through HSG D (high runoff potential and very low infiltration rates).

The cover takes into account the land use, vegetation type, surface treatment, etc.

The curve number is determined by the combination of the component soil types and cover. Curve numbers were selected from the tables published and provided by the SCS. It is possible to calculate areal weighted curve numbers for the overall soil types and each runoff subarea.

The curve number is also used to calculate the initial abstraction (all losses before runoff begins) for each runoff subarea. This initial abstraction (I_a) is defined as 20% of the maximum available retention capacity of the soil after the runoff begins.

Time of Concentration and Lag

The time of concentration (T_c) of each runoff subarea is the amount of time that it takes for runoff to travel from the hydraulically most distant point to the outlet. It is the sum of the travel times (T_t) through the components of the runoff system.

The SCS method provides procedures for computing three travel time components for the time of concentration calculations: 1) sheet flow, 2) shallow concentrated flow, and 3) open channel flow.

Sheet flow is the runoff that occurs over the surface of the ground prior to becoming concentrated into small gullies. It is limited, by definition in the SCS method, to a maximum of 300 feet from the most upstream drainage divide. Shallow concentrated flow occurs from the end of sheet flow until the runoff enters a channel, by definition a stream shown on a USGS map. Appropriate changes in slopes were incorporated into the calculations of sheet and shallow concentrated flows. HEC-HMS computed values for the 10 and 100 year flows were input to the HEC-RAS hydraulic model of the valley fill drainage area to provide travel times for the channel flow component. The undisturbed portion of Seng Creek was used for the open channel flow component for the subareas below the valley fill operation.

The sum of the three travel time components is the time of concentration for a runoff subarea.

Several flow routes were considered when calculating the time of concentration for each runoff subarea. The different routes were selected to maximize the effect of each of the three components on the time of concentration. They maximized the flow distances for each component; the flow route giving the greatest time of concentration was selected.

The lag (L) is defined as the time from the center of mass of the excess rainfall to the peak of the calculated hydrograph. The lag is defined and calculated by the SCS method as 60% of the time of concentration.

Base Flow

A base flow of 2 CFS/SM was adopted for each runoff subbasin. Since the base flow contribution to the volume and peak discharge is minor, the recession constant and threshold were estimated in the HEC-HMS model to be 1 (no recession) and 0 CFS, respectively. This gives a constant base flow value of 2 CFS/SM during the entire flow hydrograph.

Routing Reaches

A HEC-RAS hydraulic model was used to determine the required inputs for the hydrologic routing. This model was formulated using survey cross sections and topographic map information. Channel reach lengths and slopes were estimated from the mining company's 1:6,000 scale maps that had a contour interval of 20'. Cross section geometry, channel roughness, reach lengths, energy slopes and average travel times from the HEC-RAS model were used as input to the Muskingum-Cunge and Lag routing methods in the HEC-HMS models.

The HEC-HMS hydrology models route upstream flows through intervening runoff subareas, then combine routed flows and local runoff at the downstream end of the routing reaches. This hydrologic routing provides the translation of the flow hydrograph along the channels and the timing and attenuation that reflect the storage characteristics of the channel and overbank sections of the routing reaches.

The HEC-RAS model was formulated to add in the local runoff in five increments through each routing reach, increasing the channel flow progressing downstream. The HEC-HMS model results show that there was little change in the routed flow through the routing reaches, so this assumption of local flow increasing along a routing reach was not affected by routing considerations.

FUTURE FORESTED CONDITIONS

Drainage Areas

The future forested drainage area was delineated on a 1:6,000 scale regraded drainage map provided by the coal company. The future forested drainage area encompasses 0.74 square miles.

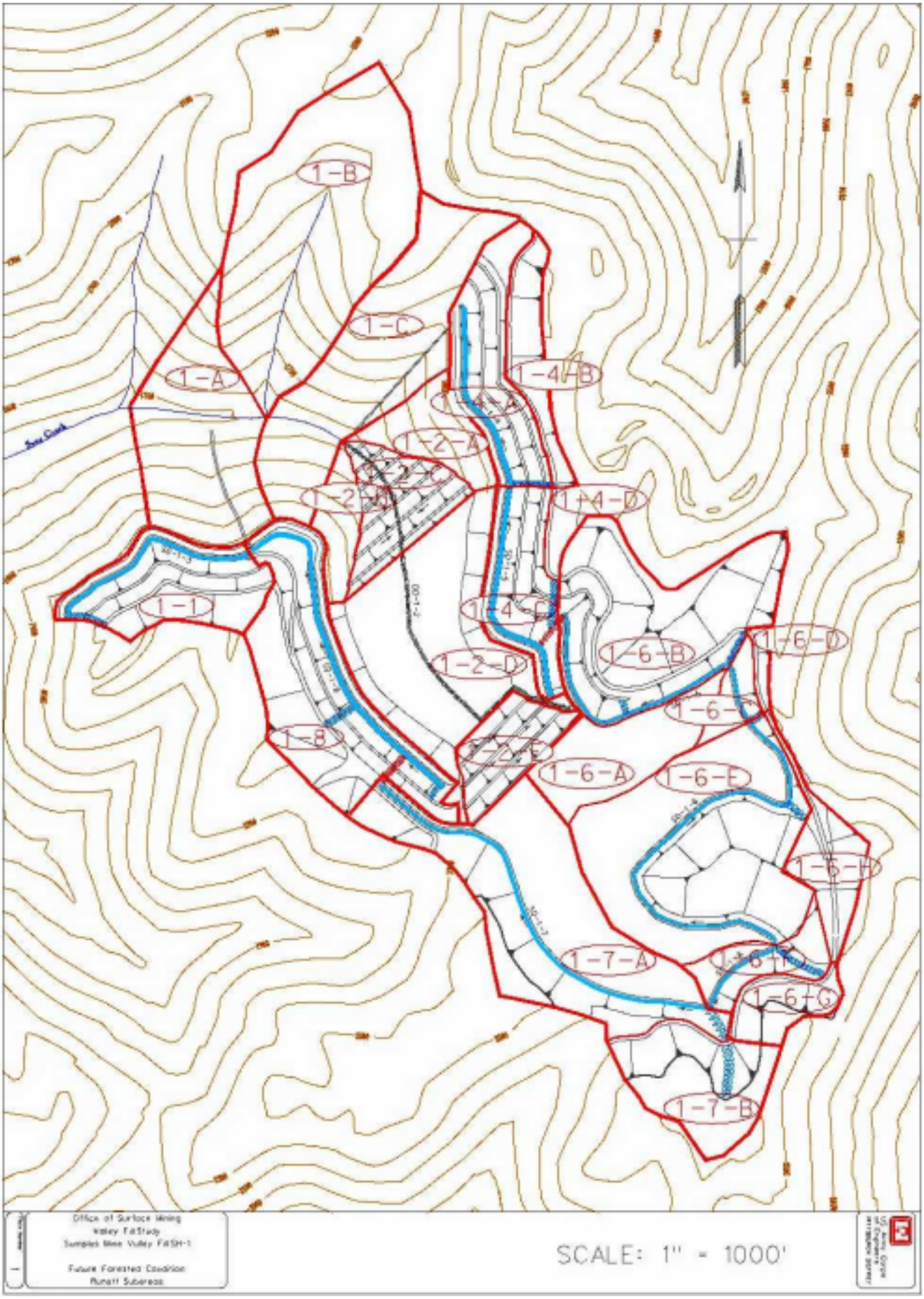
The drainage area was divided into fifteen runoff subareas to define the future forested condition. These subareas were selected to define tributary areas created by sediment and diversion ditches in the regrading plan and the hydrologic routing reaches connecting them. The downstream end of the drainage area is relatively unchanged from premining conditions; the unchanged land use, soil types and tributary justified further subdivision. The regraded drainage map shows that the future land use is forested valley fill and backstack areas for 72% of the drainage area.

The regraded drainage plan used sediment and diversion ditches to create four tributary areas. These four tributary areas were: 1) below the valley fill, 2) the valley fill area, 3) flows diverted around the left side of the valley fill, and 4) flows diverted around the right side of the valley fill. The following table shows the runoff subareas for the future forested condition:

Runoff Subarea	Description	Area		
		[ACRES]	[MI^2]	[%]
1-A	Most downstream area	29.78	0.05	6.3
1-B	Right bank tributary	53.48	0.08	11.2
1-C	Subarea below valley fill	36.06	0.06	7.6
1-2-A	Right abutment of lower valley fill	7.21	0.01	1.5
1-2-B	Left abutment of lower valley fill	6.34	0.02	1.3
1-2-C	Face of lower valley fill	12.00	0.02	2.5
1-2-D	Top of lower valley fill	37.23	0.06	7.9
1-2-E	Face of upper valley fill	9.55	0.01	2.0
1-1	Downstream left diversion area	18.37	0.03	3.9
1-8	Middle left diversion area	32.37	0.05	6.8
1-7-AB	Upstream left diversion area	61.39	0.10	12.9
1-4-AB	Downstream right diversion area	25.36	0.04	5.4
1-4-CD	Middle right diversion area	16.89	0.03	3.5
1-6-AD	Middle right diversion area	57.05	0.09	12.0
1-6-EH	Upstream right diversion area	71.49	0.10	15.2
Total		474.57	0.74	100

This area represents an 8% increase from pre to future forested conditions and mainly reflects differences in the regraded topography on the southwest side of the drainage area.

Plate 1 shows the runoff subareas.


1-B
1-C
1-A
1-4-B
1-4-A
1-2-A
1-2-C
1-2-B
1-4-D
1-1
1-4-C
1-6-B
1-6-D
1-2-D
1-6-C
1-8
1-2-E
1-6-A
1-6-E
1-6-H
1-7-A
1-6-F
1-6-G
1-7-B
Office of Surface Mining
Valley Fill Study
Sumpter Mine Valley Fill SH-1
Future Forested Condition
Runoff Subareas
SCALE: 1" = 1000'

Soil Types and SCS Runoff Curve Numbers

The regraded drainage map shows the area that was covered by the valley fill and regraded backstacks. These areas were considered to be future forested (FF) areas. The future forested conditions represent a 20 year forestry plan which covers the reclaimed surface mine areas with appropriate trees.

The following table shows the soil types and their percent distribution within the runoff subareas for the future forested condition:

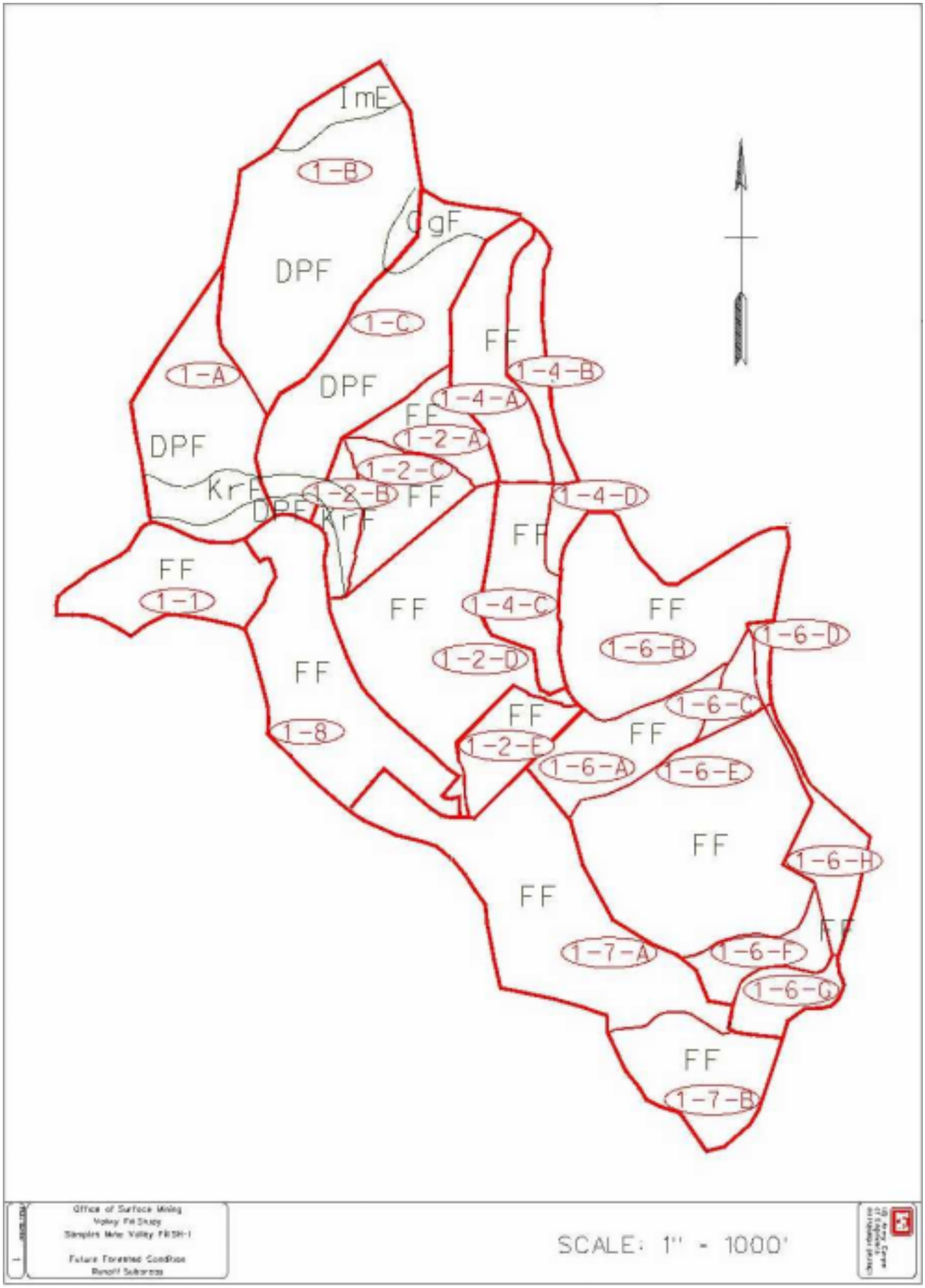
Runoff Subarea	Soil Type				
	CgF	DPF	ImE	KrF	FF
	Percent Distribution				
1-A		77.8		22.5	
1-B	1.9	88.9	9.2		
1-C	13.0	82.0		5.0	
1-2-A		100			
1-2-B		66.4		33.6	
1-2-C					100
1-2-D					100
1-2-E					100
1-1					100
1-8					100
1-7-AB					100
1-4-AB					100
1-4-CD					100
1-6-AD					100
1-6-EH					100
Total	1.2	23.5	1.0	2.2	72.1

Plate 2 shows the soil type subareas.

This table shows that future forested areas make up the majority (72%) of the land use in the drainage area.

The land use for the undisturbed portion of the valley fill drainage area is wooded with a fair hydrologic condition due to its disturbance by previous logging and surface mining activity.

The following table shows the results of the weighted curve number calculations for the future forested condition:


ImE
1-B
CgF
DPF
1-C
FF
1-4-B
1-A
DPF
1-4-A
FF
1-2-A
DPF
1-2-C
KrF
1-2-B
FF
1-4-D
DPF
KrF
FF
FF
1-1
FF
1-4-C
FF
1-6-B
1-6-D
1-2-D
FF
1-6-C
FF
1-8
FF
1-2-E
1-6-A
1-6-E
FF
1-6-H
FF
FF
1-7-A
1-6-F
1-6-G
FF
1-7-B
Office of Surface Mining
Valley Fill Study
Samples Mine Valley FILSH-1
Future Forested Condition
Runoff Subareas
SCALE: 1" = 1000'

Runoff Subarea	Weighted CN	% Impervious	I_a [IN]
1-A	67	3.3	0.99
1-B	67	0.3	0.99
1-C	67	2.7	0.99
1-2-A	64		1.13
1-2-B	66	5.1	1.03
1-2-C	71		0.82
1-2-D	71		0.82
1-2-E	71		0.82
1-1	71		0.82
1-8	71		0.82
1-7AB	71		0.82
1-4-AB	71		0.82
1-4-CD	71		0.82
1-6-AD	71		0.82
1-6-EH	71		0.82

Time of Concentration and Lag

The regraded drainage map was used to define the distance for sheet flow. The runoff was considered to have concentrated once it encountered a road or bench and continued to flow downslope to a sediment ditch. The sediment ditches were considered the open channel portion of the flow components.

The following table shows the results of the time of concentration and lag calculations for the future forested condition:

Runoff Subarea	Frequency [YR]			
	10		100	
	Time of Concentration	Lag	Time of Concentration	Lag
	[MIN]			
1-A	18	11	18	11
1-B	35	21	33	20
1-C	25	15	25	15
1-2-A	15	9	15	9
1-2-B	14	8	14	8
1-2-C	14	8	12	7
1-2-D	41	25	39	23
1-2-E	24	14	22	13
1-1	38	23	35	21
1-8	33	20	30	18
1-7-AB	84	50	77	46
1-4-AB	17	10	15	9
1-4-CD	27	16	26	16
1-6-AD	69	41	66	40
1-6-EH	67	40	58	35

Base Flow

The future forested condition base flow values were as follows:

Runoff Subarea	Area [MI^2]	Base Flow [CFS]
1-A	0.05	0.09
1-B	0.08	0.17
1-C	0.06	0.11
1-2-A	0.01	0.02
1-2-B	0.01	0.02
1-2-C	0.02	0.04
1-2-D	0.06	0.12
1-2-E	0.01	0.03
1-1	0.03	0.06
1-8	0.05	0.10
1-7-AB	0.10	0.19
1-4-AB	0.04	0.08
1-4-CD	0.03	0.05
1-6-AD	0.09	0.18
1-6-EH	0.10	0.22

Routing Reaches

The valley fill drainage area was divided into fifteen runoff subareas to model the future forested condition. Fifteen reaches connected the runoff subareas and routed the flows through the drainage area.

Two methods of hydrologic routing were used to route the runoff flows through the drainage area. The Lag method was used for channels with slopes greater than 10% (flumes, natural drains and channels down the sides of the valley fill); the amount of lag was taken as the average travel time through the reach from the HEC-RAS model. Since these channels have little if any storage they were modeled to translate the flow hydrograph with no attenuation. The Muskingum-Cunge method was used to route the runoff flows through the flatter sloped (2%) sediment and diversion ditches and the undisturbed portion of the drainage area. This method has the advantage over others of using physically based parameters that can be modified to represent changes to the watershed conditions.

HYDROLOGIC AND HYDRAULIC MODEL RESULTS

The HEC-HMS hydrology models were formulated to calculate the outflow from the Valley Fill #1 drainage area at the downstream permit limit.

The HEC-RAS hydraulic model was formulated to calculate the corresponding stages. Survey sections were taken and approximately 800′ of the undisturbed Seng Creek channel downstream of the permit limit was modeled. The flows from the HEC-HMS model were used to perform the backwater analysis.

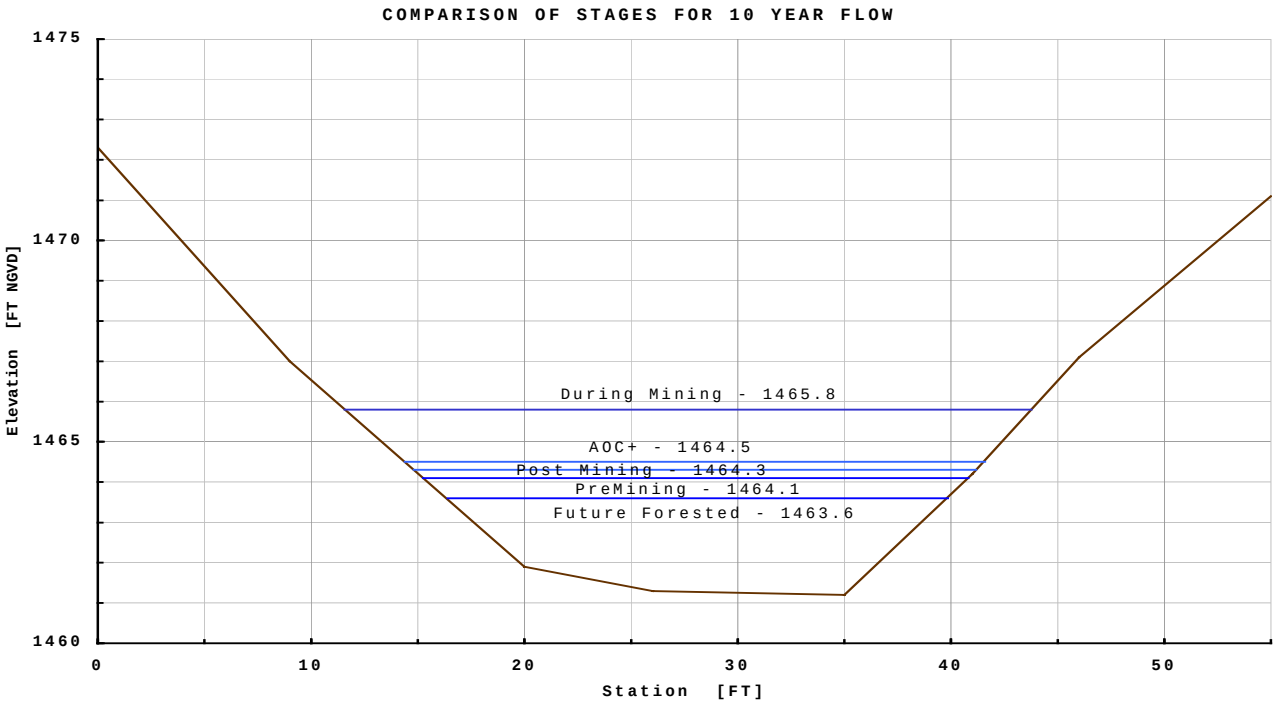
The following tables show the 10 and 100 year flows and water surface elevations:

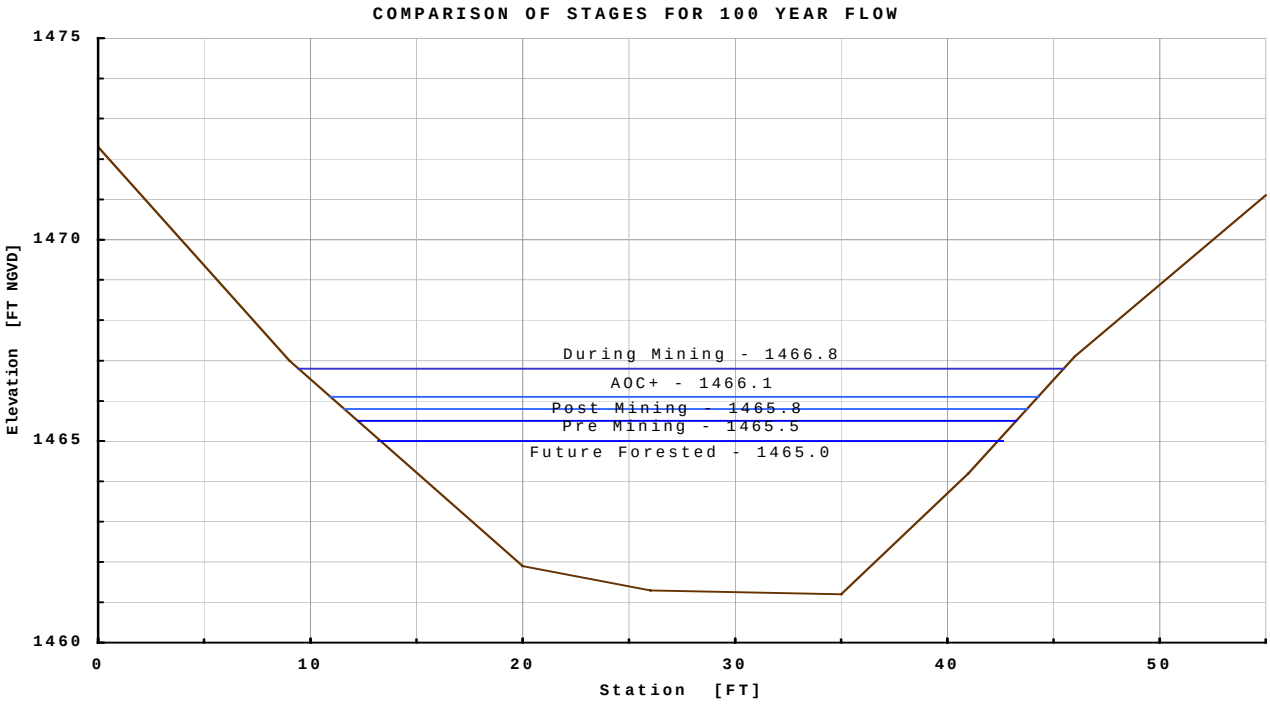
Frequency [YR]	Pre Mining		During Mining		Post Mining	
	Flow [CFS]	Elevation [FT NGVD]	Flow [CFS]	Elevation [FT NGVD]	Flow [CFS]	Elevation [FT NGVD]
10	330	1464.1	525	1465.8	376	1464.3
100	742	1465.5	931	1466.8	832	1465.8

Frequency [YR]	AOC+		Future Forested	
	Flow [CFS]	Elevation [FT NGVD]	Flow [CFS]	Elevation [FT NGVD]
10	432	1464.5	246	1463.6
100	932	1466.1	580	1465.0

These results show a 25-59% (10-100 YR) increase in discharge from premining conditions as the area is disturbed during mining operations; this decreases to about 13% after the area is reclaimed in the post mining conditions. The stage increases by 1.3-1.7′ from pre to during mining operations; this decreases to about a 0.2-0.3′ increase for pre to post mining conditions. The AOC+ conditions would cause a 31-26% (10-100 YR) increase in discharge and a 0.4-0.6′ increase in stage from premining conditions. The future forested conditions would cause a 25-22% (10-100 YR) decrease in discharge and a 0.5′ decrease in stage from the premining conditions.

The following cross sections show comparisons of the water surfaces for each condition.


COMPARISON OF STAGES FOR 10 YEAR FLOW
1475
1470
1465
1460
Elevation [FT NGVD]
During Mining - 1465.8
AOC+ - 1464.5
Post Mining - 1464.3
PreMining - 1464.1
Future Forested - 1463.6
0
10
20
30
40
50
Station [FT]


COMPARISON OF STAGES FOR 100 YEAR FLOW
1475
1470
1465
1460
Elevation [FT NGVD]
During Mining - 1466.8
AOC+ - 1466.1
Post Mining - 1465.8
Pre Mining - 1465.5
Future Forested - 1465.0
0
10
20
30
40
50
Station [FT]

CONCLUSIONS

1. The SCS, HEC-HMS and HEC-RAS methods are appropriate for computing flows and stages from a valley fill operation.

2. The information typically contained in a permit application is suitable for hydrologic and hydraulic analysis. Some interpretation of the information, aerial photos and maps is required.

3. Required additional information about soil types is available from soil surveys.

4. Field views are required to determine the type and extent of cover for HEC-HMS, to verify drainage routes, etc.

5. Field surveys are required to determine channel size and compute stages in HEC-RAS.

6. Subdivision of the valley fill area by soil type, slopes, etc, is required to model the runoff characteristics of each subarea. Subdivision will increase the complexity of the hydrologic and hydraulic models.

7. It is not possible to generalize the impacts of changes to the drainage area on the discharge. Changes to the topography, soils, land use, vegetation will cause corresponding changes to the discharge. Changes to the flow paths will affect the discharge by changing the runoff time of concentration, flow routing times and hydrograph combination.

8. Differences in stages are very site specific and may depend on conditions in receiving streams. Stage differences cannot be translated up or down stream away from the computed location and results should not be generalized. Unchanged watershed and channel downstream of a valley fill operation may tend to return stages to the premining condition.

9. This study shows that an ongoing valley fill operation will increase the discharge from 25-59% (10-100 YR) from premining conditions; this decreases to about 13% after the area is reclaimed in the post mining conditions. The stage increases by 1.3-1.7’ from pre to during mining operations; this decreases to about a 0.2-0.3’ increase for pre to post mining conditions. The AOC+ conditions would cause a 31-26% (10-100 YR) increase in discharge and a 0.4-0.6’ increase in stage from premining conditions. The future forested conditions would cause a 25-22% (10-100 YR) decrease in discharge and a 0.5’ decrease in stage from the premining conditions.

RECOMMENDATIONS

1. Recording streamflow and rainfall gages should be installed and maintained in a valley fill area from before mining begins until after the area is reclaimed. Data logger type streamflow gages should be installed at good hydraulic control points and be set to record at five minute intervals. Tipping bucket type rainfall gages should be located to capture representative rainfall amounts. A formal maintenance and data retrieval/reduction plan should be established. Analysis of actual rainfall/runoff relations should be conducted.

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