DEGRADATION AND SCOUR ANALYSIS

CHANNEL IMPROVEMENTS FOR CAVE CREEK WASH
REALIGNMENT FROM BELL ROAD TO UNION HILLS
REQUIRED FOR CITY OF PEOENIX PROJECTS:

7TH AVENUE BRIDGE AT CAVE CREEK WASH (BR-860916)
7TH AVENUE PAVING; BELL TO UNION HILLS (ST-874800)
STORM DRAIN FROM BRIDGE TO BEARDSLEY INCLUDED

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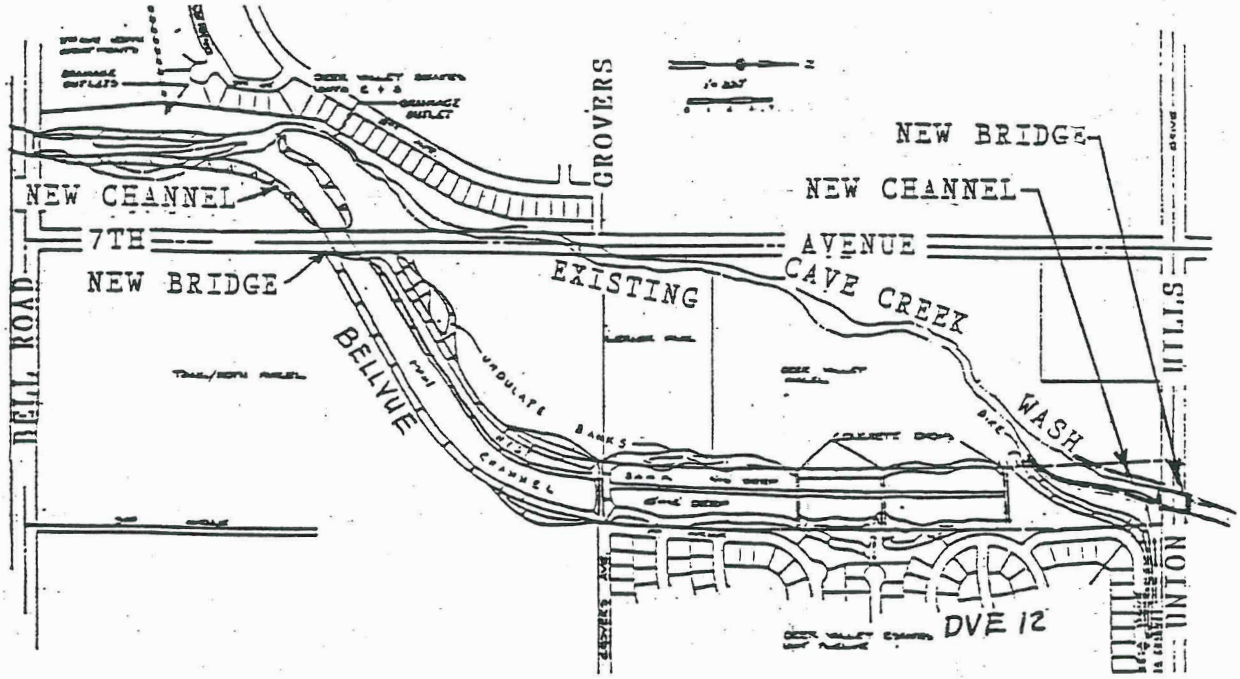

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ABBREVIATIONS USED FOR CITY OF PHOENIX
CAVE CREEK CHANNEL & BRIDGE PROJECT BR-860916

AEC - Amwest Engineering Company

Bellvue Channel - Sand and gravel mining excavated the Wash from 7th Ave to Grovers. Bellvue subdivision now adjacent.

BOR - Bureau of Reclamation Technical Guidelines for Computing Degradation and Local Scour (Manual)

COP - City of Phoenix, Arizona.

Degradation - The long-term process by which stream beds are lowered in elevation due to the removal of material by flowing water.

DVE 12 Channel - Deer Valley Estates Unit 12 (south of Union Hills Dr) and the excavation for future Cave Creek Channel.

EL - elevation in feet above mean sea level.

FCD - Maricopa County Flood Control District.

FIS - Flood Insurance Study authorized by FEMA.

FL - Flowline of Wash, channel, culvert, pipe, etc.

Input - (also coding) data entered into a computer to be used for calculation of HEC-2 water surface elevations.

Model - The coded data entered in a HEC-2 computer program.

Q - Quantity of storm flow in cubic feet per second.

R/W - Drainage Right of Way dedicated to COP.

Scour - The enlargement of a flow section by the removal of boundary material through the action of fluid motion during a single discharge event.

Second Level - Area 5'± above bottom EL west of deep channel (see typical cross section on page 2.)

SECTION - Cross section on location map shows deep bank, bottom lower bank, 2nd level, higher bank.

UH DR - Union Hills Drive at north end of DVE 12.

WS - Water surface elevation of a specified storm flow.

Wash - Term used herein will relate only to Cave Creek Wash.

Note: The location of these features are on Report Cover.

ANALYSIS OF SEDIMENT PROBABILITY

The flow regime of the wash is intermittent with long dry periods. This condition does not attain an equilibrium state found in continuous flow streams where processes of degradation and aggradation are relatively at a standstill. The state of stream equilibrium is expressed by the following equation:

$$Q_s D_m = k\ Q_b S_b \qquad (1)$$

$$Q_s = k\ Q_b \left(\frac{S_b}{D_m}\right)$$

where:

Q_s = Bed material discharge
D_m = Effective diameter of bed material mixture
Q_b = Water discharge to determine bedload transport
S_b = Slope of the streambed
k = Constant of proportionality

The Wash design slope is very flat at less than 0.001 in most reaches. The Dm for the wash is 3"± (75 mm). Therefore, Qs is small in this area of very small Sb and large Dm ie Sb/Dm = 0.00005.

Many field investigations of the wash and realigned channels were made from 1980 until 1994. Some sediment deposits were found at the following locations marked on the map on the next page.

(1) Downstream Of the bend in the east bank where currents crossed the main channel stream lines and developed eddies, ripples and turbulence. Deposits 1'± deep occurred in the 200'± from bend confluence to Bell Rd bridge.

(2) Curve in Wash south of Grovers where bottom got wider and 1'± deep sediment collected from the slower velocity flow on the inside of the curve.

(3) Sediment deposits were found after storm water dried in the 7th Ave dip at Grovers where Wash bottom width changed from 20'± to over 100' on the pavement to 20'±.

(4) Downstream of the UH DR pipe culvert where high velocity flow through the culvert and over the road dip slowed quickly in the 40'± wash bottom. COP maintenance crews grade the bottom periodically and no sample of long term sediment is allowed to collect.

All other reaches in the wash show no sediment on the large cobble and boulder armor layer on the bottom. The four sediment locations described above will be eliminated by this project.

(1) The bend in the east bank has been filled and the new channel banks are straight. Flow stream lines no longer criss-cross and disrupt the steady, tranquil current. The sediment load will not deposit north of the bridge. Past storms have left 1.5'± deposits of material under the bridge. The material is

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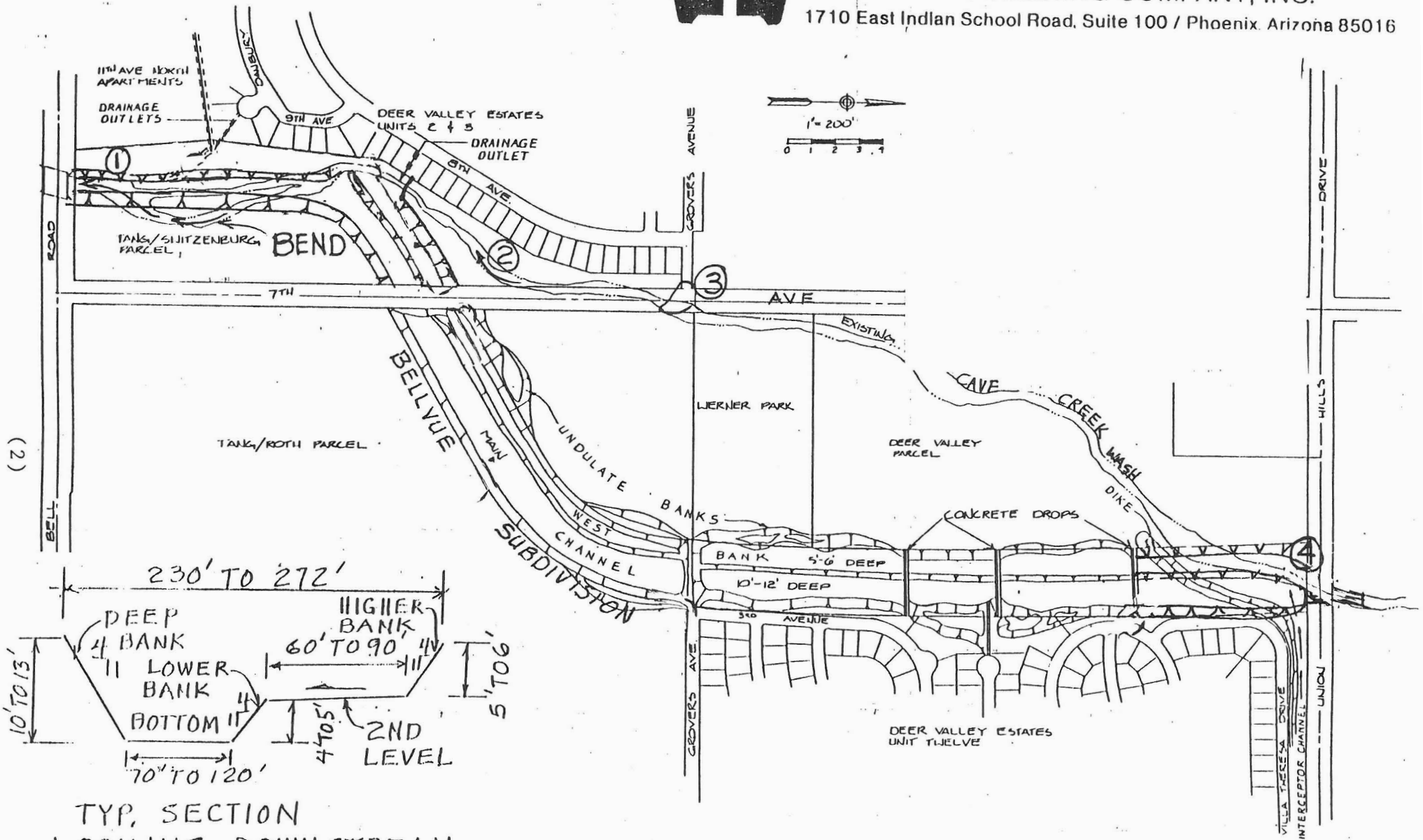


TYP. SECTION
LOOKING DOWNSTREAM
(SOUTH)

SEDIMENT LOCATION MAP
CAVE CREEK CHANNEL
BELL ROAD TO UNION HILLS DRIVE

(2)

coarse gravel and small stones. Very little fine sand or silt is on the surface indicating wash flow has carried away the sediment and does not deposit new layers since the bend was filled.

(2) The curve south of Grovers will not convey Wash flow after the DVE 12 and Bellvue channels are open.

(3) The dip at Grovers will be filled for a level intersection.

(4) The UH DR bridge will replace the pipe culvert and high velocity flow will be directed straight into the DVE 12 channel with a smooth expansion to a steady, uniform flow state.

Sheet flows across the wide area contributing storm water run-off to the wash will carry colloidal silt but the steady, uniform flow will transport the sediment load from UH DR to Bell Rd and is not expected to deposit any significant layer of fines in this reach.

CHANNEL DEGRADATION PROCESS

The smallest particles transported in Wash flow from a previous storm will settle in a thin layer on the bottom and will be picked up by the next flow, leaving coarser material on the stream bed. The type of bed material also dictates the approach used in estimating the depth of degradation. The BOR manual explains the two methods of calculations as follows:

"Situations where the streambed is composed of transportable material extending to a depth greater than that to which the channel can be expected to degrade, the approach most useful is that of computing a stable channel slope, the volume of expected degradation, and then determining a three-slope channel profile which fits these values. However, in situations where the bed material includes a sufficient quantity of large size or coarse material which cannot be transported by normal river discharges, the best approach is to compute the depth of degradation required to develop an armoring layer. The formation of the armoring layer usually can be anticipated to control vertical degradation when approximately 10 percent or more of the bed material is of armoring size or larger. This layer develops as the finer material is sorted out and transported downstream. Vertical degradation occurs at a progressively slower rate until the armoring layer is of sufficient depth to inhibit the process."

BED MATERIAL FACTOR IN DEGRADATION

In the Wash, the armor layer covers the bottom and similar material is found 1.5'± deep to the excavated design FL EL. A photo of a typical area of Wash bottom at TAB A shows the armor layer that is continuous throughout the Bell Rd to UH DR reach. A second photo shows the same material at 1.5'± below the existing bottom. The design FL EL is only about 1.5'± deeper than existing FL.

The new channel from Wash to 7th Ave has already been excavated 7'± deep for a drainage outlet ditch west of the bridge detour. The TAB A photo of the ditch bottom shows very coarse gravel and many cobbles 6"±. The small amount of fine sand will be carried away when the first flow occurs and leave only material larger than transportable size. A second photo of the ditch shows that the bank material has the same percentage of large cobbles as found on the bottom. The design excavated FL is 4'± deeper than the ditch bottom and the same gradation of very coarse gravel and cobbles is expected on the final channel bottom.

The Bellvue channel bottom photo at TAB A shows the material remaining after gravel mining for rock crushing. This bottom is 11'± below the ground surface on both sides. The design FL EL will be cut 1'± deeper. The gradation appears to have a higher percent of larger rocks over 6". The material on the bottom after the 1'± excavation is expected to be the same. A second photo on the Bellvue channel bank shows the same rocky surface.

The DVE 12 channel was also excavated by a gravel mining/rock crushing operation and the material remaining on banks and bottom is the same as Bellvue channel. Drainage from the subdivision has ponded on the bottom at 1' - 2' deep many times in the 10 years since the channel was completed and a layer of transportable material has collected at 3"± deep. The bottom will be cleared and grubbed to remove the dense brush. The layer of dirt will be mixed in with the bed material after the clear and grub is completed. The project special provisions have a requirement to spread coarse material on the bottom after the clear and grub operation and wheel roll the surface to compact the gravel and cobbles by pneumatic tire pressure. The coarse layer can be provided by the dike removals at Grovers and south of Union Hills. (See Special Provisions at TAB A). This layer of coarse material will make the DVE 12 bottom similar to Bellvue channel.

The examples of bed material at the design FL EL shown in photos, analyzed on field investigations and confirmed by soils reports is homogeneous in the wash (gravel, cobbles, and boulders over 12"). The bed material in the realigned channel cut from Wash to 7th Ave, the Bellvue Channel and DVE 12 Channel is also homogeneous with a higher percentage of coarse gravel and 6"+ cobbles but not as many boulders. BOR manual recommends "When the channel bed contains more than 10% of coarse material which cannot be transported under dominant flow conditions, armoring will develop." Wash bed material gradation is 50% less than 1.5" (33.0 mm), 90% less than 4" (102 mm). Bellvue channel is 50% less than 1.5" (33 mm) and 90% less than 3" (75 mm). The Table of Non-Scour Velocities after the photos at TAB A classifies 0.6" material as medium gravel, 1" as coarse gravel, 3" as small cobbles, 4" as also in the small cobbles range, over 10" as boulders.

STORM FLOW FACTOR IN DEGRADATION

Formation of an armoring layer at the maximum depth of degradation is determined by flow, amount of armor material and controls to prevent erosion lower than a fixed depth. This project has many control features across the channel bottom. Starting downstream of the Bell Rd bridge is an existing cut-off wall for rock lining in Bell Rd Autopark. Upstream of the bridge will have a cut-off wall at soil cement Drop No. 1. Another cut-off wall for soil cement Drop No. 2 will be installed 400'± upstream. Cut-off walls 70'± downstream and 170'± upstream of the 7th Ave bridge will protect the edges of soil cement lining at Drop No. 3 and the rock patterns across the bottom. Deep cut-off walls will be part of the bridge concrete floor. The DVE 12 channel already has 3 existing concrete drop structures. Cut-off walls north and south of the UH DR bridge will be installed by a separate project. All these channel controls limit the degradation process to a maximum of a few inches. The FL slope between fixed EL controls at cut-off walls is 0.0009± and the bottom EL only changes 0.1' every 200 LF.

Other factors in degradation flow analysis are Q and V. The design channel has a standard trapezoidal deep section with smooth transitions of bottom width. Therefore, the flow regime is steady, uniform unaccelerated flow except at drops where the channel is lined to prevent erosion. Significant flow occurs only during large storms and the channel will be dry most of the year. Both the volume and distribution of the change in flow can be illustrated by use of a flow duration curve. The flow duration curve is a cumulative frequency relationship, usually used to represent long term conditions, that shows the percent of time that specific discharges were equalled or exceeded in a given period. The approach described in BOR manual for computing degradation utilizes the dominant discharge method for representing water discharge.

Dominant discharge is defined as the discharge which, if allowed to flow constantly, would have the same overall channel shaping effect as the natural fluctuating discharges as illustrated by the flow duration curve. The dominant discharge used in channel stabilization work usually is considered to be either the bank full discharge or that peak discharge having a recurrence interval of approximately 2 years on an uncontrolled stream. When stream flow is regulated by an upstream dam, and releases from the reservoir fluctuate considerably due to incoming floods, the mean daily discharge derived from an operation study which is equalled or exceeded on the average of once every 2 years can be considered as the dominant discharge.

Cave Buttes Dam was built to control flow in Cave Creek by storage of storm water to increase time of peak Q until rainfall intensity was reduced. Dam release for a storm will not occur until the reservoir storage is near capacity. The FIS hydrology accounts for delayed time of peak to determine 100 year Q = 5,700 cfs and 10 year Q = 3300 cfs. There is no dominant discharge average 2 year flow that has the same effect as a continual fluctuating discharge.

A 2 year frequency flow can be determined but the flow is small and intermittent.

Therefore, the bank full discharge will be used for dominant discharge as a predetermined Q. The deepest flow area in DVE 12 and Bellvue channels was designed to carry 2,000 cfs without overflow on the second level. The results of input Q of 2,000 cfs in the Cave Creek HEC-2 model are at TAB B. The results show the following V at dominant discharge:

REACH		V min fps	V max* fps	Dominant Discharge
I	Bell Rd to 7th AVE	3.3 fps	4.1	3.7
II	Bellvue channel	3.6 fps	4.2	3.7
III	N&S of Grovers	3.3 fps	5.0	4.0
IV	DVE 12 channel	2.9 fps	3.5	3.2

*V max in unlined channel, not at soil cement drops.

DEGRADATION CALCULATION METHOD

Two techniques, either the armoring or limiting slope method, are recommended in BOR manual. For general degradation, the armoring method is tested first because a sediment transport study may not be necessary with a resulting savings in time and cost for computations. If the armoring method is not applicable, then the stable slope method is used.

The previous information in the BED MATERIAL FACTOR IN DEGRADATION section of this report determined that all reaches are very coarse grain sized. Therefore, only the armoring calculations are necessary. BOR manual table 3, at TAB A defines limiting V for material in this channel as 5 - 6 fps. The Wirth Report Master Development Plan for Cave Creek adopted by the COP council in 1982 has a "TABLE XV, Maximum Permissible Velocity For Unlined Channels", also at TAB A that shows 6.5 fps for this bed material. One other table of non-scour velocities for Soils at TAB A (Table 17 in AEC Final Project Report, 1992) shows very coarse gravel at dominant discharge depth between 4.7' to 6.6' will withstand V = 5.5 fps. BOR Manual Table 8 at TAB A also shows when depth of flow is between 5 and 10', the highly resistant coarse bed material will stand V of 5.9 to 6.6 fps.

CALCULATIONS OF MATERIAL SIZE FOR ARMORING

When the channel bed downstream from a dam contains more than 10 percent coarse material which cannot be transported under dominant flow conditions armoring will in time develop. BOR manual recommends five methods to compute armoring grain size and then use either an average of the five methods or a judgement decision on the best method to calculate the probable vertical degradation before stabilization is reached. The five methods are:

1. Meyer-Peter, Muller (bedload transport equation)

2. Competent bottom velocity

3. Lane's tractive force theory

4. Shields diagram

5. Yang incipient motion

Each method results in a different armoring grain size for each Reach. The average of all five results is used to calculate the vertical degradation before an armoring surface stabilization is reached. The calculations are also at TAB B. A summary of results follows:

METHOD TO CALCULATE NON-TRANSPORTABLE GRAIN SIZE	RESULTS FOR REACH (mm) I	II	III	IV
1. Meyer-Peter, Muller	13.7	12.7	18.4	12.6
2. Competent Velocity	25.7	25.7	30.0	19.2
3. Lane's Force	22.0	23.0	33.0	25.0
4. Shield Diagram	15.3	15.9	27.0	18.7
5. Yang Motion	27.5	27.5	32.0	20.7
Average	20.8	21.0	28.0	19.2
Depth of degradation (inches)	0.8	0.8	1.7	0.57

This insignificant degradation depth will only require one or two large storms to complete armoring of the entire reach. Therefore, volume of material removed by degradation is also insignificant.

CHANNEL SCOUR DURING PEAK FLOOD FLOWS

In most studies, two processes must be considered, (1) natural channel scour, and (2) scour induced by structures placed by man either in or adjacent to the main river channel. Natural scour occurs in any moveable bed river but is more severe when associated with restrictions in river widths, caused by morphological channel changes, and influenced by erosive flow patterns resulting from channel alinement such as a bend in a meandering river.

Only a few examples of scour were found during the many Wash investigations from 1980 to 1994. A photo at TAB C shows some scour at the east bank upstream of the Bell Rd bridge. The rocky bed material has stopped the scour and only caused a slightly steeper slope at the toe of the east bank. A 2'± deep scour hole formed at the downstream end of the existing culvert under UH DR where only a 4'± wide strip of concrete was poured on the bottom for scour

protection. This problem is eliminated by the extensive concrete and rock lining under the new UH DR bridge.

Although each scour problem must be analyzed individually, there are some general flow and sediment transport characteristics to be considered in making the judgmental decision on methodology. A large sediment load on scour is characteristic of transport associated with a high peak, short duration flood hydrograph. Channel scour also occurs when velocities in portions of the channel cross section transport the bed material at a greater rate than replacement materials are supplied. Thus, maximum depth of channel scour during the flood is a function of the channel geometry, obstruction created by a structure (if any), the velocity of flow, turbulence, and size of bed material.

The typical cross section of the design improvements for this project shown on page 2 of this report can be described as, "a wide bottom, trapezoidal channel, 4:1 side slopes, smooth transitions in width, large radius curves, no meander bends and very coarse grain bed material." Therefore, the design channel will not have any locations where severe scour can be expected.

Because of the complexity of scouring action as related to velocity, turbulence, and bed materials, it is difficult to prescribe a direct procedure. BOR recommends to compute scour by several methods and utilize judgement in averaging the results or selection of the most applicable procedures. Separate methods are used for channel scour and scour at mid-stream structures. Types of scour are classified as:

Type A - Channel with restrictions and bends
Type B - Channel with bank line structure
Type C - Mid channel structures (bridge piers)
Type D - Hydraulic structures across channel (drops).

Scour is computed from the average channel hydraulics for a reach. If a structure restricts the river width, scour is computed from the channel hydraulics at the restriction. In all cases, scour estimates should be based upon the portion of discharge in and hydraulic characteristics of the main channel only. The 100 year HEC-2 results at TAB C are used to select Q and V in the main channel.

METHODS OF CHANNEL SCOUR CALCULATIONS:

The channel realignment has a standard cross section with smooth transitions in width as described above. Width transitions at bridges and at side drainage channels also feature bank and bottom lining, ie concrete, rock or gabion banks and soil cement bottom. The channel at Grovers has hydraulic conditions with the highest possibility for scour. The conditions are:

(1) bottom width narrows from 131′ (HEC-2 SECTION 21.44) to 115′ (HEC-2 SECTION 21.39)

(2) FL slope is steeper than other locations at 0.0023.
(3) V = 6.49 fps at 6.42 depth at 100 YR Q.
(4) Gabions will be installed on the east bank.
(5) The bottom will not be lined but will have a 3" coarse gravel layer embedded (see specifications at TAB A). Other reaches have heavy armor bed material.

The natural channel scour shown on the typical section at TAB C is not applicable to this project. All cross sections will be cut to trapezoidal bottom where dm is constant across the main channel. However, the methods to calculate scour are applicable. Scour calculations are based on data from the 100 yr storm HEC-2 printout at TAB C.

The four methods supplemented with BOR procedures are:

(1) Field measurements of Scour Method
(2) Regime Equations Using Survey Cross Sections Method
(3) Mean Velocity Using Survey Cross Section Method
(4) Competent or Limiting Velocity Control of Scour Method

Method (1) was developed to analyze scour for FL slopes 0.006± or greater and wide, sandy bottom washes and is not applicable to this project.

Method (2) by Neill requires cross section data, bank full Q and flood depth. BOR manual has selected the basic equation expanded by Lacey and Blench. The mean depth (Lacey) and zero bed sediment depth (Blench) are multiplied by a Z factor from Table 7 to get scour depth.

Method (3) uses the mean depth from HEC-2 results and the Lacey Z factor for scour depth. BOR manual considers a calculated n factor derived from bed material particle diameters and HEC-2 results compared with known depth at measured Q. No depth has been measured in the realigned channel.

Method (4) uses a graph derived by Neill to select competent velocity (Vc) to start erosion for various flow depth and bed materials. Scour depth is determined by an equation relating mean velocity to Vc and HEC-2 mean depth.

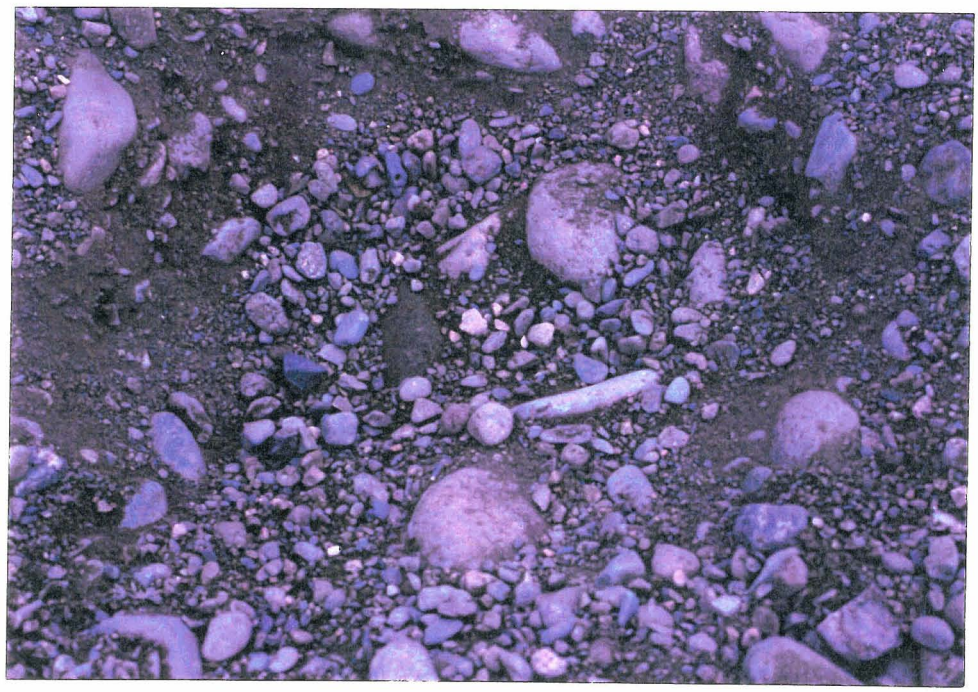
Calculations of channel scour at Grovers (most possibility for scour) are at TAB C. All other reaches have less possibility for scour, ie constant width, flat FL slope, lower V, no bank structures, more coarse bed material. The estimated average scour at Grovers from TAB C is 1.32′. Scour in other reaches is estimated to be half as deep. Channel scour will not be a problem for this project because V in other reaches are closer to 5 fps and the bottom is lined with soil cement where V = 7′± at drops.

METHODS OF BRIDGE PIER SCOUR CALCULATIONS

Numerous empirical relationships for computing scour at bridge piers include hydraulic parameters of (b) pier width, (sk) skew, (dm) flow depth, (V) velocity, (Dm) bed material size. The calculation methods are grouped as (1) regime or (2) rational. The diagram at TAB C, Sheet 7, shows the soil cement lining east and west of the bridge concrete floor and 5′ deep cut-off walls. Scour can not occur unless part of the soil cement is broken and pulled out by force of flood flows. A heavy vehicle or dropped object could crack the soil cement and cause a fracture large enough for moisture to seep into the subgrade and weaken the support. A depressed surface could open the crack enough for flow to pull at the edges. This analysis is for the worst case of soil cement lining failure. The results at TAB C are:

Average scour = 4.1′
Highest result (Rational Method) = 4.6′
5′ deep cut-off wall is adequate.

Rock armor layer in bottom of existing Wash consists of coarse gravel, cobbles and boulders.



Existing Wash bottom dug 1.5′± deep to show same mix of coarse gravel, cobbles and boulders at design FL depth.

Bottom of 7′ deep ditch excavated from Wash to 7th Ave Bridge detour. Material is coarse gravel and many cobbles 6"+. Same material is expected at design Fl 4′-5′ deeper.

North bank of ditch west of 7th Ave. The 4:1 slope does not appear to have a 7′ depth. Material has many 6"+ cobbles.

Bottom of Bellvue channel cut 11'± deep in 1986 for sand and gravel mining. Many large cobbles and some boulders 10"+.

TOP OF BANK

Lower bank of Bellvue Channel looking NW. The 4:1 slope at only 4'± deep does not appear very steep. Very rocky surface.

SPECIAL PROVISIONS BID ITEMS

GRAVEL SPREAD ON BOTTOM

DVE 12 Channel has been a retention area for the adjacent subdivision storm water drainage for 10 years. The numerous ponding/dry-up occurrences have deposited a 2"-3" layer of fine grain material on the bottom. The clearing and grubbing operations in the DVE 12 Channel will dig cavities where vegetation roots are removed and disturb all areas in the bottom where the scrub brush is roto-tilled or scraped out. Loading and haul off of cleared vegetation will further contribute to mixing the fine material into the natural bed material. A bed material gradation requires a distribution of particle size in weight with 50% over 1.5" in order to minimize degradation and scour. This bid item requires the contractor to spread a 2" minimum layer of very coarse gravel 1" minimum and cobbles to 8" maximum over all areas cleared in DVE 12 Channel from Grovers to the south side of drop structure No. 6. Wheel roll the surface with heavy equipment to embed the coarse material in the bottom by pneumatic tire pressure. Steel rollers may also be used. No compaction testing is required. The bottom surface will be inspected after the embedment process is completed for smooth bottom surface, 4:1 toe of slopes on both sides and minimal loose rock on the surface. The 1'± deep cut in the Bellvue Channel bottom, the dike removal at Grovers and the dike removal south of UH DR provide an adequate source of very coarse gravel and cobbles for embedment.

TABLE XV
MAXIMUM PERMISSIBLE VELOCITIES PROPOSED BY FORTIER AND SCOBEY (1926)*

Original material excavated for canals	n	Mean velocity, after Aging, of Canals (d 3 ft)					
		Clear water, no detritus		Water transporting colloidal silt		Water transporting noncolloidal silts, sands, gravels or rock fragments	
		ft/sec	m/sec	ft/sec	m/sec	ft/sec	m/sec
1. Fine sand (colloidal)	.02	1.5	0.46	2.50	0.76	1.50	0.46
2. Sandy loam (non-colloidal)	.02	1.45	0.53	2.50	0.76	2.00	0.61
3. Silt loam (non-colloidal)	.02	2.00	0.61	3.00	0.91	2.00	0.61
4. Alluvial silt when noncolloidal	.02	2.00	0.61	3.50	1.07	2.00	0.61
5. Ordinary firm loam	.02	2.50	0.76	3.50	1.07	2.25	0.69
6. Volcanic ash	.02	2.50	0.76	3.50	1.07	2.00	0.61
7. Fine gravel	.02	2.50	0.76	5.00	1.52	3.75	1.14
8. Stiff clay (very colloidal)	.025	3.75	1.14	5.00	1.52	3.00	0.91
9. Graded, loam to cobbles, when non-colloidal	.03	3.75	1.14	5.00	1.52	5.00	1.52
10. Alluvial silt when** colloidal	.025	3.75	1.14	5.00	1.52	3.00	0.91

SEE MATERIAL (12) & (13)

Table XV (continued)
Maximum Permissible Velocities Proposed by
Fortier and Scobey (1926)*

Original material excavated for canals	n	Mean velocity, after Aging, of Canals (d 3 ft)					
		Clear water, no detritus		Water transporting colloidal silt		Water transporting noncolloidal silts, sands, gravels or rock fragments	
		ft/sec	m/sec	ft/sec	m/sec	ft/sec	m/sec
11. Graded, silt to** cobbles, when colloidal	.03	4.00	1.22	5.50	1.68	5.00	1.52
12. Coarse gravel (non-colloidal)	.025	4.00	1.22	6.00	1.83	6.50	1.98
13. Cobbles and shingles	.035	5.00	1.52	5.50	1.68	6.50	1.98
14. Shales and hard pans	.025	6.00	1.83	6.00	1.83	5.00	1.52

* Developed in the Imperial Valley area of California.
** Cave Creek Wash soil types.

Table 17. Nonscour velocities for soils.

[Modified from a report by Keown and others, 1977]

Kind of soil	Grain dimensions: Millimeters	Grain dimensions: Feet	Approximate nonscour velocities (feet per second). Mean depth: 1.3 ft	3.3 ft	6.6 ft	9.8 ft
			For noncohesive soils			
Boulders	>256	>0.840	15.1	16.7	19.0	20.3
Large cobbles	256-128	0.840-0.420	11.8	13.4	15.4	16.4
Small cobbles	128-64	0.420-0.210	7.5	8.9	10.2	11.2
Very coarse gravel	64-32	0.210-0.105	5.2	6.2	7.2	8.2
Coarse gravel	32-16	0.105-0.0525	4.1	4.7	5.4	6.1
Medium gravel	16-8.0	0.0525-0.0262	3.3	3.7	4.1	4.6
Fine gravel	8.0-4.0	0.0262-0.0131	2.6	3.0	3.3	3.8
Very fine gravel	4.0-2.0	0.0131-0.00656	2.2	2.5	2.8	3.1
Very coarse sand	2.0-1.0	0.00656-0.00328	1.8	2.1	2.4	2.7
Coarse sand	1.0-0.50	0.00328-0.00164	1.5	1.8	2.1	2.3
Medium sand	0.50-0.25	0.00164-0.000820	1.2	1.5	1.8	2.0
Fine sand	0.25-0.125	0.000820-0.000410	.98	1.3	1.6	1.8
			For compact cohesive soils			
Sandy loam (heavy)			3.3	3.9	4.6	4.9
Sandy loam (light)			3.1	3.9	4.6	4.9
Loess soils in the conditions of finished settlement			2.6	3.3	3.9	4.3

Effect of Alinement Changes on Channel Slope

Alluvial streams develop meanders that are confined in lateral movement by nonerosive rock or other material at the valley boundary or by levees constructed to prevent flooding. The degree of stream meandering is indicated by channel sinuosity, which is determined as the ratio of a reach length measured along the channel centerline to the reach length measured as a straight line between ends of the reach. A characteristic of all sinuous channels is the migration of the meanders over a period of time. Eventually, the neck of the meander loop may become so small in relation to the width of the channel that a cutoff (referred to as a chute or neck cutoff) between meander loops occurs. Associated with the cutoff is an increase in channel slope, and lateral erosion of the banks at adjacent bends, with the length of reach affected by the cutoff a function of the channel size.

Table 3. - Comparison of Fortier and Scobey's limiting velocities with tractive force values (straight channels after aging) [inch-pound units (metric units)]

Material	Manning's n	For clear water		Water transporting colloidal silts	
		Velocity ft/s (m/s)	Tractive force lb/ft^2 (g/m^2)	Velocity ft/s (m/s)	Tractive force lb/ft^2 (g/m^2)
Fine sand colloidal	0.020	1.50 (0.457)	0.027 (132)	2.50 (0.762)	0.075 (366)
Sandy Loam noncolloidal	0.020	1.75 (0.533)	0.037 (181)	2.50 (0.762)	0.075 (366)
Silt loam noncolloidal	0.020	2.00 (0.610)	0.048 (234)	3.00 (0.914)	0.11 (537)
Alluvial silts noncolloidal	0.020	2.00 (0.610)	0.048 (234)	3.50 (1.07)	0.15 (732)
Ordinary firm loam	0.020	2.50 (0.762)	0.075 (366)	3.50 (1.07)	0.15 (732)
Volcanic ash	0.020	2.50 (0.762)	0.075 (366)	3.50 (1.07)	0.15 (732)
Stiff clay very colloidal	0.025	3.75 (1.14)	0.26 (1270)	5.00 (1.52)	0.46 (2250)
Alluvial silts colloidal	0.025	3.75 (1.14)	0.26 (1270)	5.00 (1.52)	0.46 (2250)
Shales and hardpans	0.025	6.00 (1.83)	0.67 (3270)	6.00 (1.83)	0.67 (3270)
Fine gravel	0.020	2.50 (0.762)	0.075 (366)	5.00 (1.52)	0.32 (1560)
Graded loam to cobbles when noncolloidal	0.030	3.75 (1.14)	0.38 (1860)	5.00 (1.52)	0.66 (3220)
Graded silts to cobbles when colloidal	0.030	4.00 (1.22)	0.43 (2100)	5.50 (1.68)	0.80 (3910)
Coarse gravel noncolloidal	0.025	4.00 (1.22)	0.30 (1460)	6.00 (1.83)	0.67 (3270)
Cobbles and shingles	0.035	5.00 (1.52)	0.91 (4440)	5.50 (1.68)	1.10 (5370)

COMPUTING
DEGRADATION AND
LOCAL SCOUR

by

Ernest L. Pemberton
Joseph M. Lara

TECHNICAL GUIDELINE FOR
BUREAU OF RECLAMATION

SEDIMENTATION AND RIVER HYDRAULICS SECTION
HYDROLOGY BRANCH
DIVISION OF PLANNING TECHNICAL SERVICES
ENGINEERING AND RESEARCH CENTER

DENVER, COLORADO

JANUARY 1984

Table 8. - Tentative guide to competent velocities for erosion of cohesive materials* (after Neill, 1973)

Depth of flow		Competent mean velocity					
		Low values - easily erodible material		Average values		High values - resistant material VERY COURSE GRAVEL	
ft	m	ft/s	m/s	ft/s	m/s	ft/s	m/s
5	1.5	1.9	0.6	3.4	1.0	5.9	1.8
10 6.4	3	2.1	0.65	3.9	1.2	6.6	2.0
20	6	2.3	0.7	4.3	1.3	7.4	2.3
50	15	2.7	0.8	5.0	1.5	8.6	2.6

* Notes: (1) This table is to be regarded as a rough guide only, in the absence of data based on local experience. Account must be taken of the expected condition of the material after exposure to weathering and saturation. (2) It is not considered advisable to relate the suggested low, average, and high values to soil shear strength or other conventional indices, because of the predominating effects of weathering and saturation on the erodibility of many cohesive soils.

THIS RUN EXECUTED 09-08-94

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  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
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T1 CAVE CREEK WASH FLOODWAY AMWEST ENGINEERING STARTING SOUTH OF BELL RD.
T2 AT WATER SURFACE ELEVATIONS FROM BURGESS & NIPLE FIS APPROVED BY FEMA
T3 IMPROVEMENTS UPSTREAM FOR CITY OF PHOENIX 7TH AVENUE PROJECT.(BELLN)

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	2.	0.	0.	.000000	.00	.0	0.	1348.200	.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1.000	.000	-10.000	1.000	.000	.000	.000	.000	.000	.000

DOMINANT DISCHARGE

NC	.040	.040	.035	.100	.300	.000	.000	.000	.000	.000
OT	2.000	2000.000	5700.000	.000	.000	.000	.000	.000	.000	.000
X1	20.628	16.000	9909.000	10076.000	.000	.000	.000	.000	.000	.000
GR	1357.300	9532.000	1357.300	9624.000	1356.800	9754.000	1357.200	9808.000	1357.100	9909.000
GR	1351.500	9922.000	1350.200	9947.000	1343.300	9959.000	1343.600	9991.000	1343.600	10000.000
GR	1343.700	10044.000	1356.300	10076.000	1357.000	10082.000	1357.100	10137.000	1357.200	10282.000
GR	1358.000	10337.000	.000	.000	.000	.000	.000	.000	.000	.000
X1	20.725	20.000	9951.000	10036.000	510.000	520.000	512.000	.000	.000	.000
GR	1360.300	9544.000	1361.100	9631.000	1361.300	9734.000	1361.000	9783.000	1362.000	9858.000
GR	1360.800	9940.000	1360.400	9951.000	1350.400	9970.000	1350.400	9981.000	1348.300	9984.000
GR	1347.400	9992.000	1347.200	10000.000	1347.400	10010.000	1361.000	10036.000	1363.400	10046.000
GR	1363.800	10101.000	1364.100	10156.000	1364.700	10184.000	1365.100	10212.000	1364.700	10291.000
NC	.000	.000	.000	.300	.500	.000	.000	.000	.000	.000
X1	20.737	16.000	9968.000	10019.000	80.000	80.000	80.000	.000	3.400	.000
X3	10.000	.000	.000	.000	.000	.000	.000	1363.000	1363.000	.000
GR	1360.300	9544.000	1361.100	9631.000	1361.300	9734.000	1361.000	9783.000	1362.000	9858.000
GR	1360.800	9940.000	1360.400	9951.000	1347.500	9968.000	1347.500	10019.000	1361.000	10036.000
GR	1363.400	10046.000	1363.800	10101.000	1364.100	10156.000	1364.700	10184.000	1365.100	10212.000
GR	1364.700	10291.000	.000	.000	.000	.000	.000	.000	.000	.000
SB	1.250	1.560	3.000	100.000	51.000	3.000	576.000	.000	1351.000	1350.900
X1	20.750	.000	.000	.000	71.000	71.000	71.000	.000	.100	.000
X2	.000	.000	1.000	1363.000	1366.000	.000	.000	.000	.000	.000
X3	10.000	.000	.000	.000	.000	.000	.000	1364.000	1364.000	.000
X1	20.819	12.000	9965.000	10043.000	375.000	345.000	365.000	.000	-.900	.000
X3	10.000	.000	.000	.000	.000	.000	.000	1366.900	1366.900	.000
GR	1366.500	9554.000	1365.400	9663.000	1365.500	9777.000	1365.500	9846.000	1365.300	9942.000
GR	1357.400	9965.000	1357.400	10043.000	1367.600	10066.000	1366.200	10107.000	1366.200	10146.000
GR	1367.000	10166.000	1367.200	10169.000	.000	.000	.000	.000	.000	.000

GR	1367.000	10188.000	1367.200	10187.000	.000	.000	.000	.000	.000	.000

SB	1.050	1.560	3.000	100.000	77.300	3.300	648.000	.000	1357.400	1356.700
X1	20.841	12.000	9953.000	10031.000	115.000	115.000	115.000	.000	.000	.000
X2	.000	.000	1.000	1365.400	1369.900	.000	.000	.000	.000	.000
X3	10.000	.000	.000	.000	.000	.000	.000	1367.900	1367.900	.000
GR	1367.400	9538.000	1366.500	9690.000	1367.000	9800.000	1367.000	9930.000	1357.400	9953.000
GR	1357.400	10023.000	1358.400	10025.000	1358.400	10031.000	1368.500	10054.000	1368.000	10100.000
GR	1368.500	10140.000	1368.500	10170.000	.000	.000	.000	.000	.000	.000
NC	.045	.045	.060	.000	.000	.000	.000	.000	.000	.000
X1	20.845	13.000	9915.000	10050.000	15.000	15.000	15.000	.000	.000	.000
GR	1366.500	9850.000	1367.000	9915.000	1359.800	9953.000	1359.800	9982.000	1357.500	9986.000
GR	1357.500	9992.000	1359.800	9998.000	1359.800	10022.000	1360.500	10028.000	1360.600	10034.000
GR	1368.000	10050.000	1369.000	10115.000	1370.000	10140.000	.000	.000	.000	.000
X1	20.847	9.000	9915.000	10050.000	15.000	15.000	15.000	.000	.000	.000
GR	1367.000	9840.000	1367.000	9915.000	1357.400	9953.000	1357.400	10022.000	1361.000	10030.000
GR	1361.100	10036.000	1368.000	10050.000	1369.000	10115.000	1369.500	10141.000	.000	.000
X1	20.850	10.000	9931.000	10041.000	25.000	25.000	25.000	.000	.000	.000
GR	1367.300	9840.000	1367.200	9915.000	1363.200	9931.000	1357.400	9954.000	1357.400	10022.000
GR	1364.200	10041.000	1364.300	10047.000	1368.000	10062.000	1368.000	10095.000	1369.500	10142.000
NC	.045	.045	.035	.100	.300	.000	.000	.000	.000	.000
X1	20.860	10.000	9931.000	10037.000	45.000	45.000	45.000	.000	.000	.000
GR	1367.300	9845.000	1367.500	9915.000	1363.500	9931.000	1357.400	9955.000	1357.400	10022.000
GR	1365.000	10037.000	1366.200	10092.000	1368.000	10110.000	1369.000	10127.000	1370.000	10143.000
X1	20.890	9.000	9931.000	10055.000	155.000	155.000	155.000	.000	.000	.000
GR	1368.300	9840.000	1368.300	9915.000	1364.300	9931.000	1357.500	9955.000	1357.500	10025.000
GR	1366.000	10055.000	1368.000	10065.000	1368.000	10110.000	1370.000	10151.000	.000	.000
X1	20.910	11.000	9931.000	10043.000	100.000	100.000	100.000	.000	.000	.000
GR	1369.000	9850.000	1368.900	9915.000	1364.900	9931.000	1357.500	9959.000	1357.500	10025.000
GR	1362.000	10043.000	1362.000	10065.000	1366.000	10075.000	1368.000	10085.000	1369.000	10145.000
GR	1370.100	10156.000	.000	.000	.000	.000	.000	.000	.000	.000
NC	.045	.045	.060	.300	.500	.000	.000	.000	.000	.000
X1	20.920	19.000	9931.000	10020.000	20.000	20.000	20.000	.000	.000	.000
GR	1369.000	9847.000	1369.000	9915.000	1365.000	9931.000	1361.000	9955.000	1361.000	9960.000
GR	1359.000	9963.000	1359.000	9974.000	1361.000	9981.000	1361.000	10015.000	1362.000	10020.000
GR	1358.500	10025.000	1358.500	10035.000	1364.000	10050.000	1362.000	10060.000	1362.000	10070.000
GR	1366.000	10080.000	1368.000	10095.000	1369.000	10140.000	1370.200	10162.000	.000	.000
X1	20.930	14.000	9931.000	10030.000	20.000	20.000	20.000	.000	.000	.000
GR	1369.000	9847.000	1369.000	9915.000	1365.000	9931.000	1358.500	9955.000	1358.500	10015.000
GR	1364.000	10030.000	1359.000	10045.000	1359.000	10055.000	1364.000	10070.000	1364.000	10078.000
GR	1366.000	10084.000	1368.000	10100.000	1369.000	10135.000	1370.000	10156.000	.000	.000

NC	.045	.045	.035	.100	.300	.000	.000	.000	.000	.000
X1	20.942	12.000	9931.000	10041.000	143.000	143.000	143.000	.000	.000	.000
GR	1369.500	9805.000	1369.700	9915.000	1365.700	9931.000	1358.500	9957.000	1358.500	10015.000
GR	1365.000	10041.000	1365.000	10075.000	1366.000	10085.000	1366.000	10103.000	1364.000	10115.000
GR	1364.000	10145.000	1369.400	10168.000	.000	.000	.000	.000	.000	.000
X1	20.960	12.000	9931.000	10043.000	77.000	77.000	77.000	.000	.000	.000
GR	1369.300	9830.000	1369.800	9915.000	1365.800	9931.000	1358.500	9960.000	1358.500	10015.000
GR	1365.200	10043.000	1364.600	10078.000	1366.000	10095.000	1367.000	10107.000	1366.500	10143.000
GR	1368.500	10185.000	1370.500	10190.000	.000	.000	.000	.000	.000	.000
X1	20.980	13.000	9931.000	10048.000	100.000	100.000	100.000	.000	.000	.000
GR	1370.000	9830.000	1370.000	9915.000	1366.000	9931.000	1358.600	9960.000	1358.600	10015.000
GR	1367.000	10048.000	1367.000	10050.000	1366.000	10063.000	1366.000	10080.000	1367.000	10088.000
GR	1368.000	10130.000	1369.000	10140.000	1371.000	10175.000	.000	.000	.000	.000
X1	21.000	14.000	9931.000	10053.000	100.000	100.000	100.000	.000	.000	.000
GR	1370.000	9890.000	1369.800	9915.000	1365.800	9931.000	1358.600	9960.000	1358.600	10016.000
GR	1369.000	10053.000	1366.500	10062.000	1366.500	10074.000	1368.000	10082.000	1370.000	10086.000
GR	1371.200	10110.000	1370.000	10125.000	1370.000	10145.000	1371.000	10160.000	.000	.000
X1	21.030	13.000	9931.000	10050.000	140.000	150.000	160.000	.000	.000	.000
GR	1372.000	9873.000	1372.000	9915.000	1368.000	9931.000	1359.000	9965.000	1359.000	10025.000
GR	1364.000	10050.000	1364.000	10058.000	1360.000	10068.000	1360.000	10076.000	1371.000	10100.000
GR	1372.000	10107.000	1372.000	10140.000	1372.500	10170.000	.000	.000	.000	.000
X1	21.036	10.000	9931.000	10054.000	25.000	70.000	25.000	.000	.000	.000
GR	1372.200	9875.000	1372.200	9915.000	1368.200	9931.000	1359.000	9965.000	1359.000	10034.000
GR	1364.700	10054.000	1364.700	10076.000	1365.000	10106.000	1368.000	10132.000	1372.500	10165.000
X1	21.060	8.000	9931.000	10055.000	110.000	170.000	140.000	.000	.000	.000
GR	1372.500	9850.000	1372.500	9915.000	1368.500	9931.000	1359.200	9965.000	1359.200	10035.000
GR	1364.700	10055.000	1366.000	10108.000	1372.000	10135.000	.000	.000	.000	.000
X1	21.080	9.000	9931.000	10055.000	90.000	160.000	120.000	.000	.000	.000
GR	1372.600	9865.000	1373.000	9915.000	1369.000	9931.000	1359.400	9965.000	1359.400	10035.000
GR	1364.400	10055.000	1366.000	10108.000	1374.000	10140.000	1375.000	10145.000	.000	.000
X1	21.100	9.000	9931.000	10055.000	98.000	160.000	120.000	.000	.000	.000
GR	1373.000	9865.000	1373.000	9915.000	1369.000	9931.000	1359.600	9965.000	1359.600	10035.000
GR	1365.100	10055.000	1366.000	10100.000	1374.000	10132.000	1375.100	10175.000	.000	.000
X1	21.127	9.000	9931.000	10054.000	76.000	85.000	78.000	.000	.000	.000
GR	1374.200	9900.000	1374.200	9915.000	1370.200	9931.000	1359.700	9963.000	1359.700	10035.000
GR	1366.000	10054.000	1367.000	10087.000	1368.000	10100.000	1375.000	10130.000	.000	.000
NC	.045	.045	.060	.300	.500	.000	.000	.000	.000	.000
X1	21.130	11.000	9935.000	10050.000	55.000	55.000	55.000	.000	.000	.000
GR	1376.000	9915.000	1376.000	9935.000	1369.000	9935.000	1361.000	9961.000	1360.000	9962.000
GR	1362.000	10032.000	1366.000	10050.000	1367.000	10067.000	1367.500	10093.000	1372.000	10107.000
GR	1375.500	10128.000	.000	.000	.000	.000	.000	.000	.000	.000

why

X1	21.140	9.000	9961.000	10046.000	30.000	30.000	30.000	.000	.000	.000
GR	1378.000	9800.000	1378.500	9961.000	1363.000	9961.000	1360.000	10028.000	1366.000	10046.000
GR	1366.000	10058.000	1374.000	10100.000	1374.500	10112.000	1376.000	10126.000	.000	.000
X1	21.145	10.000	9961.000	10039.000	12.000	20.000	15.000	.000	.000	.000
GR	1378.000	9800.000	1378.500	9961.000	1363.500	9961.000	1361.500	10022.000	1365.800	10039.000
GR	1365.800	10051.000	1375.000	10081.000	1376.000	10102.000	1376.000	10114.000	1376.500	10124.000
NC	.020	.020	.020	.200	.400	.000	.000	.000	.000	.000
X1	21.150	10.000	9961.000	10039.000	12.000	20.000	15.000	.000	.000	.000
GR	1378.500	9800.000	1378.500	9961.000	1363.500	9961.000	1363.500	10020.000	1365.500	10028.000
GR	1365.500	10039.000	1378.400	10039.000	1377.000	10057.000	1377.000	10105.000	1377.000	10120.000
SB	1.050	1.560	3.000	200.000	78.000	6.000	864.000	.000	1365.000	1363.500
X1	21.160	8.000	9961.000	10039.000	110.000	110.000	110.000	.000	.000	.000
X2	.000	.000	1.000	1377.500	1379.000	.000	.000	1.330	.000	.000
X3	10.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
GR	1376.000	9800.000	1379.000	9961.000	1365.000	9961.000	1365.000	10019.000	1366.000	10027.000
GR	1367.000	10039.000	1379.000	10039.000	1379.000	10200.000	.000	.000	.000	.000
NC	.045	.045	.040	.200	.400	.000	.000	.000	.000	.000
X1	21.165	9.000	9931.000	10055.000	58.000	40.000	50.000	.000	.000	.000
GR	1376.000	9915.000	1372.000	9931.000	1365.900	9955.000	1365.400	10020.000	1368.400	10032.000
GR	1368.700	10045.000	1372.200	10055.000	1378.200	10056.000	1380.000	10100.000	.000	.000
X1	21.170	12.000	9926.000	10047.000	40.000	40.000	40.000	.000	.000	.000
GR	1376.000	9910.000	1372.000	9926.000	1366.200	9950.000	1366.200	9970.000	1367.200	9971.000
GR	1367.200	10005.000	1366.200	10006.000	1366.200	10029.000	1370.600	10047.000	1371.000	10061.000
GR	1377.000	10085.000	1380.500	10115.000	.000	.000	.000	.000	.000	.000
X1	21.175	19.000	9921.000	10056.000	30.000	30.000	30.000	.000	.000	.000
GR	1376.000	9905.000	1372.000	9921.000	1367.500	9945.000	1367.500	9960.000	1371.500	9961.000
GR	1371.500	9964.000	1367.500	9965.000	1367.500	9975.000	1371.500	9976.000	1371.500	9979.000
GR	1367.500	9980.000	1367.500	10002.000	1366.500	10003.000	1366.500	10030.000	1367.500	10038.000
GR	1371.200	10056.000	1372.000	10069.000	1378.000	10095.000	1378.000	10110.000	.000	.000
X1	21.180	14.000	9921.000	10073.000	45.000	45.000	45.000	.000	.000	.000
GR	1376.000	9905.000	1372.000	9921.000	1367.600	9945.000	1367.600	10008.000	1371.600	10009.000
GR	1371.600	10015.000	1367.600	10016.000	1367.600	10055.000	1371.800	10073.000	1372.000	10087.000
GR	1374.500	10114.000	1374.600	10126.000	1375.000	10135.000	1378.000	10155.000	.000	.000
X1	21.185	16.000	9921.000	10078.000	20.000	20.000	20.000	.000	.000	.000
GR	1376.000	9905.000	1372.000	9921.000	1367.600	9945.000	1367.600	9954.000	1368.600	9955.000
GR	1368.600	9993.000	1372.600	9994.000	1372.600	9997.000	1368.600	9998.000	1368.600	10060.000
GR	1371.800	10078.000	1372.000	10091.000	1372.800	10119.000	1373.000	10131.000	1373.500	10140.000
GR	1378.000	10160.000	.000	.000	.000	.000	.000	.000	.000	.000
NC	.045	.045	.035	.100	.300	.000	.000	.000	.000	.000
X1	21.190	15.000	9921.000	10080.000	40.000	40.000	40.000	.000	.000	.000
GR	1376.000	9905.000	1372.000	9921.000	1368.600	9945.000	1368.600	9973.000	1368.600	9974.000
GR	1368.600	9977.000	1368.600	9978.000	1368.600	10022.000	1368.600	10023.000	1368.600	10026.000
GR	1368.600	10027.000	1368.600	10066.000	1371.800	10080.000	1372.800	10145.000	1378.000	10165.000

X1	21.195	7.000	9921.000	10080.000	45.000	45.000	45.000	.000	.000	.000
GR	1376.100	9905.000	1372.000	9921.000	1368.600	9945.000	1368.600	10065.000	1372.200	10080.000
GR	1373.000	10155.000	1377.500	10175.000	.000	.000	.000	.000	.000	.000
X1	21.200	7.000	9921.000	10080.000	200.000	200.000	200.000	.000	.000	.000
GR	1376.100	9905.000	1372.100	9921.000	1368.700	9945.000	1368.700	10064.000	1372.600	10080.000
GR	1373.600	10155.000	1378.500	10175.000	.000	.000	.000	.000	.000	.000
X1	21.230	7.000	9921.000	10080.000	200.000	200.000	200.000	.000	.000	.000
GR	1377.000	9905.000	1373.000	9921.000	1368.800	9945.000	1368.800	10064.000	1373.000	10080.000
GR	1374.000	10155.000	1379.200	10175.000	.000	.000	.000	.000	.000	.000
X1	21.260	7.000	9921.000	10080.000	205.000	195.000	200.000	.000	.000	.000
GR	1377.000	9905.000	1373.000	9921.000	1368.900	9945.000	1368.900	10064.000	1373.100	10080.000
GR	1374.100	10155.000	1379.400	10175.000	.000	.000	.000	.000	.000	.000
X1	21.300	7.000	9921.000	10080.000	235.000	165.000	200.000	.000	.000	.000
GR	1376.500	9905.000	1372.500	9921.000	1369.100	9945.000	1369.100	10064.000	1373.200	10080.000
GR	1374.200	10155.000	1379.600	10175.000	.000	.000	.000	.000	.000	.000
X1	21.330	7.000	9921.000	10080.000	235.000	165.000	200.000	.000	.000	.000
GR	1376.700	9905.000	1372.700	9921.000	1369.300	9945.000	1369.300	10064.000	1373.600	10080.000
GR	1374.600	10155.000	1379.800	10175.000	.000	.000	.000	.000	.000	.000
X1	21.363	7.000	9921.000	10093.000	235.000	165.000	200.000	.000	.000	.000
GR	1377.500	9905.000	1373.500	9921.000	1369.700	9945.000	1369.700	10075.000	1374.100	10093.000
GR	1375.100	10155.000	1380.400	10175.000	.000	.000	.000	.000	.000	.000
X1	21.370	8.000	9906.000	10088.000	60.000	50.000	55.000	.000	.000	.000
GR	1382.000	9890.000	1378.000	9906.000	1369.800	9939.000	1369.800	9951.000	1369.800	10070.000
GR	1374.600	10088.000	1375.600	10140.000	1380.600	10160.000	.000	.000	.000	.000
X1	21.380	8.000	9903.000	10084.000	80.000	60.000	70.000	.000	.000	.000
GR	1382.000	9875.000	1376.500	9903.000	1376.500	9915.000	1370.000	9942.000	1370.000	10064.000
GR	1375.000	10084.000	1376.000	10125.000	1380.200	10145.000	.000	.000	.000	.000
NC	.045	.045	.040	.200	.400	.000	.000	.000	.000	.000
X1	21.390	7.000	9915.000	10082.000	90.000	60.000	75.000	.000	.000	.000
GR	1382.000	9863.000	1382.800	9915.000	1370.500	9946.000	1370.300	10062.000	1375.000	10082.000
GR	1376.100	10120.000	1380.000	10150.000	.000	.000	.000	.000	.000	.000
NC	.045	.045	.040	.000	.000	.000	.000	.000	.000	.000
X1	21.440	12.000	9917.000	10048.000	240.000	260.000	250.000	.000	.000	.000
GR	1384.000	9864.000	1382.900	9877.000	1377.600	9897.000	1372.400	9917.000	1372.100	10040.000
GR	1370.900	10044.000	1371.400	10048.000	1375.000	10072.000	1375.600	10129.000	1379.000	10167.000
GR	1379.400	10219.000	1381.000	10244.000	.000	.000	.000	.000	.000	.000
NC	.045	.045	.040	.100	.300	.000	.000	.000	.000	.000
X1	21.484	13.000	9929.000	10038.000	253.000	247.000	250.000	.000	.000	.000
GR	1384.800	9864.000	1384.000	9889.000	1378.400	9909.000	1372.900	9929.000	1372.300	10030.000
GR	1371.200	10034.000	1371.700	10038.000	1376.200	10062.000	1376.000	10097.000	1377.200	10126.000
GR	1379.400	10152.000	1379.700	10200.000	1381.300	10230.000	.000	.000	.000	.000

X1	21.560	13.000	9916.000	10014.000	314.000	304.000	310.000	.000	.000	.000
GR	1386.000	9830.000	1382.000	9876.000	1379.500	9896.000	1373.100	9916.000	1372.500	9970.000
GR	1372.000	10006.000	1371.400	10010.000	1373.000	10014.000	1375.900	10045.000	1376.800	10108.000
GR	1380.800	10140.000	1381.900	10155.000	1382.400	10175.000	.000	.000	.000	.000
X1	21.570	9.000	9916.000	10014.000	20.000	20.000	20.000	.000	.000	.000
GR	1386.500	9830.000	1385.500	9876.000	1376.500	9896.000	1371.500	9916.000	1370.500	10006.000
GR	1370.500	10010.000	1375.500	10014.000	1376.500	10117.000	1382.000	10136.000	.000	.000
X1	21.576	11.000	9916.000	10014.000	30.000	30.000	30.000	.000	.000	.000
GR	1388.000	9830.000	1386.000	9876.000	1384.000	9896.000	1380.000	9916.000	1379.000	9998.000
GR	1375.100	10006.000	1374.500	10010.000	1375.000	10014.000	1382.000	10039.000	1383.000	10117.000
GR	1386.000	10136.000	.000	.000	.000	.000	.000	.000	.000	.000
X1	21.580	10.000	9916.000	10014.000	15.000	15.000	15.000	.000	.000	.000
GR	1388.000	9830.000	1386.300	9876.000	1381.500	9896.000	1377.200	9916.000	1376.100	10006.000
GR	1375.500	10010.000	1375.000	10014.000	1379.800	10034.000	1380.500	10117.000	1385.600	10136.000
OT	2.000	2000.000	5500.000	.000	.000	.000	.000	.000	.000	.000
X1	21.590	11.000	9906.000	10016.000	50.000	50.000	50.000	.000	.000	.000
GR	1388.400	9826.000	1386.000	9844.000	1385.500	9872.000	1381.600	9890.000	1377.000	9906.000
GR	1376.200	10006.000	1374.600	10011.000	1375.500	10016.000	1380.600	10038.000	1381.600	10117.000
GR	1386.100	10136.000	.000	.000	.000	.000	.000	.000	.000	.000
X1	21.640	10.000	9914.000	10016.000	273.000	267.000	270.000	.000	.000	.000
GR	1386.500	9849.000	1386.100	9876.000	1382.100	9894.000	1378.100	9914.000	1376.600	10006.000
GR	1375.400	10011.000	1376.400	10016.000	1380.000	10038.000	1382.300	10117.000	1386.200	10136.000
X1	21.650	8.000	9914.000	10016.000	20.000	20.000	20.000	.000	.000	.000
GR	1386.900	9876.000	1380.900	9894.000	1375.900	9914.000	1374.900	10006.000	1374.900	10016.000
GR	1380.900	10038.000	1380.900	10108.000	1390.000	10136.000	.000	.000	.000	.000
X1	21.669	10.000	9908.000	10016.000	30.000	30.000	30.000	.000	.000	.000
GR	1390.400	9876.000	1388.100	9888.000	1384.000	9908.000	1383.000	9998.000	1379.000	10006.000
GR	1379.000	10011.000	1379.400	10016.000	1386.000	10038.000	1387.000	10120.000	1390.400	10136.000
X1	21.680	9.000	9908.000	10016.000	15.000	15.000	15.000	.000	.000	.000
GR	1390.400	9876.000	1385.900	9888.000	1391.200	9908.000	1380.400	10006.000	1379.000	10011.000
GR	1379.600	10016.000	1383.700	10038.000	1385.500	10116.000	1390.800	10136.000	.000	.000
X1	21.700	10.000	9898.000	10018.000	50.000	50.000	50.000	.000	.000	.000
GR	1390.500	9786.000	1388.300	9813.000	1387.800	9861.000	1381.500	9898.000	1380.500	10008.000
GR	1379.000	10013.000	1379.500	10018.000	1384.500	10038.000	1385.500	10118.000	1390.500	10146.000
X1	21.742	9.000	9906.000	10018.000	253.000	247.000	250.000	.000	.000	.000
GR	1392.700	9858.000	1387.300	9886.000	1381.900	9906.000	1380.800	10008.000	1380.000	10013.000
GR	1380.800	10018.000	1384.700	10040.000	1385.800	10118.000	1392.200	10156.000	.000	.000

X1	21.760	10.000	9916.000	10018.000	217.000	213.000	215.000	.000	.000	.000
GR	1391.100	9874.000	1386.800	9896.000	1382.600	9916.000	1381.500	10008.000	1380.100	10013.000
GR	1380.300	10018.000	1384.600	10040.000	1387.100	10118.000	1389.400	10138.000	1394.800	10168.000
X1	21.770	7.000	9916.000	10018.000	24.000	24.000	24.000	.000	.000	.000
GR	1390.700	9876.000	1386.000	9896.000	1381.100	9916.000	1380.100	10013.000	1380.100	10018.000
GR	1386.100	10116.000	1395.000	10138.000	.000	.000	.000	.000	.000	.000
X1	21.780	10.000	9914.000	10016.000	30.000	30.000	30.000	.000	.000	.000
GR	1394.000	9876.000	1390.900	9894.000	1387.000	9914.000	1386.000	9998.000	1382.200	10006.000
GR	1381.600	10011.000	1382.100	10016.000	1389.000	10038.000	1390.000	10116.000	1394.100	10136.000
X1	21.790	9.000	9918.000	10016.000	15.000	15.000	15.000	.000	.000	.000
GR	1394.000	9874.000	1388.600	9898.000	1384.100	9918.000	1383.200	10006.000	1381.600	10011.000
GR	1382.100	10016.000	1386.600	10034.000	1387.400	10104.000	1395.100	10136.000	.000	.000
X1	21.800	9.000	9922.000	10016.000	66.000	66.000	66.000	.000	.000	.000
GR	1396.000	9874.000	1390.000	9898.000	1384.200	9922.000	1383.300	10006.000	1381.700	10011.000
GR	1382.200	10016.000	1386.700	10034.000	1387.500	10104.000	1396.000	10136.000	.000	.000
X1	21.820	9.000	9922.000	10016.000	95.000	95.000	95.000	.000	.000	.000
GR	1396.000	9874.000	1390.000	9898.000	1384.400	9922.000	1383.500	10006.000	1381.900	10011.000
GR	1382.400	10016.000	1386.900	10034.000	1387.800	10116.000	1392.000	10136.000	.000	.000
X1	21.840	9.000	9922.000	10016.000	150.000	150.000	150.000	.000	.000	.000
GR	1396.000	9874.000	1390.000	9898.000	1384.600	9922.000	1383.700	10006.000	1382.100	10011.000
GR	1382.600	10016.000	1387.100	10034.000	1388.000	10116.000	1392.300	10136.000	.000	.000
X1	21.870	9.000	9922.000	10016.000	155.000	160.000	160.000	.000	.000	.000
GR	1396.500	9874.000	1390.000	9898.000	1384.900	9922.000	1384.000	10006.000	1382.400	10011.000
GR	1382.900	10016.000	1387.400	10034.000	1388.500	10100.000	1398.000	10136.000	.000	.000
X1	21.895	10.000	9918.000	10014.000	95.000	90.000	90.000	.000	.000	.000
GR	1398.000	9864.000	1398.000	9874.000	1392.000	9894.000	1386.000	9918.000	1383.000	9990.000
GR	1382.300	10009.000	1382.800	10014.000	1387.400	10034.000	1389.000	10100.000	1398.400	10136.000
X1	21.900	8.000	9930.000	10038.000	60.000	60.000	60.000	.000	.000	.000
GR	1398.000	9874.000	1397.800	9880.000	1386.000	9930.000	1383.000	10000.000	1383.000	10018.000
GR	1387.600	10038.000	1389.000	10112.000	1398.200	10146.000	.000	.000	.000	.000
NC	.035	.035	.035	.300	.500	.000	.000	.000	.000	.000
X1	21.910	6.000	9950.000	10031.000	55.000	85.000	70.000	.000	.000	.000
GR	1398.000	9814.000	1382.300	9950.000	1383.000	9983.000	1384.000	10031.000	1389.000	10052.000
GR	1398.000	10135.000	.000	.000	.000	.000	.000	.000	.000	.000
NC	.020	.020	.020	.300	.500	.000	.000	.000	.000	.000
X1	21.920	10.000	9956.500	10043.500	30.000	30.000	30.000	.000	.000	.000
GR	1399.300	9900.000	1399.300	9956.500	1395.000	9956.500	1395.000	9958.500	1383.400	9970.500
GR	1383.400	10029.500	1395.000	10041.500	1395.000	10043.500	1399.300	10043.500	1399.300	10100.000

SB	1.050	1.560	3.000	200.000	59.000	6.000	877.000	1.000	1384.400	1383.400
X1	21.940	10.000	9956.500	10043.500	103.000	103.000	103.000	.000	.000	.000
X2	.000	.000	1.000	1399.300	1397.000	.000	.000	1.330	.000	.000
X3	10.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
GR	1399.300	9900.000	1399.300	9956.500	1395.000	9956.500	1395.000	9958.500	1384.300	9970.500
GR	1384.300	10029.500	1395.000	10041.500	1395.000	10043.500	1399.300	10043.500	1399.300	10100.000
X1	21.950	6.000	9942.000	10048.000	30.000	55.000	40.000	.000	.000	.000
GR	1400.000	9922.000	1396.000	9942.000	1385.000	9967.000	1385.000	10026.000	1399.000	10048.000
GR	1400.000	10053.000	.000	.000	.000	.000	.000	.000	.000	.000
NC	.035	.035	.035	.000	.000	.000	.000	.000	.000	.000
X1	21.960	7.000	9930.000	10061.000	60.000	65.000	62.000	.000	.000	.000
GR	1400.000	9893.000	1394.000	9918.000	1394.000	9930.000	1390.000	9952.000	1390.000	10034.000
GR	1399.000	10061.000	1400.000	10072.000	.000	.000	.000	.000	.000	.000
X1	21.970	7.000	9934.000	10084.000	80.000	80.000	80.000	.000	.000	.000
GR	1400.000	9893.000	1394.000	9922.000	1394.000	9934.000	1390.500	9952.000	1390.500	10044.000
GR	1400.000	10084.000	1401.000	10094.000	.000	.000	.000	.000	.000	.000
X1	21.980	4.000	9893.000	10100.000	20.000	20.000	20.000	.000	.000	.000
GR	1402.000	9893.000	1394.000	9938.000	1394.000	10062.000	1401.500	10100.000	.000	.000
NC	.045	.035	.035	.300	.500	.000	.000	.000	.000	.000
NH	4.000	.030	9650.000	.045	9905.000	.035	10054.000	.035	10117.000	.000
X1	22.000	22.000	9965.000	10054.000	70.000	100.000	100.000	.000	.000	.000
GR	1403.000	9490.000	1402.000	9515.000	1402.400	9540.000	1397.400	9560.000	1397.000	9600.000
GR	1397.400	9650.000	1397.800	9655.000	1399.000	9700.000	1400.000	9740.000	1402.000	9760.000
GR	1402.000	9880.000	1400.000	9930.000	1400.100	9965.000	1397.000	9990.000	1395.000	10012.000
GR	1394.500	10024.000	1395.000	10036.000	1398.000	10043.000	1400.000	10048.000	1402.000	10054.000
GR	1403.000	10116.000	1407.600	10117.000	.000	.000	.000	.000	.000	.000
NH	4.000	.030	9720.000	.045	9957.000	.035	10053.000	.045	10117.000	.000
X1	22.020	20.000	9957.000	10053.000	60.000	120.000	100.000	.000	.000	.000
GR	1402.400	9510.000	1402.400	9540.000	1397.500	9555.000	1397.100	9600.000	1397.500	9645.000
GR	1400.000	9665.000	1400.000	9680.000	1398.600	9720.000	1402.000	9760.000	1402.000	9895.000
GR	1400.000	9908.000	1400.000	9957.000	1398.000	9985.000	1395.000	10006.000	1394.700	10016.000
GR	1395.000	10031.000	1400.000	10043.000	1402.000	10053.000	1403.200	10116.000	1407.800	10117.000
NC	.045	.035	.035	.100	.300	.000	.000	.000	.000	.000
NH	4.000	.030	9785.000	.045	9961.000	.035	10028.000	.045	10085.000	.000
X1	22.065	35.000	9961.000	10028.000	160.000	260.000	241.000	.000	.000	.000
GR	1402.700	9560.000	1402.700	9585.000	1397.700	9605.000	1397.500	9635.000	1397.700	9667.000
GR	1399.600	9690.000	1400.500	9700.000	1400.000	9717.000	1400.000	9731.000	1400.000	9746.000
GR	1400.000	9761.000	1400.100	9776.000	1400.000	9785.000	1401.100	9796.000	1401.000	9816.000
GR	1403.700	9829.000	1403.700	9843.000	1400.700	9861.000	1399.700	9869.000	1402.700	9890.000
GR	1403.500	9899.000	1404.100	9915.000	1404.800	9934.000	1403.600	9950.000	1404.100	9961.000
GR	1401.400	9977.000	1398.000	9989.000	1395.800	9995.000	1395.800	10000.000	1395.900	10006.000
GR	1399.400	10010.000	1402.000	10028.000	1402.600	10043.000	1406.600	10061.000	1407.100	10085.000

NH	4.000	.030	9830.000	.045	9970.000	.035	10048.000	.045	10100.000	.000
X1	22.090	19.000	9970.000	10048.000	150.000	150.000	150.000	.000	.000	.000
GR	1403.600	9610.000	1398.300	9628.000	1398.000	9650.000	1398.300	9680.000	1402.000	9700.000
GR	1402.000	9760.000	1400.000	9780.000	1400.000	9830.000	1402.000	9845.000	1404.700	9880.000
GR	1404.000	9900.000	1402.000	9920.000	1402.000	9950.000	1401.800	9970.000	1395.300	9986.000
GR	1396.000	10000.000	1397.000	10016.000	1404.000	10048.000	1405.700	10100.000	.000	.000
EJ	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*PROF 1

CCHV=    .100 CEHV=    .300
*SECNO 20.628
    20.63     4.90  1348.20      .00  1348.20  1348.52      .32      .00      .00  1357.10
    2000.       0.    2000.       0.       0.     440.       0.       0.       0.   1356.30
      .00      .00     4.54      .00     .040     .035     .040     .000  1343.30  9950.48
  .001740       0.       0.       0.        0        0        0      .00   104.95 10055.43


*SECNO 20.725

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    20.73     5.19  1352.39  1352.39      .00  1354.18     1.78     1.90      .44  1360.40
    2000.       0.    2000.       0.       0.     187.       0.       4.       1.   1361.00
      .01      .00    10.72      .00     .040     .035     .040     .000  1347.20  9966.22
  .012743     510.     512.     520.       20        8        0      .00    53.32 10019.54


CCHV=    .300 CEHV=    .500
*SECNO 20.737
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1363.00 ELREA=     1363.00

    20.74     3.62  1354.52  1354.52      .00  1356.34     1.83      .98      .02  1350.90
    2000.       0.    2000.       0.       0.     184.       0.       4.       1.   1350.90
      .02      .00    10.85      .00     .040     .035     .040     .000  1350.90  9968.00
  .011761      80.      80.      80.       20       19        0      .00    51.00 10019.00


SPECIAL BRIDGE
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

5227 DOWNSTREAM ELEV IS 1353.90 ,NOT 1354.52 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.25	1.56	3.00	100.00	51.00	3.00	576.00	.00	1351.00	1350.90

*SECNO 20.750

3301 HV CHANGED MORE THAN HVINS

CLASS B LOW FLOW

3420 BRIDGE W.S.= 1354.73 BRIDGE VELOCITY=, 11.03 CALCULATED CHANNEL AREA=, 179.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
.00	1356.82	.00	0.	2000.	576.	576.	1363.00	1366.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1364.00 ELREA= 1364.00

20.75	4.76	1355.78	.00	.00	1356.82	1.05	.48	.00	1351.00
2000.	0.	2000.	0.	0.	244.	0.	4.	1.	1351.00
.02	.00	8.21	.00	.000	.035	.000	.000	1351.00	9968.00
.004653	71.	71.	71.	0	0	0	.00	51.00	10019.00

*SECNO 20.819
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1366.90 ELREA= 1366.90

20.82	2.73	1359.23	1359.23	.00	1360.60	1.37	2.65	.16	1356.50
2000.	0.	2000.	0.	0.	213.	0.	6.	2.	1356.50
.03	.00	9.39	.00	.040	.035	.040	.000	1356.50	9965.00
.012826	375.	365.	345.	2	11	0	.00	78.00	10043.00

SPECIAL BRIDGE

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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


5227 DOWNSTREAM ELEV IS   1359.04 ,NOT   1359.23 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     1.05      1.56      3.00    100.00     77.30      3.30    648.00       .00   1357.40   1356.70

*SECNO 20.841
CLASS B LOW FLOW

3420 BRIDGE W.S.=   1359.88 BRIDGE VELOCITY=,      9.55      CALCULATED CHANNEL AREA=,      184.

 EGPRS      EGLWC       H3       QWEIR      QLOW      BAREA   TRAPEZOID      ELLC     ELTRD
                                                                 AREA
       .00   1361.77       .00        0.     2000.      648.      592.     1365.40   1369.90


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1367.90 ELREA=     1367.90

    20.84     3.47  1360.87      .00      .00  1361.77      .89     1.17      .00  1357.40
    2000.       0.    2000.       0.       0.     264.       0.       7.       2.   1358.40
      .03      .00     7.58      .00     .000     .035     .000     .000  1357.40  9953.00
  .006293     115.     115.     115.        0        0        0      .00    78.00 10031.00


*SECNO 20.845
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    20.84     4.68  1362.18  1362.18      .00  1363.36     1.18      .19      .14  1367.00
    2000.       0.    2000.       0.       0.     230.       0.       7.       2.   1368.00
      .03      .00     8.71      .00     .045     .060     .045     .000  1357.50  9940.41
  .040113      15.      15.      15.       20       11        0      .00    97.01 10037.43


*SECNO 20.847

3301 HV CHANGED MORE THAN HVINS

    20.85     6.15  1363.55      .00      .00  1363.75      .20      .10      .29  1367.00
    2000.       0.    2000.       0.       0.     556.       0.       7.       2.   1368.00
      .03      .00     3.60      .00     .045     .060     .045     .000  1357.40  9928.61
  .002561      15.      15.      15.        2        0        0      .00   112.38 10040.99
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 20.850
    20.85     6.22  1363.62       .00       .00  1363.82       .20       .06       .00  1363.20
    2000.       0.    2000.        0.        0.     553.        0.       7.        2.   1364.20
      .04      .57     3.62       .00      .045     .060      .045      .000  1357.40  9929.34
  .002481      25.      25.       25.         2        0         0       .00   110.03 10039.37


CCHV=    .100 CEHV=    .300
*SECNO 20.860
    20.86     6.27  1363.67       .00       .00  1363.88       .22       .06       .00  1363.50
    2000.       0.    2000.        0.        0.     536.        0.       8.        2.   1365.00
      .04      .01     3.73       .00      .045     .035      .045      .000  1357.40  9930.33
  .000886      45.      45.       45.         2        0         0       .00   104.05 10034.37


*SECNO 20.890
    20.89     6.33  1363.83       .00       .00  1364.01       .18       .13       .00  1364.30
    2000.       0.    2000.        0.        0.     585.        0.      10.        2.   1366.00
      .05      .00     3.42       .00      .045     .035      .045      .000  1357.50  9932.65
  .000754     155.     155.      155.         2        0         0       .00   114.71 10047.35


*SECNO 20.910
    20.91     6.42  1363.92       .00       .00  1364.09       .17       .07       .00  1364.90
    2000.       0.    1940.       60.        0.     576.       47.      11.        3.   1362.00
      .06      .00     3.37      1.28      .045     .035      .045      .000  1357.50  9934.73
  .000688     100.     100.      100.         0        0         0       .00   135.06 10069.79


CCHV=    .300 CEHV=    .500
*SECNO 20.920

3265 DIVIDED FLOW

    20.92     5.29  1363.79       .00       .00  1364.28       .50       .03       .16  1365.00
    2000.       0.    1072.      928.        0.     234.      139.      12.        3.   1362.00
      .06      .00     4.58      6.70      .045     .060      .045      .000  1358.50  9938.27
  .008576      20.      20.       20.         2        0         0       .00   134.56 10074.47


*SECNO 20.930
    20.93     5.78  1364.28       .00       .00  1364.46       .18       .08       .10  1365.00
    2000.       0.    1494.      506.        0.     454.      139.      12.        3.   1364.00
      .06      .00     3.29      3.65      .045     .060      .045      .000  1358.50  9933.64
  .002281      20.      20.       20.         2        0         0       .00   145.22 10078.86
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


CCHV=    .100 CEHV=    .300
*SECNO 20.942

3265 DIVIDED FLOW

    20.94     5.96  1364.46      .00      .00  1364.72      .26      .24      .03  1365.70
    2000.       0.    1990.      10.       0.     481.      15.      14.       3.   1365.00
      .07      .00     4.14      .67     .045     .035     .045     .000  1358.50  9935.48
  .001249     143.     143.     143.        2        0        0      .00   138.05 10146.95


*SECNO 20.960
    20.96     6.05  1364.55      .00      .00  1364.82      .27      .10      .00  1365.80
    2000.       0.    2000.       0.       0.     482.       0.      14.       4.   1365.20
      .08      .00     4.15      .00     .045     .035     .045     .000  1358.50  9935.96
  .001264      77.      77.      77.        2        0        0      .00   104.33 10040.29


*SECNO 20.980
    20.98     6.08  1364.68      .00      .00  1364.95      .27      .13      .00  1366.00
    2000.       0.    2000.       0.       0.     479.       0.      16.       4.   1367.00
      .08      .00     4.17      .00     .045     .035     .045     .000  1358.60  9936.18
  .001264     100.     100.     100.        0        0        0      .00   102.70 10038.88


*SECNO 21.000
    21.00     6.21  1364.81      .00      .00  1365.07      .25      .12      .00  1365.80
    2000.       0.    2000.       0.       0.     494.       0.      17.       4.   1369.00
      .09      .00     4.05      .00     .045     .035     .045     .000  1358.60  9935.00
  .001150     100.     100.     100.        1        0        0      .00   103.09 10038.09


*SECNO 21.030
    21.03     6.06  1365.06      .00      .00  1365.23      .17      .15      .01  1368.00
    2000.       0.    1778.     222.       0.     522.     108.      19.       5.   1364.00
      .11      .00     3.40     2.07     .045     .035     .045     .000  1359.00  9942.10
  .000798     140.     160.     150.        2        0        0      .00   144.94 10087.04


*SECNO 21.036
    21.04     6.06  1365.06      .00      .00  1365.26      .20      .02      .01  1368.20
    2000.       0.    1994.       6.       0.     550.      14.      19.       5.   1364.70
      .11      .00     3.62      .43     .045     .035     .045     .000  1359.00  9942.60
  .000883      25.      25.      70.        2        0        0      .00   163.92 10106.52
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 21.060
    21.06     5.98  1365.18       .00       .00  1365.39       .21       .12       .00  1368.50
    2000.       0.    1998.        2.        0.     548.        5.       21.        5.   1364.70
      .12      .00     3.64       .38      .045     .035      .045      .000  1359.20  9943.15
  .000901     110.     140.      170.         0        0         0       .00   131.32 10074.46


*SECNO 21.080
    21.08     5.89  1365.29       .00       .00  1365.50       .21       .11       .00  1369.00
    2000.       0.    1992.        8.        0.     542.       13.       23.        6.   1364.40
      .13      .00     3.68       .58      .045     .035      .045      .000  1359.40  9944.13
  .000920      90.     120.      160.         0        0         0       .00   140.44 10084.57


*SECNO 21.100
    21.10     5.80  1365.40       .00       .00  1365.62       .22       .12       .00  1369.00
    2000.       0.    1999.        1.        0.     528.        2.       24.        6.   1365.10
      .14      .00     3.78       .30      .045     .035      .045      .000  1359.60  9944.00
  .001010      98.     120.      160.         0        0         0       .00   126.23 10070.23


*SECNO 21.127
    21.13     5.77  1365.47       .00       .00  1365.70       .23       .08       .00  1370.20
    2000.       0.    2000.        0.        0.     517.        0.       25.        6.   1366.00
      .14      .00     3.87       .00      .045     .035      .045      .000  1359.70  9945.41
  .001042      76.      78.       85.         0        0         0       .00   107.01 10052.41


CCHV=    .300 CEHV=    .500
*SECNO 21.130
    21.13     5.55  1365.55       .00       .00  1365.82       .28       .10       .02  1376.00
    2000.       0.    2000.        0.        0.     473.        0.       26.        6.   1366.00
      .15      .00     4.23       .00      .045     .060      .045      .000  1360.00  9946.22
  .003888      55.      55.       55.         2        0         0       .00   102.41 10048.64


*SECNO 21.140
    21.14     5.57  1365.57       .00       .00  1366.18       .61       .19       .17  1378.50
    2000.       0.    2000.        0.        0.     319.        0.       26.        6.   1366.00
      .15      .00     6.27       .02      .045     .060      .045      .000  1360.00  9961.00
  .011391      30.      30.       30.         2        0         0       .00    83.70 10044.70
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 21.145

3301 HV CHANGED MORE THAN HVINS

    21.15     3.97  1365.47  1365.44      .00  1366.84     1.37      .29      .38  1378.50
    2000.       0.    2000.       0.       0.     213.       0.      26.       6.   1365.80
      .15      .00     9.39      .00     .045     .060     .045     .000  1361.50  9961.00
  .038497      12.      15.      20.        4       19        0      .00    76.73 10037.73


CCHV=    .200 CEHV=    .400
*SECNO 21.150
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    21.15     3.10  1366.60  1366.60      .00  1367.98     1.38      .15      .00  1378.50
    2000.       0.    2000.       0.       0.     212.       0.      26.       6.   1378.40
      .15      .00     9.43      .00     .020     .020     .020     .000  1363.50  9961.00
  .004567      12.      15.      20.       20       15        0      .00    78.00 10039.00



SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS   1365.71 ,NOT   1366.60 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     1.05      1.56      3.00    200.00     78.00      6.00    864.00       .00   1365.00   1363.50

*SECNO 21.160

3301 HV CHANGED MORE THAN HVINS

CLASS B LOW FLOW

3420 BRIDGE W.S.=   1367.13 BRIDGE VELOCITY=,      9.63      CALCULATED CHANNEL AREA=,      154.

 EGPRS      EGLWC       H3       QWEIR      QLOW      BAREA   TRAPEZOID      ELLC     ELTRD
                                                                 AREA
       .00   1369.60       .00        0.     2000.      864.      900.     1377.50   1379.00


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1379.00 ELREA=     1379.00
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  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
  Q        QLOB     QCH      OROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


   21.16     3.74  1368.74      .00      .00  1369.60      .85     1.61      .00  1379.00
   2000.       0.    2000.       0.       0.     270.       0.      27.       7.   1379.00
     .15      .00     7.41      .00     .000     .020     .000     .000  1365.00  9961.00
 .002080     110.     110.     110.        0        0        0      .00    78.00 10039.00


CCHV=    .200 CEHV=    .400
*SECNO 21.165
   21.17     3.51  1368.91      .00      .00  1369.84      .93      .21      .03  1372.00
   2000.       0.    2000.       0.       0.     258.       0.      27.       7.   1372.20
     .15      .00     7.74      .00     .045     .040     .045     .000  1365.40  9943.16
 .012767      58.      50.      40.        0        0        0      .00   102.43 10045.60


*SECNO 21.170
   21.17     3.28  1369.48      .00      .00  1370.35      .87      .49      .01  1372.00
   2000.       0.    2000.       0.       0.     268.       0.      27.       7.   1370.60
     .15      .00     7.47      .00     .045     .040     .045     .000  1366.20  9936.46
 .012001      40.      40.      40.        3        0        0      .00   105.93 10042.39


*SECNO 21.175

3265 DIVIDED FLOW

   21.17     3.34  1369.84      .00      .00  1370.78      .94      .41      .03  1372.00
   2000.       0.    2000.       0.       0.     257.       0.      27.       7.   1371.20
     .16      .00     7.77      .00     .045     .040     .045     .000  1366.50  9932.47
 .015372      30.      30.      30.        0        0        0      .00   109.32 10049.43


*SECNO 21.180

3265 DIVIDED FLOW


3301 HV CHANGED MORE THAN HVINS

   21.18     3.23  1370.83      .00      .00  1371.26      .42      .37      .10  1372.00
   2000.       0.    2000.       0.       0.     383.       0.      28.       7.   1371.80
     .16      .00     5.22      .00     .045     .040     .045     .000  1367.60  9927.36
 .005190      45.      45.      45.        3        0        0      .00   135.11 10068.86
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 21.185

3265 DIVIDED FLOW

    21.18     3.22  1370.82      .00      .00  1371.52      .70      .15      .11  1372.00
    2000.       0.    2000.       0.       0.     298.       0.      28.       7.   1371.80
      .16      .00     6.71      .00     .045     .040     .045     .000  1367.60  9927.40
  .012555      20.      20.      20.        2        0        0      .00   141.24 10072.53


CCHV=    .100 CEHV=    .300
*SECNO 21.190
    21.19     2.81  1371.41      .00      .00  1371.83      .42      .28      .03  1372.00
    2000.       0.    2000.       0.       0.     386.       0.      28.       7.   1371.80
      .16      .00     5.19      .00     .045     .035     .045     .000  1368.60  9925.15
  .004378      40.      40.      40.        2        0        0      .00   153.16 10078.30


*SECNO 21.195
    21.19     3.05  1371.65      .00      .00  1372.00      .36      .17      .01  1372.00
    2000.       0.    2000.       0.       0.     418.       0.      29.       7.   1372.20
      .16      .00     4.78      .00     .045     .035     .045     .000  1368.60  9923.47
  .003371      45.      45.      45.        2        0        0      .00   154.24 10077.71


*SECNO 21.200
    21.20     3.57  1372.27      .00      .00  1372.52      .25      .51      .01  1372.10
    2000.       0.    2000.       0.       0.     496.       0.      31.       8.   1372.60
      .18      .01     4.04      .00     .045     .035     .045     .000  1368.70  9920.33
  .001973     200.     200.     200.        2        0        0      .00   158.31 10078.64


*SECNO 21.230
    21.23     3.85  1372.65      .00      .00  1372.87      .22      .35      .00  1373.00
    2000.       0.    2000.       0.       0.     529.       0.      33.       9.   1373.00
      .19      .00     3.78      .00     .045     .035     .045     .000  1368.80  9922.99
  .001563     200.     200.     200.        2        0        0      .00   155.69 10078.67


*SECNO 21.260
    21.26     4.07  1372.97      .00      .00  1373.16      .20      .28      .00  1373.00
    2000.       0.    2000.       0.       0.     564.       0.      36.       9.   1373.10
      .21      .00     3.55      .00     .045     .035     .045     .000  1368.90  9921.20
  .001294     205.     200.     195.        2        0        0      .00   158.28 10079.49
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 21.300
    21.30     4.12  1373.22      .00      .00  1373.41      .18      .25      .00  1372.50
    2000.       1.    1999.       0.       1.     582.       0.      38.      10.   1373.20
      .22      .56     3.43      .01     .045     .035     .045     .000  1369.10  9918.10
  .001167     235.     200.     165.        2        0        0      .00   163.73 10081.83


*SECNO 21.330
    21.33     4.16  1373.46      .00      .00  1373.64      .18      .23      .00  1372.70
    2000.       1.    1999.       0.       1.     587.       0.      41.      11.   1373.60
      .24      .57     3.41      .00     .045     .035     .045     .000  1369.30  9917.94
  .001131     235.     200.     165.        1        0        0      .00   161.55 10079.49


*SECNO 21.363
    21.36     3.99  1373.69      .00      .00  1373.87      .17      .23      .00  1373.50
    2000.       0.    2000.       0.       0.     601.       0.      44.      12.   1374.10
      .26      .01     3.33      .00     .045     .035     .045     .000  1369.70  9920.25
  .001151     235.     200.     165.        0        0        0      .00   171.06 10091.31


*SECNO 21.370
    21.37     3.95  1373.75      .00      .00  1373.94      .19      .07      .00  1378.00
    2000.       0.    2000.       0.       0.     579.       0.      44.      12.   1374.60
      .26      .00     3.45      .00     .045     .035     .045     .000  1369.80  9923.07
  .001217      60.      55.      50.        0        0        0      .00   161.77 10084.84


*SECNO 21.380
    21.38     3.82  1373.82      .00      .00  1374.04      .22      .10      .01  1376.50
    2000.       0.    2000.       0.       0.     527.       0.      45.      12.   1375.00
      .27      .00     3.80      .00     .045     .035     .045     .000  1370.00  9926.11
  .001556      80.      70.      60.        1        0        0      .00   153.20 10079.31


CCHV=    .200 CEHV=    .400
*SECNO 21.390
    21.39     3.63  1373.93      .00      .00  1374.23      .30      .16      .03  1382.80
    2000.       0.    2000.       0.       0.     451.       0.      46.      12.   1375.00
      .27      .00     4.43      .00     .045     .040     .045     .000  1370.30  9937.37
  .003018      90.      75.      60.        0        0        0      .00   140.05 10077.42
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  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 21.440
   21.44     3.96  1374.86      .00      .00  1375.26      .41      .99      .04  1372.40
   2000.      32.    1830.     138.      12.     349.      40.      49.      13.   1371.40
     .29     2.73     5.24     3.47     .045     .040     .045     .000  1370.90  9907.55
 .005405     240.     250.     260.        2        0        0      .00   163.50 10071.05


CCHV=    .100 CEHV=    .300
*SECNO 21.484
   21.48     4.76  1375.96      .00      .00  1376.30      .34     1.03      .01  1372.90
   2000.      42.    1809.     150.      17.     375.      48.      51.      14.   1371.70
     .30     2.45     4.83     3.09     .045     .040     .045     .000  1371.20  9917.86
 .003265     253.     250.     247.        2        0        0      .00   142.87 10060.74


*SECNO 21.560
   21.56     5.41  1376.81      .00      .00  1377.05      .24      .74      .01  1373.10
   2000.      44.    1750.     206.      21.     419.     102.      54.      15.   1373.00
     .32     2.06     4.18     2.02     .045     .040     .045     .000  1371.40  9904.42
 .001828     314.     310.     304.        2        0        0      .00   203.62 10108.04


*SECNO 21.570
   21.57     6.44  1376.94      .00      .00  1377.08      .14      .02      .01  1371.50
   2000.     103.    1815.      82.      59.     576.      97.      55.      16.   1375.50
     .32     1.75     3.15      .84     .045     .040     .045     .000  1370.50  9895.02
 .000699      20.      20.      20.        2        0        0      .00   223.51 10118.53


*SECNO 21.576

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL.CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   21.58     6.37  1380.87  1380.87      .00  1381.84      .98      .06      .25  1380.00
   2000.       5.    1459.     536.       2.     191.      61.      55.      16.   1375.00
     .32     2.47     7.63     8.73     .045     .040     .045     .000  1374.50  9911.67
 .017500      30.      30.      30.       20        6        0      .00   123.28 10034.95
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 21.580

3301 HV CHANGED MORE THAN HVINS

    21.58      6.84  1381.84       .00       .00  1381.96       .11       .03       .09  1377.20
    2000.       79.    1539.      382.       50.     519.      234.       55.       16.   1375.00
      .33      1.57     2.97      1.64      .045      .040      .045      .000  1375.00  9894.54
  .000692       15.      15.       15.         2         0         0       .00   227.50 10122.03


*SECNO 21.590
    21.59      7.27  1381.87       .00       .00  1381.99       .12       .03       .00  1377.00
    2000.       63.    1723.      213.       41.     594.      146.       56.       16.   1375.50
      .33      1.53     2.90      1.46      .045      .040      .045      .000  1374.60  9888.73
  .000646       50.      50.       50.         2         0         0       .00   229.43 10118.16


*SECNO 21.640
    21.64      6.66  1382.06       .00       .00  1382.22       .15       .21       .01  1378.10
    2000.       63.    1646.      291.       39.     494.      157.       61.       17.   1376.40
      .36      1.61     3.33      1.85      .045      .040      .045      .000  1375.40  9894.22
  .000985      273.     270.      267.         0         0         0       .00   214.38 10108.60


*SECNO 21.650
    21.65      7.25  1382.15       .00       .00  1382.23       .08       .01       .01  1375.90
    2000.      108.    1686.      207.       77.     694.      184.       61.       17.   1374.90
      .36      1.39     2.43      1.12      .045      .040      .045      .000  1374.90  9890.24
  .000332       20.      20.       20.         2         0         0       .00   221.61 10111.85


*SECNO 21.669

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    21.67      5.83  1384.83  1384.83       .00  1385.77       .94       .03       .26  1384.00
    2000.        4.    1585.      411.        2.     207.       49.       61.       18.   1379.40
      .36      2.42     7.65      8.38      .045      .040      .045      .000  1379.00  9903.97
  .018017       30.      30.       30.        20        14         0       .00   130.11 10034.08
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 21.680

3301 HV CHANGED MORE THAN HVINS

    21.68      6.76  1385.76       .00       .00  1385.88       .12       .03       .08  1381.20
    2000.       68.    1636.      297.       44.     550.      182.       62.       18.   1379.60
      .36      1.53     2.98      1.63      .045     .040      .045      .000  1379.00  9888.56
  .000735       15.      15.       15.         2        0         0       .00   228.45 10117.01


*SECNO 21.700
    21.70      6.80  1385.80       .00       .00  1385.92       .12       .04       .00  1381.50
    2000.       80.    1709.      211.       54.     592.      141.       63.       18.   1379.50
      .37      1.47     2.89      1.50      .045     .040      .045      .000  1379.00  9872.71
  .000722       50.      50.       50.         2        0         0       .00   247.00 10119.71


*SECNO 21.742
    21.74      5.99  1385.99       .00       .00  1386.14       .15       .21       .01  1381.90
    2000.       51.    1740.      209.       31.     529.      129.       67.       19.   1380.80
      .39      1.64     3.29      1.62      .045     .040      .045      .000  1380.00  9890.87
  .000992      253.     250.      247.         0        0         0       .00   228.24 10119.11


*SECNO 21.760
    21.76      6.11  1386.21       .00       .00  1386.41       .19       .26       .01  1382.60
    2000.       57.    1649.      293.       31.     440.      124.       70.       20.   1380.30
      .41      1.84     3.75      2.37      .045     .040      .045      .000  1380.10  9898.79
  .001450      217.     215.      213.         2        0         0       .00   191.61 10090.39


*SECNO 21.770
    21.77      6.26  1386.36       .00       .00  1386.44       .08       .02       .01  1381.10
    2000.       74.    1450.      476.       56.     590.      320.       70.       20.   1380.10
      .41      1.32     2.46      1.49      .045     .040      .045      .000  1380.10  9894.46
  .000421       24.      24.       24.         2        0         0       .00   222.18 10116.64


*SECNO 21.780

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    21.78      6.21  1387.81  1387.81      .00  1388.80      .99      .04      .27  1387.00
    2000.       4.    1545.     451.       2.     199.      52.      71.      21.   1382.10
      .41      2.40     7.77     8.68     .045     .040     .045     .000  1381.60  9909.86
  .018177      30.      30.      30.       20        6        0      .00   124.34 10034.20


*SECNO 21.790

3301 HV CHANGED MORE THAN HVINS

    21.79      7.19  1388.79      .00      .00  1388.91      .12      .03      .09  1384.10
    2000.       77.    1568.     355.      49.     520.     210.      71.      21.   1382.10
      .41      1.58     3.01     1.69     .045     .040     .045     .000  1381.60  9897.11
  .000714      15.      15.      15.        2        0        0      .00   212.71 10109.82


*SECNO 21.800
    21.80      7.13  1388.83      .00      .00  1388.97      .13      .05      .00  1384.20
    2000.       72.    1568.     361.      44.     493.     203.      72.      21.   1382.20
      .42      1.61     3.18     1.77     .045     .040     .045     .000  1381.70  9902.83
  .000808      66.      66.      66.        2        0        0      .00   206.18 10109.01


*SECNO 21.820
    21.82      7.01  1388.91      .00      .00  1389.05      .14      .08      .00  1384.40
    2000.       72.    1567.     362.      44.     481.     207.      74.      21.   1382.40
      .43      1.65     3.26     1.75     .045     .040     .045     .000  1381.90  9902.69
  .000874      95.      95.      95.        0        0        0      .00   218.58 10121.27


*SECNO 21.840
    21.84      6.94  1389.04      .00      .00  1389.18      .14      .13      .00  1384.60
    2000.       73.    1573.     353.      44.     474.     200.      76.      22.   1382.60
      .44      1.68     3.32     1.77     .045     .040     .045     .000  1382.10  9902.29
  .000924     150.     150.     150.        0        0        0      .00   218.53 10120.82


*SECNO 21.870
    21.87      6.78  1389.18      .00      .00  1389.35      .17      .16      .01  1384.90
    2000.       77.    1624.     299.      43.     460.     155.      79.      23.   1382.90
      .45      1.78     3.53     1.93     .045     .040     .045     .000  1382.40  9901.85
  .001090     155.     160.     160.        0        0        0      .00   200.74 10102.59
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 21.895
    21.90     6.99  1389.29      .00      .00  1389.44      .15      .09      .00  1386.00
    2000.      29.    1687.     284.      22.     504.     155.      80.      23.   1382.80
      .46     1.34     3.35     1.83     .045     .040     .045     .000  1382.30  9904.87
  .000891      95.      90.      90.        1        0        0      .00   196.21 10101.08


*SECNO 21.900
    21.90     6.33  1389.33      .00      .00  1389.51      .18      .06      .01  1386.00
    2000.      35.    1881.     84.      23.     532.      76.      81.      24.   1387.60
      .47     1.50     3.53     1.11     .045     .040     .045     .000  1383.00  9915.91
  .001087      60.      60.      60.        2        0        0      .00   197.30 10113.20


CCHV=    .300 CEHV=    .500
*SECNO 21.910
    21.91     7.17  1389.47      .00      .00  1389.57      .11      .04      .02  1382.30
    2000.     434.    1460.     106.     222.     511.      63.      82.      24.   1384.00
      .48     1.95     2.86     1.67     .035     .035     .035     .000  1382.30  9887.92
  .000388      55.      70.      85.        2        0        0      .00   168.38 10056.30


CCHV=    .300 CEHV=    .500
*SECNO 21.920
    21.92     5.93  1389.33      .00      .00  1389.74      .42      .01      .15  1399.30
    2000.       0.    2000.       0.       0.     386.       0.      83.      24.   1399.30
      .48      .00     5.18      .00     .020     .020     .020     .000  1383.40  9964.37
  .000558      30.      30.      30.        2        0        0      .00    71.26 10035.63


SPECIAL BRIDGE

SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     1.05      1.56      3.00    200.00     59.00      6.00    877.00      1.00   1384.40   1383.40

*SECNO 21.940
CLASS A LOW FLOW

3420 BRIDGE W.S.=   1389.71 BRIDGE VELOCITY=,      5.85      CALCULATED CHANNEL AREA=,      310.
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
.00	1389.99	.09	0.	2000.	877.	1012.	1399.30	1397.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1399.30 ELREA= 1399.30

21.94	5.12	1389.42	.00	.00	1389.99	.57	.24	.00	1399.30
2000.	0.	2000.	0.	0.	331.	0.	83.	24.	1399.30
.48	.00	6.03	.00	.000	.020	.000	.000	1384.30	9964.76
.000899	103.	103.	103.	0	0	0	.00	70.48	10035.24

*SECNO 21.950

21.95	4.39	1389.39	.00	.00	1390.10	.71	.04	.07	1396.00
2000.	0.	2000.	0.	0.	296.	0.	84.	24.	1399.00
.48	.00	6.75	.00	.020	.020	.020	.000	1385.00	9957.01
.001394	30.	40.	55.	2	0	0	.00	75.89	10032.90

*SECNO 21.960
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

21.96	2.52	1392.52	1392.52	.00	1393.66	1.13	.20	.21	1394.00
2000.	0.	2000.	0.	0.	234.	0.	84.	24.	1399.00
.49	.00	8.55	.00	.035	.035	.035	.000	1390.00	9938.12
.013760	60.	62.	65.	20	11	0	.00	103.45	10041.57

*SECNO 21.970

3301 HV CHANGED MORE THAN HVINS

21.97	3.43	1393.93	.00	.00	1394.38	.45	.52	.21	1394.00
2000.	0.	2000.	0.	0.	371.	0.	85.	25.	1400.00
.49	.00	5.39	.00	.035	.035	.035	.000	1390.50	9934.33
.003765	80.	80.	80.	2	0	0	.00	124.13	10058.46

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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 21.980
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    21.98     1.95  1395.95  1395.95      .00  1396.85      .91      .13      .23  1402.00
    2000.       0.    2000.       0.       0.     262.       0.      85.      25.   1401.50
      .49      .00     7.64      .00     .035     .035     .035     .000  1394.00  9927.05
  .014782      20.      20.      20.       20       11        0      .00   144.81 10071.86


CCHV=    .300 CEHV=    .500
1490 NH CARD USED
*SECNO 22.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    22.00     3.97  1398.47  1398.47      .00  1399.25      .77     1.14      .04  1400.10
    2000.     701.    1299.       0.     130.     167.       0.      85.      25.   1402.00
      .49     5.40     7.80      .00     .031     .035     .035     .000  1394.50  9555.71
  .010009      70.     100.     100.       20       14        0      .00   190.58 10044.18


1490 NH CARD USED
*SECNO 22.020

3265 DIVIDED FLOW

    22.02     4.80  1399.50      .00      .00  1399.80      .30      .42      .14  1400.00
    2000.     992.    1008.       0.     237.     220.       0.      86.      25.   1402.00
      .50     4.19     4.59      .00     .030     .035     .035     .000  1394.70  9548.87
  .002992      60.     100.     120.        2        0        0      .00   226.42 10041.81


CCHV=    .100 CEHV=    .300
1490 NH CARD USED
*SECNO 22.065

3265 DIVIDED FLOW

7185 MINIMUM SPECIFIC ENERGY
```

```
  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


3720 CRITICAL DEPTH ASSUMED
   22.07     4.31  1400.11  1400.11      .00  1400.82      .71      .84      .12  1404.10
   2000.    1446.     554.       0.     211.      86.       0.      88.      26.   1402.00
     .51     6.86     6.45      .00     .030     .035     .035     .000  1395.80  9595.34
 .007080     160.     241.     260.        4       12        0      .00   213.03 10014.95


1490 NH CARD USED
*SECNO 22.090

3265 DIVIDED FLOW

   22.09     5.82  1401.12      .00      .00  1401.39      .27      .52      .04  1401.80
   2000.     963.    1037.       0.     256.     231.       0.      89.      27.   1404.00
     .52     3.76     4.49      .00     .030     .035     .035     .000  1395.30  9618.43
 .002058     150.     150.     150.        2        0        0      .00   209.51 10034.83
```

HEC-2 RESULTS AT DOMINANT DISCHARGE

LOCATION	SECNO.	B	S	d	V
BELL RD.	20.841				
	20.845				
DROP NO. 1	20.847				
SOIL CEMENT	20.85	65		6.2	3.6
WASH	20.86	68	.0009	6.2	3.7
	20.89	68	.0007	6.3	3.4
	20.91	68	.0007	6.4	3.4
DROP NO 2					
SOIL CEMENT	20.97				4.8
	20.93			5.8	3.3
	20.942	55	.0012	6.0	4.1
OLD	20.96	56	.0012	6.0	4.1
	20.98	59	.0012	6.4	4.1
REACH I AVERAGE	21.00	61	.0011	6.7	4.1
	21.03	63	.0008	6.0	3.4
	21.036	66	.0008	6.0	3.6
	21.06	70	.0009	6.0	3.6
CHANNAL TO 7TH AVE	21.08	70	.0009	5.9	3.7
	21.10	70	.0010	5.8	3.8
	21.127	70	.0010	5.8	3.8
DROP NO. 3	21.13				
SOIL CEMENT					7.4
7TH AVE	21.15				
BRIDGE	21.16				9.6
ROCK					
PATTERNS &					7.6
SOIL CEMENT	21.195	119			
BELLVUE CHANNEL REACH II AVERAGE	21.20	119	.0019	3.6	4.0
	21.23	119	.0015	3.8	3.8
	21.26	119	.0012	4.1	3.6
	21.30	119	.0011	4.1	3.4
	21.33	119	.0011	4.2	3.4

LOCATION	SECNO	B	S	d	V
SOUTH OF GROVERS	21.363	130	.0011	4.0	3.3
	21.37	119	.0012	4.0	3.4
REACH III AVERAGE	21.38	122	.0015	3.8	3.8
	21.39	115	.003	3.6	4.4
	21.44	131	.005	4.0	5.0
NORTH OF GROVERS	21.48	110	.002	4.7	4.8
	21.56				
DROP NO 4	21.57				
BOULDERS	21.576				
UNIT 12	21.58	110	.0007	6.8	3.0
	21.59	110	.0006	7.2	2.9
	21.64	110	.0009	6.6	3.3
DROP NO 5	21.65				
BOULDERS	21.67				
ESTATES IV	21.68	110	.0007	6.8	3.0
	21.70	110	.0007	6.8	2.9
	21.74	110	.0010	6.0	3.3
	21.76				
DROP NO. 6	21.77				
BOULDERS	21.78				
VALLEY REACH AVERAGE	21.79	110	.0007	7.1	3.0
	21.80	110	.0009	7.1	3.2
	21.82	110	.0009	7.0	3.2
	21.84	110	.0009	7.0	3.3
	21.87	110	.0010	6.8	3.3
DEER	21.895	110	.0009	6.9	3.4
	21.90	112	.0010	6.3	3.5
	21.91				
UNION HILLS BRIDGE	21.92				
	21.94				

	REACH I	REACH II	REACH III	REACH IV
FACTORS: n	.035	.035	.04	.04
Q	2000	2000	2000	2000

1" = 25.43 mm
1' = 305 mm
1' = .305 m

Sheet 1 of

Soils reports for material particle size gradation by weight east of 7th Ave (Bellvue and DVE 12 channels) were used for calculations where Dm or D_{90} values were required. The material in the channel west of 7th Ave has a more coarse gradation of cobbles and boulders over 10". Therefore, the degradation and scour results are conservative for the Wash reach. The Amwest copy of the soils report west of 7th Ave prepared for this project in 1990 has not been located in the Cave Creek file. The secretary will search some related files in storage to find the report. A new copy will be requested from the soils engineer if necessary. A notice to all offices that get this Degradation and Scour Analysis will be sent to confirm that the project soils report has the same or higher Dm or D_{90} values.

Bill Leimkuehler

BED MATERIAL GRADATION

NEW CHANNEL / BELLVUE / DVE 12 (WITH GRAVEL LAYER)

% BY WEIGHT	SIZE (inches)	SIZE (mm)	D % SMALLER	ΔP % LARGER
10	6+	153		
10	3+	75	90	10
20	2+	51	80	20
15	1.5+	38	60	40
	1.3+	33	50	50
15	1.0+	25		70
10	.5+	18		80
10	.4+	10		90
10	.25+	6		100

OLD WASH HAS MORE BOULDERS 10"+

ROUGHNESS COEFFICIENT n

1991 FIS USED n = .035 IN CHANNEL TO MODEL VEGETATION IN WASH BOTTOM.

AEC USED n = .035 IN WASH, NEW CHANNEL TO 7TH AVE, AND BELLVUE CHANNEL. WASH BOTTOM WILL BE CUT DEEPER AND WIDER

BUT SAME VEGETATION WILL RETURN. ALSO LANDSCAPE PLANS SHOW TREES AND BUSHES IN THE BOTTOM OF NEW CHANNEL AND BELLVUE.

DVE 12 CHANNEL BOTTOM WAS PLANTED WITH TREES AND BUSHES IN 1983. THE GROWTH WAS TOO THICK IN 1994. THE TREES AND BUSHES WILL BE TAGGED TO SAVE BEFOR CLEAR AND GRUB RETURNS n TO 0.04

Meyer-Peter, Muller (Bedload Transport Equation)

Bedload transport equations provide a method to compute a nontransportable particle size representing coarse bed material capable of forming an armoring layer.

$$D_c = \frac{dS}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}} \qquad (2)$$

where:

D_c = Individual particle size in millimeters
K = 0.19 inch-pound units (0.058 metric units)
d = Mean water depth at dominant discharge, ft (m)
S = Slope of energy gradient, ft/ft (m/m)
n_s = Manning's "n" for bed of stream
D_{90} = Particle size in millimeter at which 90 percent of bed material by weight is finer

REACH	I	II	III	IV
d	6.1	3.9	4.0	6.7
S	.0009	.0013	.0023	.0009
dS	.00549	.00507	.0092	.00603
n	.035	.035	.04	.04
D_{90}	75	75	75	75

REACH I & II $K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2} = .19\left(\frac{.035}{75^{.167}}\right)^{1.5} = .19\left(\frac{.035}{2.057}\right)^{1.5} = .0004$

III & IV $.19\left(\frac{.04}{2.057}\right)^{1.5} = .0005$

$$D_c = \frac{dS}{.0004} = \text{REACH I } \frac{.00549}{.0004} = 13.7 \text{ mm}$$

$$= \text{II } \frac{.00507}{.0004} = 12.7 \text{ mm}$$

$$= \text{III } \frac{.0092}{.0005} = 18.4 \text{ mm}$$

$$= \text{IV } \frac{.00603}{.0005} = 12.6 \text{ mm}$$

Competent Bottom Velocity

Investigations show that the size of a particle plucked from a streambed is proportional to the velocity of flow near the bed. The particle starts to move at what is called the competent bottom velocity (Mavis and Laushey, 1948) which is approximately 0.7 times V_m, the mean channel velocity.

$$D_c = 1.88\ V_m^2 \text{ inch-pound units} \qquad (3)$$

$$D_c = 20.2\ V_m^2 \text{ metric units}$$

where:

D_c = Armor size, mm
V_m = Mean channel velocity, ft/s (m/s)

REACH

I $D_c = 1.88\ V_m^2 = 1.88(3.7)^2 = 25.7$ mm

II $1.88(3.7)^2 = 25.7$ mm

III $1.88(4.0)^2 = 30.0$ mm

IV $1.88(3.2)^2 = 19.2$ mm

Lane's Tractive Force

BOR manual Figure 4 on next pages shows the relationship of critical tractive force vs the mean particle size diameter. Calculate the critical tractive force using channel hydraulics for dominant discharge and select the curve on Figure 4 where critical tractive force intersects a line to the lower grain size limit of nontransportable material , (Dc). BOR recommends use of the "curves for canals with clear water" in coarse, non-cohesive material".

$$\tau_c = \gamma_w d S \qquad (4)$$

where:

τ_c = Critical tractive force, lb/ft^2 (g/m^2)
γ_w = Specific weight)(mass) of water, 62.4 lb/ft^3 (1 t/m^3)
d = Mean water depth, ft (m)
S = Slope, ft/ft (m/m)

RESULTS FROM MEYER-PETER, MULLER

REACH	I	II	III	IV
dS	.00549	.00507	.0092	.00603
$\tau_c = \gamma_w dS$	x62.4	x62.4	x62.4	x62.4
$\tau_c =$	.34	.32	.57	.38

FROM FIG. 4 NEXT PAGE TRACTIVE FORCE CURVE COARSE, NON-COHESIVE MATERIAL

D (mm)	22	23	33	25

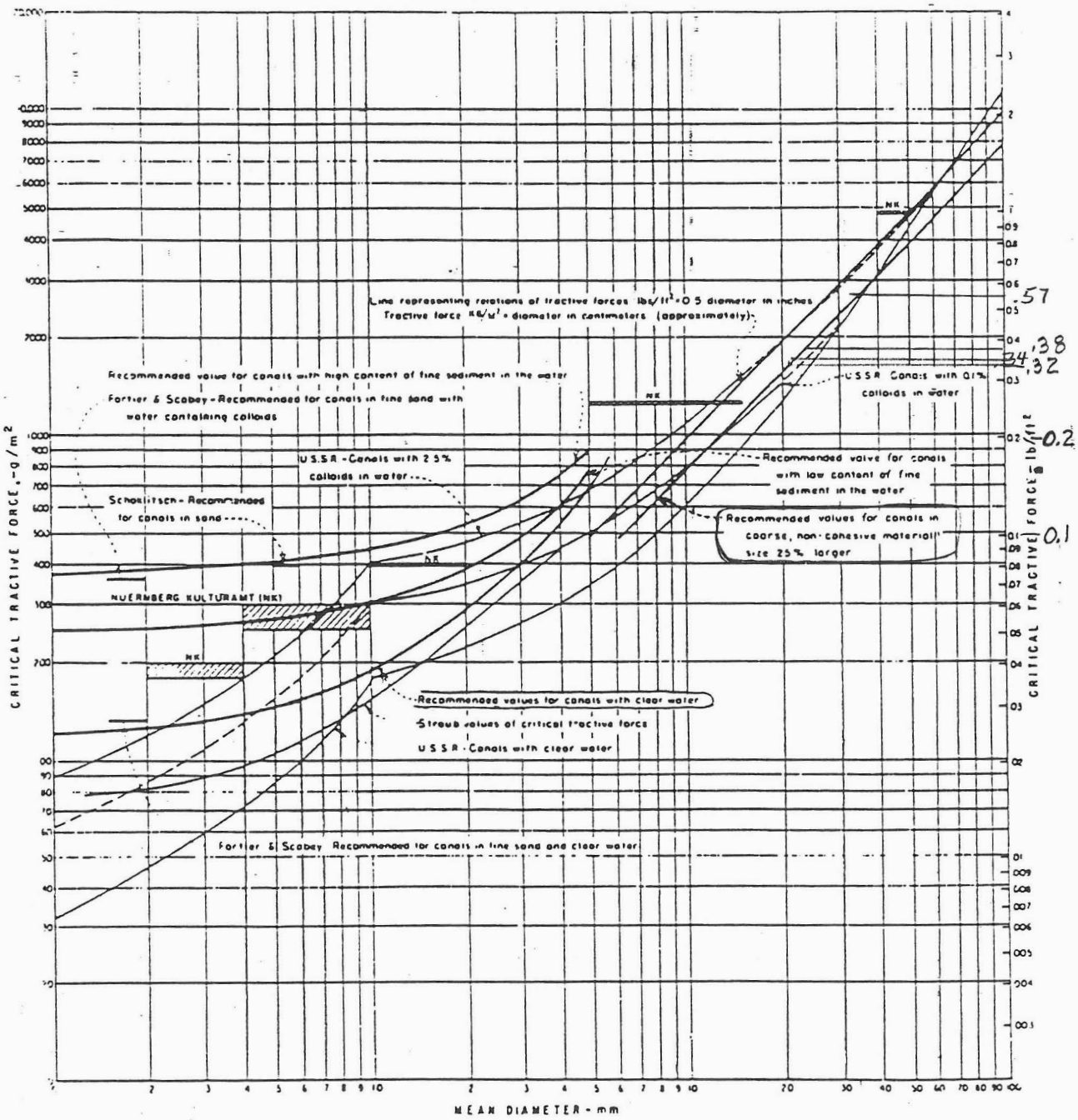


Figure 4. - Tractive force versus transportable sediment size (after Lane, 1952).

Sheet 6

Shields Diagram

Many investigators use the Shields diagram (Shields, 1936), figure 5 (next page) to define the initiation of motion for various particle sizes. In the process of armoring of a streambed for predominately gravel size material >1.0 mm and high Reynold's number $R_* > 500$, the Shields parameter given below provides a method for determining an armor size.

R_* = boundary Reynold's number
U_* = Shear velocity $\sqrt{S_L R g}$, ft/s (m/s)
S_L = Slope, ft/ft (m/m)
R = Hydraulic radius or mean depth for wide channels, ft (m)
g = Acceleration due to gravity, 32.2 ft/s^2 (9.81 m/s^2)
D = Particle diameter, ft (m)
ν = Kinematic viscosity of water varying with temperature, ft^2/s (m^2/s) (1×10^{-5})

and

$$T_* = \frac{T_c}{(\gamma_s - \gamma_w)\, D} \qquad (5)$$

where:

T_* = Dimensionless shear stress
T_c = Critical shear stress lb/ft^2 (t/m^2) equal to $\gamma_w d S_L$
γ_s = Specific weight (mass) of particles, 165.4 lb/ft^3 (2.65 t/m^3)
γ_w = Specific weight (mass), 62.4 lb/ft^3 (1 t/m^3)
d = Mean depth, ft (m)
S_L = Slope, ft/ft (m/m)
D = Particle diameter, ft (m)

$R_* = \frac{U_* D}{\nu}$ $\quad U_* = (S_L R g)$ WIDE BOTTOM $R = d$

TEST SMALL GRAIN $\quad$ Highest S_L @ REACH III $= (.0023 \times 4 \times 32.2)^{0.5} = .544$

6mm = $\frac{.236''}{12''} = .0197'$

HIGHEST d @ REACH IV $= (.0009 \times 6.6 \times 32.2)^{.5} = .437$

III $\quad R_* = \frac{.544(.0197)}{1 \times 10^{-5}} = 1070$

IV $\quad R_* = \frac{.437(.0197)}{1 \times 10^{-5}} = 860$

COURSE BED MATERIAL WILL HAVE EVEN HIGHER R_*. SHIELDS DIAGRAM NEXT PAGE

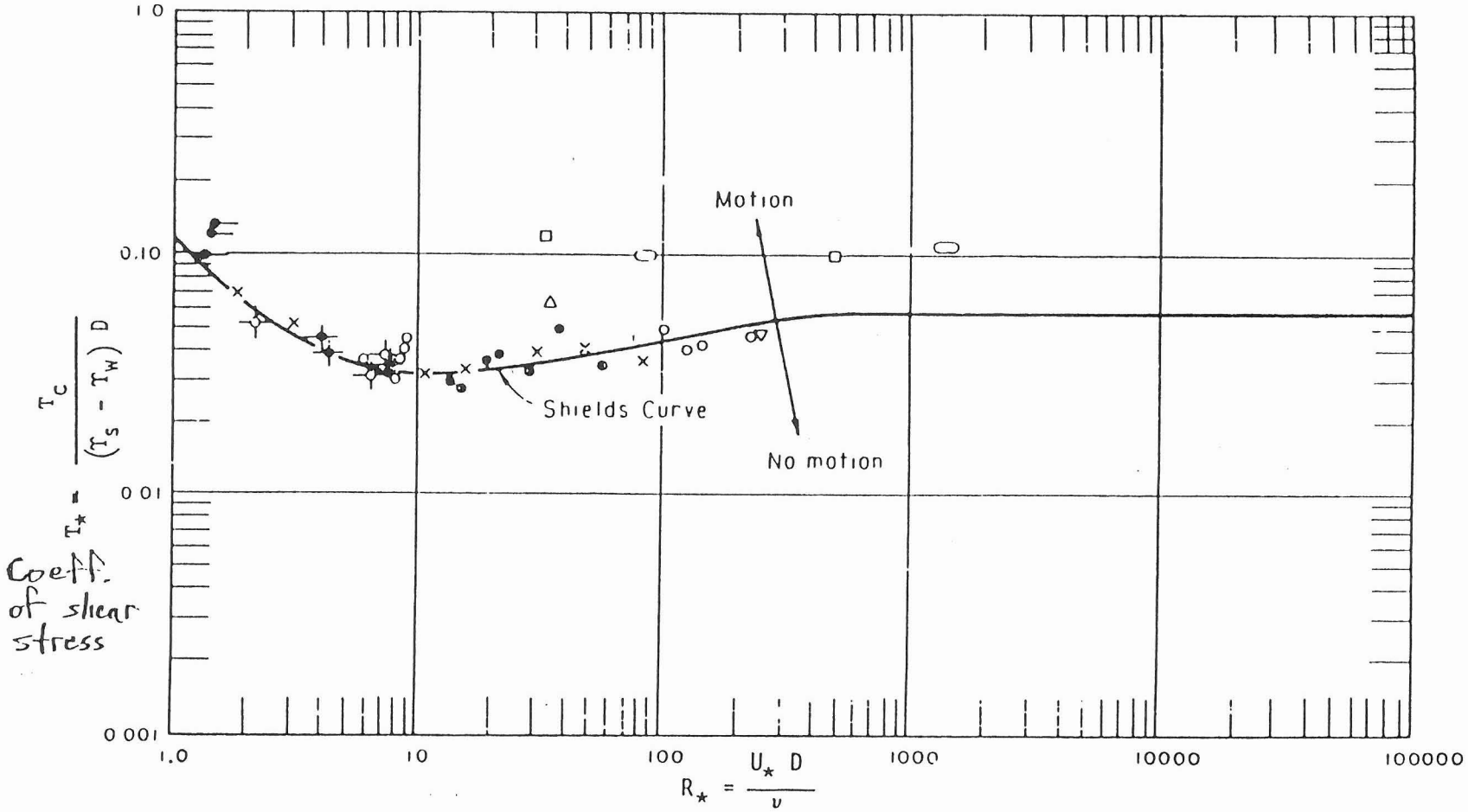
T_* COEFFICIENT CONSTANT .06 @ $R_* > 500$

$.06 = \frac{T_c}{(\gamma_s - \gamma_w) D}$

$D = \frac{T_c}{(165.4 - 62.4)(.06)}$

$D = \frac{T_c}{6.2} = \longrightarrow$

REACH	I	II	III	IV
$T_c = \gamma_w d S_L$ (LANE METHOD RESULTS)	.34	.32	.57	.38
FT.	.05	.052	.09	.06
mm	15.3	15.9	27	18.7



Sym	Description	γ_s, g/cm³
○	Amber	1.06
●	Lignite (Shields)	1.27
●	Granite	2.7
●	Barite	4.25
×	Sand (Casey)	2.65
✦	Sand (Kramer)	2.65
✦	Sand (U.S.W.E.S.)	2.65
▽	Sand (Gilbert)	2.65

Fully developed turbulent velocity profile

●—	Sand (Vanoni)	2.65
—●	Glass beads (Vanoni)	2.49
□	Sand (White)	2.61
⬭	Sand in air (White)	2.10
△	Steel shot (White)	7.9

Turbulent boundary layer

$U_* = \text{Shear velocity}$

$= \sqrt{\frac{\tau_c}{\rho}}$ $\rho = \frac{62.4}{32.2} = 1.93$

$= \sqrt{gRS}$

Figure 5. - Shields diagram for initiation of bed material movement

Sheet 8

Yang Incipient Motion

Yang (1973) developed a relationship between dimensionless critical velocity, V_{cr}/w, and shear velocity Reynold's number, R_*, at incipient motion. Under rough regime conditions where $R_*>70$, the equation for incipient motion which is considered applicable to bed material size larger than about 2 mm by Reclamation is:

$$\frac{V_{cr}}{w} = 2.05 \qquad (6)$$

where:

V_{cr} = Critical average water velocity at incipient motion, ft/s (m/s)
w = Terminal fall velocity, ft/s (m/s)

The settling velocity by Rubey (1933) for material larger than 2 mm in diameter will approximate the fall velocity by:

$$w = 6.01\ D_c^{1/2} \text{ inch-pound units} \qquad (7)$$

$$w = 3.32\ D_c^{1/2} \text{ metric units}$$

Equations 6 and 7 can be combined to give:

$$D_c = 0.00659\ V_{cr}^2 \text{ inch-pound units} \qquad (8)$$

$$D_c = 0.0216\ V_{cr}^2 \text{ metric units}$$

	REACH	I	II	III	IV
$D_c = .00659\ V_{cr}^2 =$		3.7	3.7	4.0	3.2
	$V^2 =$	13.7	13.7	16.0	10.2
		x.00659	x.00659	x.00659	x.00659
	D_c (FT)	.0903	.0903	.105	.068
	mm/FT	x 305	x 305	x 305	x 305
METHOD 5	D_c mm	27.5	27.5	32	20.7
4		15.3	15.9	27	18.7
3		22.0	23.0	33	25.0
2		25.7	25.7	30	19.2
1		13.7	12.7	18.4	12.6
AVERAGE		20.8	21.0	28.0	19.2

Depth to Armor and Volume Computations

After determining the size of the material required to armor the streambed, from either an average of the five methods or a judgment decision on the best method, an estimate can be made of the probable vertical degradation before stabilization is reached. The armoring computations assume that an armoring layer will form as shown on figure 6 by the equations:

$$y_a = y - y_d \qquad (9)$$

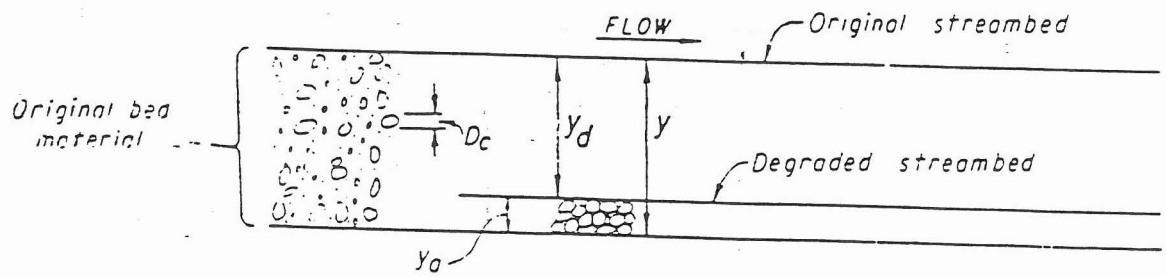
and

$$y_a = (\Delta p)\ y \qquad (10)$$

which are combined to:

$$\boxed{y_d = y_a\left(\frac{1}{\Delta p} - 1\right)} \qquad (11)$$

y_a = Thickness of armoring layer
y = Depth from original streambed to bottom of the armoring layer
y_d = Depth from original streambed to top of armoring layer or the depth of degradation
Δp = Decimal percentage of original bed material larger than the armor size, D_c



y = Depth to bottom of the armoring layer

y_d = Depth of degradation

y_a = Armoring layer

D_c = Diameter of armor material

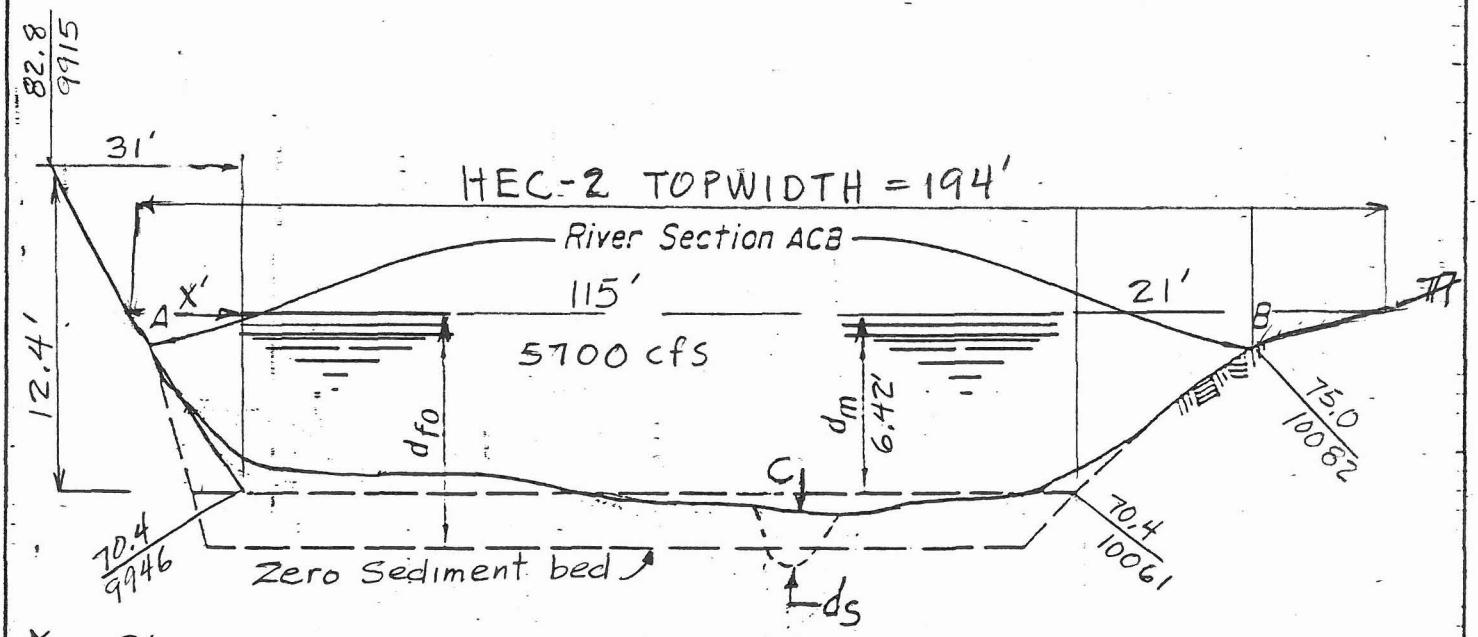
Δ_p = Decimal percentage of original bed material larger than D_c

Figure 6. - Armoring definition sketch.

REACH	I	II	III	IV
ARMOR SIZE D_c AVERAGE	20.8	21.0	28.0	19.2
$Y_a = 3$ D_c (mm)	62	63	84	57
D_c (FT)	0.2	0.2	0.27	0.19
Δp% SIZE > D_c GRADATION	.75	.75	.65	.80
$(1/\Delta_p - 1)$	.33	.33	.54	.25
$Y_d = Y_a(1/\Delta_p - 1)$ (FT)	.066	.066	.145	.048
Y_d (inches)	.8"	.8"	1.7"	.57"

DEGRADATION INSIGNIFICANT

This example of scour is at Bell Rd bridge looking north at east bank. The armor layer of large rocks on the bottom has kept the scour from cutting deeper than the FL. The flow has scoured the toe of 4:1 slope about 1'± at about 1:1 slope. No significant scour is expected at the design FL 1.5'± deeper in the Wash. The realigned channel bed material has less boulders and large cobbles 6"+ and possibility of scour is only analyzed in other reaches.



$\frac{X}{6.42} = \frac{31}{12.4}$

$X = 16'$

NOTE: $d_{fo} > d_f > d_m$. Point C is low point of natural section.

Figure 10. - Sketch of natural channel scour by regime method.

Table 7. - Multiplying factors, Z, for use in scour depths by regime equations

$d_s = Z d_f$ (28) $d_s = Z d_m$ (29) $d_s = Z d_{fo}$ (30)

Condition	Value of Z		
	Neill $d_s = Z\ d_f$	Lacey $d_s = Z\ d_m$	Blench $d_s = Z\ d_{fo}$
Equation Types A and B			
Straight reach	0.5	0.25	1/ 0.6 BENDS
Moderate bend	0.6	0.5	
Severe bend	0.7	0.75	
Right angle bends		1.0	1.25
Vertical rock bank or wall		1.25	
Equation Types C and D			
Nose of piers	1.0		0.5 to 1.0
Nose of guide banks	0.4 to 0.7	1.50 to 1.75	1.0 to 1.75
Small dam or control across river		1.5	0.75 to 1.25

1/ Z value selected by USBR for use on bends in river.

HEC-2 RESULTS $D_{50} = D_m = 33$ mm

Q_{100} (FIS) = 5700 cfs

$q = Q/w = 29.4$ cfs

$d = 6.42$

$V = 6.49$

Sheet 1 of

Regime equations supported by field measurements method (2): This approach as suggested by Neill (1973) on recommendations by Blench (1969) involves obtaining field measurements in an incised reach of river from which the bankfull discharge and hydraluics can be determined. From the bankfull hydraulics in the incised reach of river, the flood depths can be computed. This method has been expanded for Reclamation use to include the empirical regime equation by Lacey (1930) and the method of zero bed-sediment transport by Blench (1969) in the form of the Lacey equation:

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3} \qquad (26)$$

d_m = Mean depth at design discharge, ft (m)
Q = Design discharge, ft^3/s (m^3/s)
f = Lacey's silt factor equals 1.76 $(D_m)^{1/2}$ where D_m equal mean grain size of bed material in millimeters

and the Blench equation for "zero bed factor":

$$d_{fo} = \frac{q_f^{\,2/3}}{F_{bo}^{\,1/3}} \qquad (27)$$

d_{fo} = Depth for zero bed sediment transport, ft (m)
q_f = Design flood discharge per unit width, ft^3/s per ft (m^3/s per m)
F_{bo} = Blench's "zero bed factor" in ft/s^2 (m/s^2) from figure 9

CHANNEL DATA ON SHEET 1.

(26) $f = 1.76(D_m)^{1/2} = 1.76(.33)^{1/2} = 10.1$

$d_m = .47\left(\frac{Q}{f}\right)^{1/3} = .47\left(\frac{5700}{10.1}\right)^{1/3} = 3.80'$

(29) $Z = 0.25$ $d_s = Z\,d_m = .25(3.80) = 0.95'$
(STRAIGHT)

(27) F_{bo} from GRAPH NEXT PAGE $\doteq 5$

$d_{fo} = \frac{q_f^{\,2/3}}{F_{bo}^{\,1/3}} = \frac{(29.4)^{.67}}{(5)^{.33}} = \frac{9.6}{1.7} = 5.6'$

(30) $d_s = Z\,d_{fo} = .25(5.6) = 1.4'$

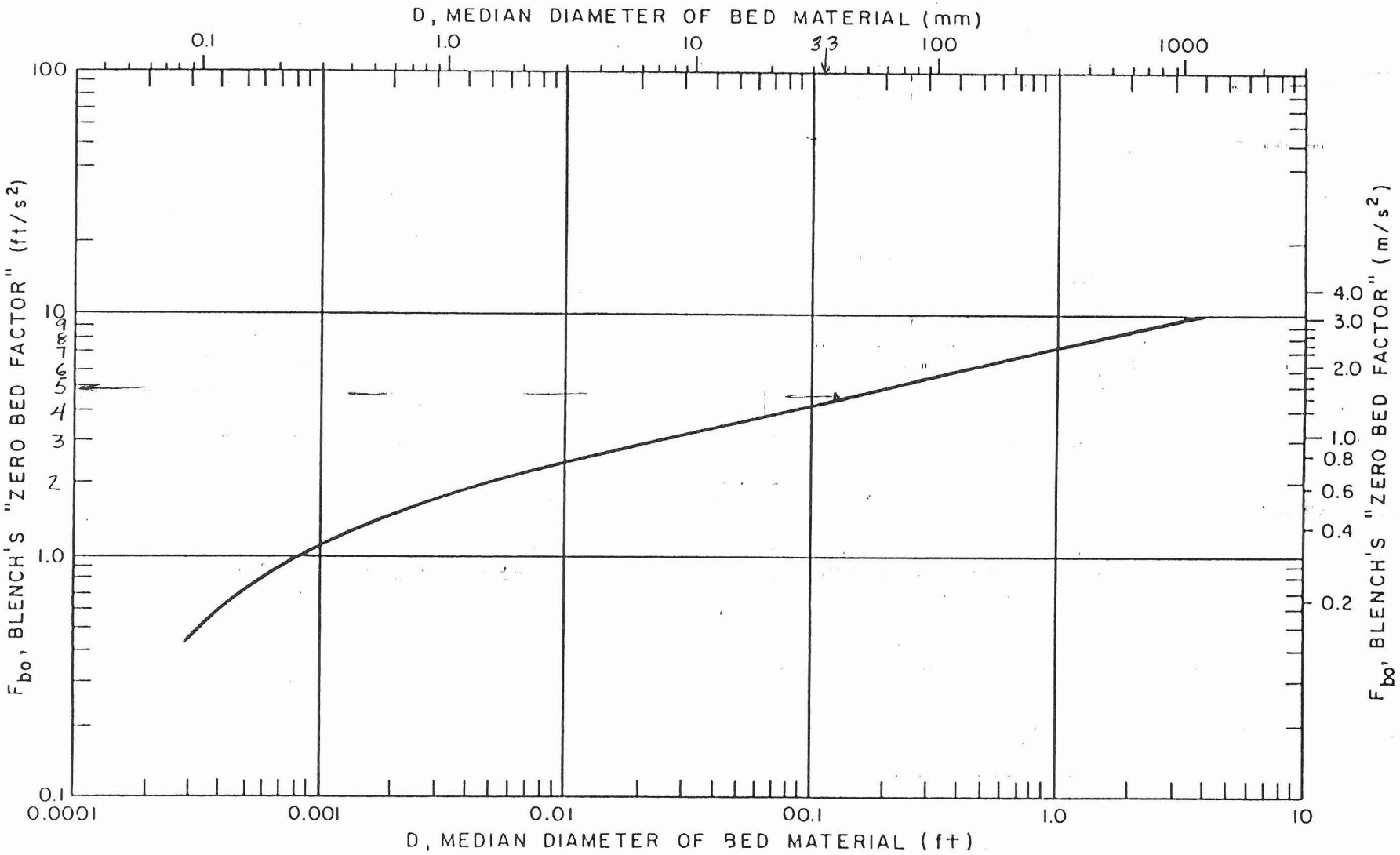


CHART FOR ESTIMATING F_{bo} (AFTER BLENCH)

Figure 9. - Chart for estimating F_{bo} (after Blench, 1969)

Sheet 3

Mean velocity using Survey Cross Sections Method (3):
No measured WS in the new channel alignment has been made to use for a check on channel roughness coefficient n. BOR manual recommends use dm from HEC-2 and apply Z.

$$d_s = Z\,d_m = .25(6.42) = 1.6$$
(HEC-2)

CHANNEL DATA ON SHEET 1

Competent or limiting velocity control to scour method (4): This method assumes that scour will occur in the channel cross section until the mean velocity is reduced to that where little or no movement of bed material is taking place. It gives the maximum limit to scour existing in only the deep scour hole portion of the channel cross section and is similar to the Blench equation 27 for a "zero bed factor."

$$d_s = d_m\left(\frac{V_m}{V_c} - 1\right) = 6.42\left(\frac{6.49}{7.2} - 1\right) = 6.42(-.1)$$

V_c from FIG 12 next page = 7.2 fps

$\left(\frac{V_m}{V_c} - 1\right)$ = negative means no scour
OMIT THIS METHOD

AVERAGE SCOUR

LACEY	.95
BLENCH	1.4
BOR	1.6
	3.95'
AVERAGE	1.32'

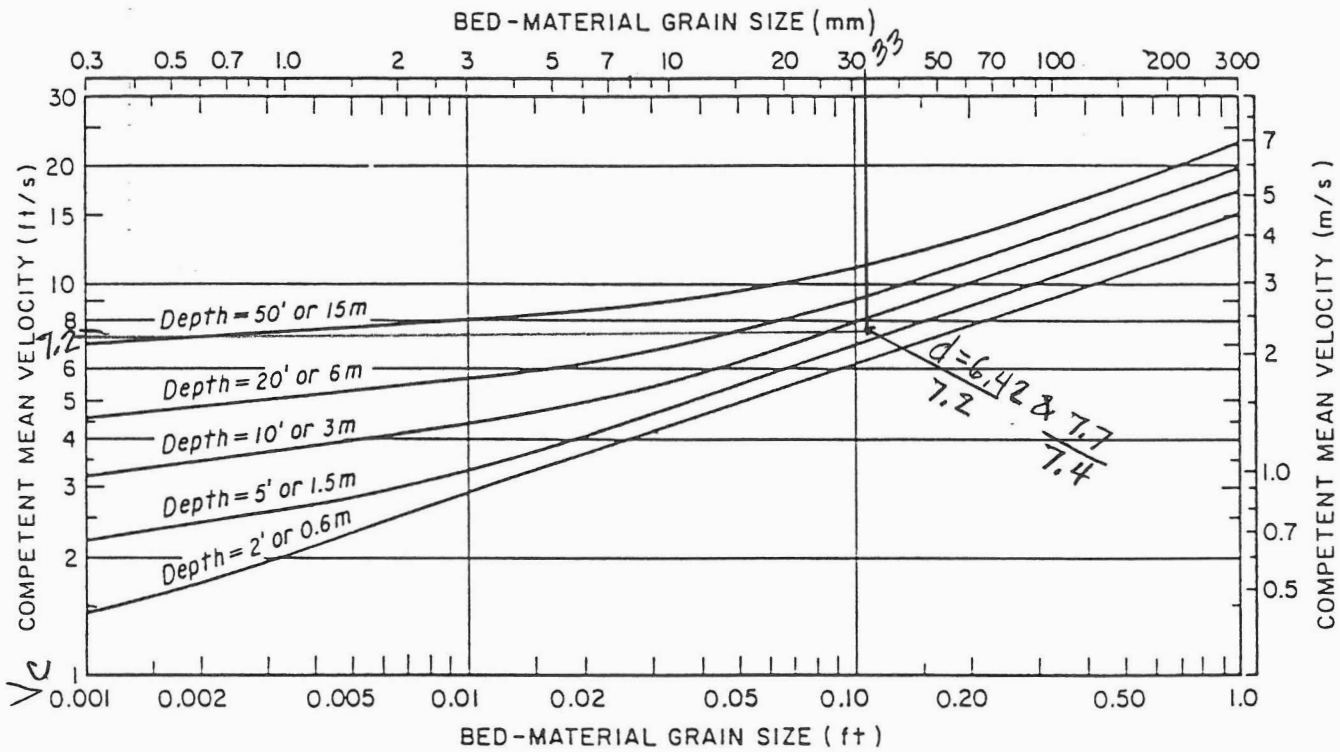


Figure 12. - Suggested competent mean velocities for significant bed movement of cohesionless materials, in terms of grain size and depth of flow (after Neill, 1973).

Sheet 5

Equation Type C SCOUR AT BRIDGE PIER

The numerous empirical relationships for computing scour at bridge piers include one or more of the following hydraulic parameters: pier width and skewness, flow depth, velocity, and size of sediment (Dm). Two different approaches (1) regime, and (2) rational are used. The regime approach is to use either equations 26, 27, 28, or 30 and a Z value from table 7. An appropriate value to use for piers is 1.0 to the Lacey equation 29. Use Table 7 value for Blench equation (30).

SCOUR NEAR PIERS CAN ONLY ACCUR IF SOIL CEMENT LINING UPSTREAM BREAKS OUT.

RESULTS FROM SHEET 2.

LACEY (26) $d_m = 3.8'$

BLENCH (27) $d_{fo} = 5.6'$

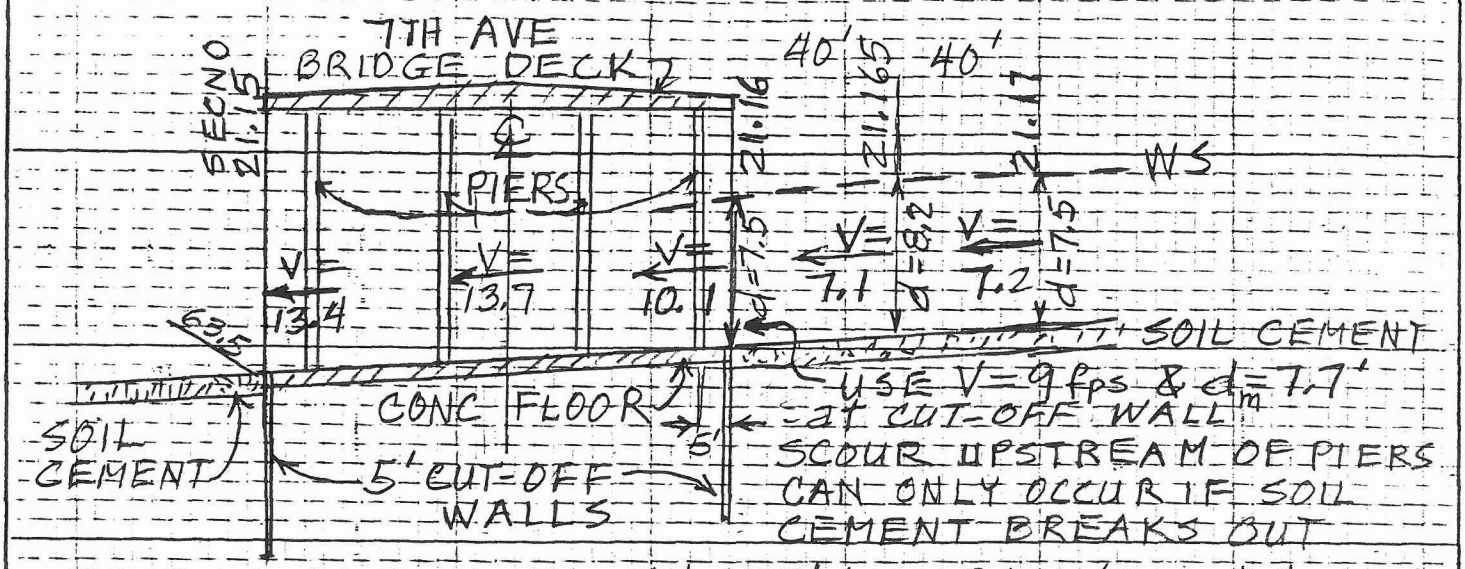
USE Z FACTOR FOR EQUATION TYPE C (PIERS)

BOR RECOMMENDS $Z = 1.0$ IN (29)

TABLE 7 $Z = .5$ TO 1.0 USE MID VALUE 0.7

LACEY (29) $d_s = Z\, d_m = 1.0 \times 3.8 = 3.8'$

BLENCH (30) $d_s = Z\, d_{fo} = 0.7 \times 5.6 = 3.9'$



BRIDGE DATA/SKEW = 0 / d_m = 7.7' / V = 9 fps / PIER Ø d = 2.5'
5' UPSTREAM ROUND PIER EFFECTIVE (b) = 0.8 d
(b) = 2

The rational equation selected for scour at piers is described by Jain (1981) in the form:

$$\frac{d_s}{b} = 1.84 \left(\frac{d}{b}\right)^{0.3} \left(F_c\right)^{0.25} \qquad (33)$$

where:

d_s = Depth of scour below streambed, ft (m)
b = Pier size, ft (m)
d = Flow depth, ft (m)
$F_c = V_c/\sqrt{gd}$ = Threshold Froude number
V_c = Threshold velocity, ft/s (m/s) from figure 12
g = Acceleration due to gravity, 32.2 ft/s^2 (9.81 m/s^2)

V_c from FIG 12 on Sheet 5 = 7.4 fps

$$F_c = \frac{V_c}{\sqrt{gd}} = \frac{7.4}{(32.2 \times 7.7)^{1/2}} = \frac{7.4}{15.7} = .47 \quad (F_c)^{.25} = .83$$

$$\left(\frac{d}{b}\right)^{.3} = \left(\frac{7.7}{2}\right)^{.3} = 1.5$$

$$d_s = b \times (1.84 \times 1.5 \times .83) = 2 \times 2.288 = 4.57'$$

AVERAGE BRIDGE SCOUR

LACEY 3.8
BLENCH 3.9
RATIONAL 4.6
12.3
AVERAGE 4.1

5' DEEP CUT-OFF WALL
OK FOR WORST CASE

THIS RUN EXECUTED 07-11-94

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************
```

```
T1    CAVE CREEK WASH FLOODWAY AMWEST ENGINEERING STARTING SOUTH OF BELL RD.
T2    AT WATER SURFACE ELEVATIONS FROM BURGESS & NIPLE FIS APPROVED BY FEMA
T3    IMPROVEMENTS UPSTREAM  FOR CITY OF PHOENIX 7TH AVENUE PROJECT.(BELLN)

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

      0.      2.       0.       0.    .000000     .00      .0       0.   1353.310   .000

J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE

    1.000     .000   -12.000    .000     .000     .000     .000     .000     .000     .000
```

100 YR Q: ALL OTHER INPUT DATA @ TAB B

```
NC      .040      .040      .035      .100      .300      .000      .000      .000      .000      .000
QT     2.000   5700.000   5700.000      .000      .000      .000      .000      .000      .000      .000
X1    20.629     16.000   9909.000  10076.000      .000      .000      .000      .000      .000      .000
GR  1357.300   9532.000   1357.300   9624.000  1356.800   9754.000  1357.200   9808.000  1357.100   9909.000
GR  1351.500   9922.000   1350.200   9947.000  1343.300   9959.000  1343.600   9991.000  1343.600  10000.000
GR  1343.700  10044.000   1356.300  10076.000  1357.000  10082.000  1357.100  10137.000  1357.200  10252.000
GR  1358.000  10337.000      .000      .000      .000      .000      .000      .000      .000      .000

X1    20.725     20.000   9951.000  10036.000   510.000   520.000   512.000      .000      .000      .000
GR  1360.300   9544.000   1361.100   9631.000  1361.300   9734.000  1361.000   9783.000  1362.000   9858.000
GR  1360.800   9940.000   1362.400   9951.000  1350.400   9970.000  1350.400   9981.000  1348.300   9984.000
GR  1347.400   9992.000   1347.200  10000.000  1347.400  10010.000  1361.000  10036.000  1363.400  10046.000
GR  1363.800  10101.000   1364.100  10156.000  1364.700  10184.000  1365.100  10212.000  1364.700  10291.000

NC      .000      .000      .000      .300      .500      .000      .000      .000      .000      .000
X1    20.737     16.000   9968.000  10019.000    80.000    80.000    80.000      .000     3.400      .000
X3    10.000      .000      .000      .000      .000      .000      .000   1363.000  1363.000      .000
GR  1360.300   9544.000   1361.100   9631.000  1361.300   9734.000  1361.000   9783.000  1362.000   9858.000
GR  1360.800   9940.000   1360.400   9951.000  1347.500   9968.000  1347.500  10019.000  1361.000  10036.000
GR  1363.400  10046.000   1363.800  10101.000  1364.100  10156.000  1364.700  10184.000  1365.100  10212.000
GR  1364.700  10291.000      .000      .000      .000      .000      .000      .000      .000      .000

BE     1.250      1.560     3.000   100.000    51.000     3.000   576.000      .000  1351.000  1350.900
X1    20.750      .000      .000      .000    71.000    71.000    71.000      .000      .100      .000
X2      .000      .000     1.000  1363.000  1366.000      .000      .000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000   1364.000  1364.000      .000

X1    20.819     12.000   9965.000  10043.000   375.000   345.000   365.000      .000     -.900      .000
X3    10.000      .000      .000      .000      .000      .000      .000   1366.900  1366.900      .000
GR  1366.500   9554.000   1365.400   9663.000  1365.500   9777.000  1365.500   9846.000  1365.300   9942.000
GR  1357.400   9965.000   1357.400  10043.000  1367.600  10066.000  1366.200  10107.000  1366.200  10146.000
GR  1367.000  10166.000   1367.200  10169.000      .000      .000      .000      .000      .000      .000
```

```
 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    BANK ELEV
 Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
 TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN       SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID      ENDST

*PROF 1

CCHV=    .100 CEHV=    .300
*SECNO 20.628
   20.63    10.01  1353.31      .00  1353.31  1353.74      .43      .00      .00  1357.10
   5700.       0.    5700.       0.       0.    1089.       0.       0.       0.   1356.30
     .00      .00     5.23      .00     .040     .035     .040     .000  1343.30  9917.80
 .001125       0.       0.       0.        0        0        0      .00   150.61 10068.41


*SECNO 20.725

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   20.73     8.84  1356.04  1356.04      .00  1359.09     3.06     1.32      .79  1360.40
   5700.       0.    5700.       0.       0.     406.       0.       9.       1.   1361.00
     .01      .00    14.03      .00     .040     .035     .040     .000  1347.20  9959.29
 .010764     510.     512.     500.       20       11        0      .00    67.22 10026.51


CCHV=    .300 CEHV=    .500
*SECNO 20.737

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1363.00 ELREA=     1363.00

   20.74     7.27  1358.17  1358.17      .00  1361.84     3.67      .80      .31  1350.90
   5700.       0.    5700.       0.       0.     371.       0.      10.       1.   1350.90
     .01      .00    15.38      .00     .040     .035     .040     .000  1350.90  9968.00
 .009320      80.      80.      80.       20       15        0      .00    51.00 10019.00
```

SECNO	DEPTH *	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS 1356.93 ,NOT 1358.17 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.25	1.56	3.00	100.00	51.00	3.00	576.00	.00	1351.00	1350.90

*SECNO 20.750

3301 HV CHANGED MORE THAN HVINS

CLASS B LOW FLOW

3420 BRIDGE W.S.= 1358.54 BRIDGE VELOCITY=, 15.64 CALCULATED CHANNEL AREA=, 362.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
.00	1362.70	.00	0.	5700.	576.	576.	1363.00	1366.00

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1364.00 ELREA= 1364.00

20.75	9.60	1360.60	.00	.00	1362.70	2.11	.86	.00	1351.00
5700.	0.	5700.	0.	0.	490.	0.	10.	1.	1351.00
.01	.00	11.64	.20	.200	.035	.000	.200	1351.00	9968.00
.003686	71.	71.	71.	0	0	0	.00	51.00	10019.00

*SECNO 20.819

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1366.90 ELREA= 1366.90

20.82	5.87	1362.37	.00	.00	1364.78	2.41	1.92	.15	1356.50
5700.	0.	5700.	0.	0.	458.	0.	14.	2.	1356.50
.02	.00	12.46	.00	.040	.035	.040	.000	1356.50	9965.00
.008133	375.	365.	345.	3	0	0	.00	78.00	10043.00

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS 1361.40 ,NOT 1362.37 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.56	3.00	100.00	77.30	3.30	648.00	.00	1357.40	1356.70

*SECNO 20.841

3301 HV CHANGED MORE THAN HVINS

CLASS B LOW FLOW

3420 BRIDGE W.S.= 1362.74 BRIDGE VELOCITY=, 13.54 CALCULATED CHANNEL AREA=, 395.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD
1364.24	1366.13	.00	0.	5700.	648.	592.	1365.40	1369.90

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1367.90 ELREA= 1367.90

20.84	6.98	1364.38	.00	.00	1366.13	1.75	1.35	.00	1357.40
5700.	0.	5700.	0.	0.	538.	0.	15.	2.	1358.40
.02	.00	10.60	.00	.000	.035	.000	.000	1357.40	9953.00
.004771	115.	115.	115.	0	0	0	.00	79.00	10031.00

*SECNO 20.845
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

20.84	7.12	1364.62	1364.62	.00	1366.74	2.12	.15	.19	1367.00
5700.	0.	5700.	0.	0.	488.	0.	16.	2.	1368.00
.02	.00	11.69	.00	.045	.060	.045	.000	1357.50	9927.57
.033376	15.	15.	15.	3	5	0	.00	115.13	10042.69

*SECNO 20.847

3301 HV CHANGED MORE THAN HVINS

20.85	9.39	1366.79	.00	.00	1367.35	.56	.14	.47	1367.00
5700.	0.	5700.	0.	0.	950.	0.	16.	2.	1368.00
.03	.00	6.00	.00	.045	.060	.045	.000	1357.40	9915.85
.004353	15.	15.	15.	3	0	0	.00	131.68	10047.53

```
  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 20.850
   20.85     9.49  1366.89       .00       .00  1367.45       .56       .10       .00   1363.20
   5700.      80.     5528.      92.      27.     913.       30.       16.        2.   1364.20
     .03     2.94      6.05     3.12     .045     .060     .045     .000   1357.40   9916.22
 .003637      25.       25.      25.        2        0        0       .00    141.29  10057.52


CCHV=    .100 CEHV=    .300
*SECNO 20.860
   20.86     9.56  1366.96       .00       .00  1367.55       .50       .09       .01   1363.50
   5700.      41.     5547.     112.      24.     883.       78.       17.        3.   1365.00
     .03     1.71      6.28     1.45     .045     .035     .045     .000   1357.40   9917.17
 .001339      45.       45.      45.        2        0        0       .00    182.40  10099.57


*SECNO 20.890
   20.89     9.76  1367.26       .00       .00  1367.75       .50       .19       .01   1364.30
   5700.      25.     5672.       3.      18.    1001.        4.       21.        3.   1366.00
     .04     1.41      5.67      .80     .045     .035     .045     .000   1357.50   9919.17
 .001125     155.      155.     155.        2        0        0       .00    142.12  10061.29


*SECNO 20.910
   20.91     9.94  1367.44       .00       .00  1367.86       .43       .10       .01   1364.90
   5700.      15.     5234.     451.      13.     969.      159.       24.        3.   1362.00
     .04     1.16      5.40     2.83     .045     .035     .045     .000   1357.50   9920.85
 .000928     100.      100.     100.        2        0        0       .00    161.34  10082.19


CCHV=    .300 CEHV=    .500
*SECNO 20.920
   20.92     8.86  1367.36       .00       .00  1368.01       .64       .04       .11   1365.00
   5700.      28.     3086.    2586.      11.     548.      354.       24.        4.   1362.00
     .04     2.47      5.63     7.31     .045     .060     .045     .000   1358.50   9921.54
 .004672      20.       20.      20.        2        0        0       .00    168.69  10090.24


*SECNO 20.930
   20.93     9.26  1367.76       .00       .00  1368.15       .39       .07       .08   1365.00
   5700.      30.     3872.    1799.      15.     798.      335.       24.        4.   1364.00
     .04     1.98      4.35     3.38     .045     .060     .045     .000   1358.50   9919.96
 .002436      20.       20.      20.        2        2        2       .00    178.13  10098.09
```

```
  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

CCHV=   .100 CEHV=   .300
*SECNO 20.942
   20.94     9.46  1367.96      .00      .00  1368.40      .44      .23      .01  1365.70
   5700.      12.     4868.     819.      10.     862.     348.      28.       4.  1365.00
     .05     1.20      5.64     2.35     .045     .035     .045     .000  1358.50  9921.96
 .001159     143.      143.     143.        2        0        0      .00   239.90 10161.86

*SECNO 20.960
   20.96     9.50  1368.00      .00      .00  1368.51      .51      .10      .02  1365.80
   5700.      12.     5187.     501.      10.     864.     241.      30.       5.  1365.20
     .06     1.26      6.00     2.09     .045     .035     .045     .000  1358.50  9922.20
 .001336      77.       77.      77.        2        0        0      .00   252.30 10174.50

*SECNO 20.980
   20.98     9.47  1368.07      .00      .00  1368.69      .62      .15      .03  1366.00
   5700.      11.     5528.     161.       9.     862.      95.      33.       5.  1367.00
     .06     1.34      6.41     1.70     .045     .035     .045     .000  1358.60  9922.71
 .001624     100.      100.     100.        2        0        0      .00   208.02 10130.73

*SECNO 21.000

3265 DIVIDED FLOW

   21.00     9.63  1368.23      .30      .00  1368.96      .63      .16      .00  1365.80
   5700.      17.     5627.      56.      12.     878.      34.      35.       6.  1369.00
     .06     1.48      6.41     1.65     .045     .035     .045     .000  1358.60  9921.31
 .001629     100.      100.     100.        0        0        0      .00   155.55 10082.44

*SECNO 21.030
   21.03     9.70  1368.70      .00      .00  1369.08      .38      .20      .03  1368.00
   5700.       0.     4847.     852.       1.     939.     257.      39.       6.  1364.00
     .07      .50      5.16     3.32     .045     .035     .045     .000  1359.00  9928.19
 .000958     140.      160.     150.        2        0        0      .00   166.80 10094.99

*SECNO 21.036
   21.04     9.73  1368.73      .00      .00  1369.11      .38      .23      .00  1368.20
   5700.       0.     5079.     621.       1.     933.     265.      40.       6.  1364.70
     .07      .41      5.16     2.34     .045     .035     .045     .000  1359.00  9928.88
 .000946      25.       25.      70.        2        0        0      .00   208.48 10137.36
```

60.0
68.23
0.77
min 12" of FB

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 21.060

21.06	9.65	1368.85	.00	.00	1369.26	.41	.14	.01	1368.50
5700.	0.	5226.	474.	0.	984.	204.	44.	7.	1364.70
.08	.33	5.31	2.32	.045	.035	.045	.000	1359.20	9929.57
.001008	110.	140.	170.	1	0	0	.00	191.28	10120.86

*SECNO 21.080

21.08	9.58	1368.98	.00	.00	1369.38	.41	.13	.00	1369.00
5700.	0.	5166.	534.	0.	973.	217.	47.	8.	1364.40
.09	.00	5.31	2.46	.045	.035	.045	.000	1359.40	9931.11
.001021	90.	120.	160.	0	0	0	.00	188.77	10119.88

*SECNO 21.100

21.10	9.49	1369.09	.00	.00	1369.52	.44	.13	.01	1369.00
5700.	0.	5265.	435.	0.	963.	179.	51.	8.	1365.10
.10	.01	5.47	2.43	.045	.035	.045	.000	1359.60	9930.61
.001102	98.	120.	160.	1	0	0	.00	181.78	10112.39

*SECNO 21.127

21.13	9.42	1369.12	.00	.00	1369.64	.51	.09	.02	1370.20
5700.	0.	5470.	230.	0.	933.	110.	53.	9.	1366.00
.10	.00	5.86	2.08	.045	.035	.045	.000	1359.70	9934.28
.001268	76.	78.	85.	2	0	0	.00	170.54	10104.82

CCHV= .300 CEHV= .500

*SECNO 21.130

21.13	9.22	1369.22	.00	.00	1369.77	.55	.12	.02	1376.00
5700.	0.	5328.	372.	0.	876.	102.	54.	9.	1366.00
.10	.00	6.08	3.64	.045	.060	.045	.000	1360.00	9935.00
.004153	55.	55.	55.	2	0	0	.00	163.36	10098.36

*SECNO 21.140

3301 HV CHANGED MORE THAN HVINS

21.14	9.13	1369.13	.00	.00	1370.23	1.12	.18	.28	1378.50
5700.	0.	5333.	367.	0.	821.	83.	55.	9.	1366.00
.10	.00	8.58	5.81	.045	.060	.045	.000	1360.00	9961.00
.009433	30.	30.	30.	2	0	0	.00	113.42	10074.42

76.0
-60.13

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  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

*SECNO 21.145

3301 HV CHANGED MORE THAN HVINS

    21.15     7.51  1369.01      .00      .00  1370.74     1.73      .19      .31  1378.50
    5700.       0.    5230.     470.       0.     488.      55.      55.       9.  1365.80
      .10      .02    10.71     8.48     .045     .060     .045     .000  1361.50  9961.00
  .017912      12.      15.      20.        2        0        0      .00   100.47 10061.47

CCHV=    .200 CEHV=    .400
*SECNO 21.150

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    21.15     5.85  1369.35  1369.35      .00  1372.13     2.77      .11      .42  1378.50
    5700.       0.    5700.       0.       0.     427.       0.      55.       9.  1378.40
      .10      .00    13.36      .00     .020     .020     .020     .000  1363.50  9961.00
  .003937      12.      15.      20.       20       15        0      .00    78.00 10039.00

SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS   1367.94 ,NOT   1369.35 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB  XK       XKOR     COFQ     RDLEN    BWC      BWP      BAREA    SS       ELCHU    ELCHD
    1.05     1.56     3.00   200.00    78.00     6.00   864.00      .00  1365.00  1363.50

*SECNO 21.160

3301 HV CHANGED MORE THAN HVINS

CLASS B LOW FLOW

3420 BRIDGE W.S.=   1370.05 BRIDGE VELOCITY=,     13.66     CALCULATED CHANNEL AREA=,     363.

 EGPRS    EGLWC     H3      CWEIR    QLOW     BAREA   TRAPEZOID    ELLC     ELTRD
                                                          AREA
     .00  1374.11     .00       0.    5700.     864.     900.    1377.50  1379.00
```

very high velocity

very high velocity

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA= 1379.00 ELREA= 1379.00

21.16	7.53	1372.53	.00	.00	1374.11	1.58	1.98	.20	1379.00
5700.	0.	5700.	0.	0.	565.	0.	56.	9.	1379.00
.11	.00	10.09	.00	.000	.020	.000	.000	1365.00	9961.00
.001618	110.	110.	110.	0	0	0	.00	78.00	10039.00

very high

ok

CCHV= .200 CEHV= .400

*SECNO 21.165

3301 HV CHANGED MORE THAN HVINS

very high velocity

21.17	8.20	1373.60	.00	.00	1374.38	.77	.11	.16	1372.00
5700.	8.	5692.	0.	5.	806.	0.	57.	9.	1372.20
.11	1.54	7.07	.43	.045	.040	.045	.000	1365.40	9924.61
.003039	58.	50.	40.	3	0	0	.00	130.62	10055.23

*SECNO 21.170

21.17	7.53	1373.73	.00	.00	1374.50	.78	.13	.00	1372.00
5700.	10.	5499.	192.	6.	766.	56.	58.	9.	1370.60
.11	1.67	7.17	3.43	.045	.040	.045	.000	1366.20	9919.10
.003254	40.	40.	40.	2	0	0	.00	152.80	10071.90

*SECNO 21.175

21.17	7.32	1373.82	.00	.00	1374.63	.81	.11	.01	1372.00
5700.	13.	5566.	121.	7.	765.	36.	58.	10.	1371.20
.11	2.00	7.27	3.35	.045	.040	.045	.000	1366.50	9913.72
.004313	30.	30.	30.	0	0	0	.00	163.17	10076.89

*SECNO 21.180

21.18	6.64	1374.24	.00	.00	1374.83	.58	.15	.04	1372.00
5700.	19.	5529.	153.	10.	892.	60.	59.	10.	1371.80
.11	1.85	6.20	2.54	.045	.040	.045	.000	1367.60	9912.02
.002799	45.	45.	45.	2	0	0	.00	199.24	10111.26

*SECNO 21.185

21.18	6.69	1374.29	.00	.00	1374.90	.62	.06	.01	1372.00
5700.	22.	5352.	326.	10.	829.	111.	60.	10.	1371.80
.11	2.09	6.46	2.93	.045	.040	.045	.000	1367.60	9911.86
.003498	20.	20.	20.	2	0	0	.00	231.63	10143.49

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  SECNO    DEPTH    CWSEL    CRIWS   WSELK    EG       HV       HL       OLOSS   BANK ELEV
  Q        QLOB     QCH      QROB    ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
  TIME     VLOB     VCH      VROB    XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR   ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

CCHV=    .100 CEHV=    .300
*SECNO 21.190
   21.19     5.87  1374.47      .00      .00  1375.02      .54      .11      .01  1372.00
   5700.      21.     5309.     370.      12.     871.     147.      61.      10.  1371.80
     .12     1.73     6.10     2.52     .045     .035     .045     .000  1368.60  9911.11
 .002149      40.      40.      40.        2        0        0      .00   240.32 10151.43

*SECNO 21.195
   21.19     5.98  1374.58      .00      .00  1375.11      .53      .09      .00  1372.00
   5700.      23.     5317.     360.      13.     885.     155.      62.      10.  1372.20
     .12     1.74     6.01     2.32     .045     .035     .045     .000  1368.60  9910.88
 .002041      45.      45.      45.        1        0        0      .00   251.20 10162.08

*SECNO 21.200
   21.20     6.26  1374.96      .00      .00  1375.52      .56      .40      .01  1372.10
   5700.      30.     5585.      85.      16.     924.      52.      66.      11.  1372.60
     .13     1.82     6.04     1.63     .045     .035     .045     .000  1368.70  9909.55
 .001952     200.     200.     200.        2        0        0      .00   214.77 10124.32

*SECNO 21.230
   21.23     6.62  1375.42      .00      .00  1375.88      .46      .35      .01  1373.00
   5700.      17.     5389.     294.      12.     969.     148.      71.      12.  1373.00
     .14     1.45     5.56     1.99     .045     .035     .045     .000  1368.80  9911.32
 .001555     200.     200.     200.        2        0        0      .00   249.14 10160.46

*SECNO 21.260
   21.26     6.86  1375.76      .00      .00  1376.17      .41      .29      .00  1373.00
   5700.      22.     5344.     333.      15.    1009.     168.      77.      14.  1373.10
     .15     1.47     5.30     1.99     .045     .035     .045     .000  1368.90  9909.94
 .001336     205.     200.     195.        1        0        0      .00   251.34 10161.28

*SECNO 21.300
   21.30     6.94  1376.04      .00      .00  1376.43      .38      .25      .00  1372.50
   5700.      42.     5294.     365.      25.    1031.     182.      82.      15.  1373.20
     .16     1.63     5.13     2.00     .045     .035     .045     .000  1369.10  9906.81
 .001217     235.     200.     165.        0        0        0      .00   255.22 10161.34
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  SECNO     DEPTH     CWSEL    CRIWS   WSELK     EG       HV       HL      OLOSS   BANK ELEV
  Q         QLOB      QCH      QROB    ALOB      ACH      AROB     VOL     TWA   LEFT/RIGHT
  TIME      VLOB      VCH      VROB    XNL       XNCH     XNR      WTN     ELMIN      SSTA
  SLOPE     XLOBL     XLCH     XLOBR   ITRIAL    IDC      ICONT    CORAR   TOPWID     ENDST

*SECNO 21.330
   21.33     6.98  1376.28      .00     .00  1376.67      .39      .24      .00  1372.70
   5700.      43.    5333.     324.     26.    1036.     170.      88.      16.   1373.60
     .17     1.67     5.15     1.91    .045     .035     .045     .000  1369.30  9906.65
 .001217     235.     200.     165.       1        0        0      .00   254.84 10161.49

*SECNO 21.363
   21.36     6.83  1376.53      .00     .00  1376.91      .38      .24      .00  1373.50
   5700.      27.    5458.     215.     18.    1089.     123.      93.      17.   1374.10
     .18     1.48     5.01     1.74    .045     .035     .045     .000  1369.70  9908.89
 .001197     235.     200.     165.       1        0        0      .00   251.50 10160.39

*SECNO 21.370
   21.37     6.77  1376.57      .00     .00  1376.99      .42      .07      .01  1378.00
   5700.       0.    5575.     125.      0.    1058.      78.      95.      17.   1374.60
     .19      .00     5.27     1.59    .045     .035     .045     .000  1369.80  9911.75
 .001427      60.      55.      50.       2        0        0      .00   232.14 10143.89

*SECNO 21.380
   21.38     6.63  1376.63      .00     .00  1377.13      .50      .11      .02  1376.50
   5700.       0.    5627.      73.      0.     985.      47.      96.      18.   1375.00
     .19      .01     5.72     1.55    .045     .035     .045     .000  1370.00  9902.33
 .001913      80.      70.      60.       2        0        0      .00   225.68 10128.01

CCHV=    .200 CEHV=    .400
*SECNO 21.390
   21.39     6.42  1376.72      .00     .00  1377.37      .65      .18      .06  1382.80
   5700.       0.    5608.      92.      0.     864.      46.      98.      18.   1375.00
     .19      .00     6.49     1.99    .045     .040     .045     .000  1370.30  9930.32
 .003049      90.      75.      60.       2        0        0      .00   194.48 10124.80

*SECNO 21.440
   21.44     6.71  1377.61      .00     .00  1378.16      .55      .77      .02  1372.40
   5700.     179.    4534.     988.     52.     710.     261.     104.      19.   1371.40
     .23     3.42     6.38     3.79    .045     .040     .045     .000  1372.90  9876.94
 .003107     240.     252.     240.       2        2        0      .00   254.57 10151.52
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV-      =HL      OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

 CCHV=    .100 CEHV=    .300
 *SECNO 21.484
    21.48     7.15  1378.35      .00      .00  1379.03      .68      .83      .04  1372.90
    5700.     202.    4529.     969.      54.     634.     243.     109.      21.   1371.70
      .22     3.74     7.14     4.00     .045     .040     .045     .000  1371.20  9909.20
  .003536     253.     250.     247.        2        0        0      .00   230.35 10139.55

 *SECNO 21.560
    21.56     7.99  1379.39      .00      .00  1379.88      .49      .84      .02  1373.10
    5700.     196.    4166.    1338.      62.     672.     371.     116.      22.   1373.00
      .23     3.19     6.20     3.61     .045     .040     .045     .000  1371.40  9896.36
  .002149     314.     310.     304.        1        0        0      .00   232.31 10128.67

 *SECNO 21.570
    21.57     9.09  1379.59      .00      .00  1379.93      .34      .03      .01  1371.50
    5700.     402.    4310.     990.     122.     836.     386.     117.      22.   1375.50
      .23     3.27     5.16     2.57     .045     .040     .045     .000  1370.50  9889.14
  .001143      20.      20.      20.        2        0        0      .00   238.52 10127.66

 *SECNO 21.576

 3301 HV CHANGED MORE THAN HVINS

 3695 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
    21.58     8.67  1383.17  1383.17      .00  1384.63     1.46      .08      .34  1380.00
    5700.     119.    4318.    1263.      25.     417.     169.     118.      23.   1375.00
      .23     4.74    10.36     7.48     .045     .040     .045     .000  1374.50  9900.16
  .011432      30.      30.      30.       20       10        0      .00   217.90 10118.06

 *SECNO 21.580

 3301 HV CHANGED MORE THAN HVINS

    21.58     9.58  1384.50      .00      .00  1384.79      .28      .34      .12  1377.12
    5700.     349.    3722.    1618.     122.     777.     533.     118.      23.   1375.22
      .23     2.97     4.78     3.23     .045     .040     .045     .000  1375.00  9887.49
  .001045      15.      15.      15.        3        0        0      .00   248.43 10131.92
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  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

*SECNO 21.590
   21.59     9.97  1384.57      .00      .00  1384.84      .27      .05      .00  1377.00
   5500.     277.    4068.    1154.     105.     890.     436.     120.      23.  1375.50
     .24     2.65     4.57     2.65     .045     .040     .045     .000  1374.60  9876.30
 .000935      50.      50.      50.        2        0        0      .00   253.23 10129.53

*SECNO 21.640
   21.64     9.42  1384.82      .00      .00  1385.13      .30      .28      .01  1378.10
   5500.     319.    3805.    1375.     111.     777.     452.     128.      24.  1376.40
     .25     2.87     4.90     3.04     .045     .040     .045     .000  1375.40  9881.72
 .001164     273.     270.     267.        1        0        0      .00   247.61 10129.33

*SECNO 21.650
   21.65    10.03  1384.93      .00      .00  1385.15      .22      .02      .01  1375.90
   5500.     395.    4040.    1065.     155.     977.     462.     129.      25.  1374.90
     .26     2.55     4.13     2.31     .045     .040     .045     .000  1374.90  9881.90
 .000608      20.      20.      20.        2        0        0      .00   238.50 10120.41

*SECNO 21.669

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   21.67     7.91  1386.91  1386.91      .00  1388.41     1.50      .05      .39  1384.00
   5500.      96.    4470.     934.      21.     432.     126.     130.      25.  1379.40
     .26     4.65    10.35     7.40     .045     .040     .045     .000  1379.00  9893.82
 .012370      30.      30.      30.       20       16        0      .00   218.54 10112.36

*SECNO 21.680

3301 HV CHANGED MORE THAN HVINS

   21.68     9.28  1388.28      .00      .00  1389.57      .28      .04      .12  1381.20
   5500.     294.    3885.    1320.     102.     821.     448.     132.      25.  1379.60
     .26     2.88     4.73     2.75     .045     .040     .045     .000  1379.00  9881.64
 .001097      15.      15.      15.        3        0        0      .00   244.86 10126.52
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK-ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 21.700
   21.70     9.37   1388.37       .00       .00   1388.62       .26       .05       .00   1381.50
   5500.     349.     4040.     1111.      153.      899.      420.      132.       25.   1379.50
     .26     2.28      4.49      2.65      .045      .040      .045      .000   1379.00   9812.17
 .001000      50.       50.       50.         2         0         0       .00    321.90  10134.06

*SECNO 21.742
   21.74     8.60   1388.60       .00       .00   1388.92       .31       .28       .02   1381.90
   5500.     234.     4067.     1200.       85.      822.      414.      140.       27.   1380.80
     .28     2.77      4.95      2.90      .045      .040      .045      .000   1380.00   9879.24
 .001245     253.      250.      247.         2         0         0       .00    255.42  10134.65

*SECNO 21.760
   21.76     8.76   1388.86       .00       .00   1389.24       .38       .31       .02   1382.60
   5500.     298.     3890.     1312.       94.      710.      389.      146.       28.   1380.30
     .29     3.17      5.48      3.38      .045      .040      .045      .000   1380.10   9885.49
 .001644     217.      215.      213.         1         0         0       .00    247.77  10133.26

*SECNO 21.770
   21.77     8.98   1389.08       .00       .00   1389.29       .20       .02       .02   1381.10
   5500.     316.     3508.     1676.      131.      868.      597.      146.       28.   1380.10
     .29     2.41      4.04      2.81      .045      .040      .045      .000   1380.10   9882.88
 .000682      24.       24.       24.         2         0         0       .00    240.49  10123.37

*SECNO 21.780

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   21.78     8.37   1389.97   1389.97       .00   1391.49      1.52       .05       .39   1387.00
   5500.     106.     4386.     1008.       23.      420.      134.      147.       28.   1382.10
     .29     4.68     10.45      7.51      .045      .040      .045      .000   1381.60   9898.76
 .012150      30.       30.       30.        20        12         0       .00    215.10  10113.86

*SECNO 21.790
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	* OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3301 HV CHANGED MORE THAN HVINS

21.79	9.76	1391.36	.00	.00	1391.65	.29	.04	.12	1394.10
5500.	337.	3728.	1435.	117.	771.	464.	148.	28.	1382.10
.29	2.88	4.84	3.09	.045	.040	.045	.000	1381.60	9885.73
.001087	15.	15.	15.	3	0	0	.00	234.72	10120.46

*SECNO 21.800

21.80	9.72	1391.42	.00	.00	1391.74	.32	.08	.01	1384.20
5500.	311.	3715.	1474.	107.	736.	456.	150.	29.	1382.20
.30	2.89	5.05	3.23	.045	.040	.045	.000	1381.70	9892.35
.001195	66.	66.	66.	2	0	0	.00	226.38	10118.73

*SECNO 21.820

21.82	9.65	1391.55	.00	.00	1391.85	.30	.11	.00	1384.40
5500.	313.	3622.	1565.	109.	729.	502.	152.	29.	1382.40
.30	2.86	4.97	3.12	.045	.040	.045	.000	1381.90	9891.81
.001167	95.	95.	95.	2	0	0	.00	242.04	10133.85

*SECNO 21.840

21.84	9.62	1391.72	.00	.00	1392.03	.30	.18	.00	1384.60
5500.	325.	3618.	1557.	112.	727.	498.	157.	30.	1382.60
.31	2.90	4.98	3.12	.045	.040	.045	.000	1382.10	9891.10
.001176	150.	150.	150.	0	0	0	.00	242.23	10133.33

*SECNO 21.870

21.87	9.50	1391.90	.00	.00	1392.23	.33	.20	.01	1384.90
5500.	345.	3675.	1480.	114.	716.	458.	162.	31.	1382.90
.32	3.03	5.13	3.23	.045	.040	.045	.000	1382.40	9890.95
.001276	155.	160.	160.	0	0	0	.00	232.22	10123.18

*SECNO 21.895

21.90	9.70	1392.00	.00	.00	1392.35	.35	.11	.01	1386.00
5500.	172.	4012.	1316.	72.	766.	407.	164.	31.	1382.80
.33	2.39	5.24	3.24	.045	.040	.045	.000	1382.30	9893.99
.001250	95.	90.	90.	1	0	0	.00	217.54	10111.52

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 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    BANK ELEV
 Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
 TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

*SECNO 21.900
   21.90     9.05  1392.05      .00      .00  1392.44      .39      .08      .01  1386.00
   5500.     197.     4447.     856.      78.     827.     295.     166.      32.  1387.60
     .33     2.54     5.38     2.90     .045     .040     .045     .000  1383.00  9924.35
 .001399      60.      60.      60.        2        0        0      .00   218.93 10123.28

CCHV=    .300 CEHV=    .500
*SECNO 21.910
   21.91     9.94  1392.24      .00      .00  1392.53      .30      .07      .03  1382.30
   5500.    1395.     3604.     501.     428.     736.     169.     168.      32.  1384.00
     .34     3.26     4.90     2.97     .035     .035     .035     .000  1382.30  9863.93
 .000703      55.      70.      85.        2        0        0      .00   217.91 10081.84

CCHV=    .300 CEHV=    .500
*SECNO 21.920

3301 HV CHANGED MORE THAN HVINS

   21.92     8.26  1391.66      .00      .00  1393.17     1.51      .03      .60  1399.30
   5500.       0.     5500.       0.       0.     559.       0.     169.      32.  1399.30
     .34      .00     9.85      .00     .020     .020     .020     .000  1383.40  9961.95
 .001378      30.      30.      30.        2        0        0      .00    76.11 10038.05

SPECIAL BRIDGE

SB  XK       XKOR     COFQ     RDLEN    BWC      BWP      BAREA    SS       ELCHU    ELCHD
    1.05     1.56     3.00    200.00    59.00     6.00   877.00     1.00  1384.40  1383.40

*SECNO 21.940
CLASS A LOW FLOW

3420 BRIDGE W.S.=   1391.29 BRIDGE VELOCITY=,     12.32     CALCULATED CHANNEL AREA=,     413.

 EGPRS    EGLWC    HB       QWEIR    QLOW     BAREA    TRAPEZOID    ELLC     ELTRD
                                                          AREA
     .00  1392.59      .65       0.    5500.     877.     1012.    1399.30  1397.02

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1399.30 ELREA=    1399.30
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  SECNO     DEPTH     CWSEL     CRIWS   WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB    ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB    XNL       XNCH      XNR       WTN       ELMIN      SSTA
  SLOPE     XLOBL     XLCH      XLOBR   ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

   21.94     8.01   1392.31      .00     .00   1393.89      1.58      .73       .00   1399.30
   5500.       0.     5500.       0.      0.     544.        0.     170.       32.   1399.30
     .34      .00     10.10      .00    .000     .020      .000     .000   1384.30   9961.52
 .001507     103.      103.     103.       0         0         0      .00     76.96  10038.48

*SECNO 21.950
   21.95     7.36   1392.36      .00     .00   1393.98      1.62      .07       .02   1396.00
   5500.       0.     5500.       0.      0.     539.        0.     171.       32.   1399.00
     .34      .00     10.21      .00    .020     .020      .020     .000   1385.00   9950.27
 .001764      30.       40.      55.       1         0         0      .00     87.31  10037.57

*SECNO 21.960
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   21.96     4.78   1394.78   1394.78      .00   1396.72      1.94      .22       .16   1394.00
   5500.       38.     5462.       0.      11.     487.        0.     171.       33.   1399.00
     .34     3.55     11.22      .00    .035     .035      .035     .000   1390.00   9914.76
 .010714      60.       62.      65.      20        14         0      .00    133.57  10048.33

*SECNO 21.970

3301 HV CHANGED MORE THAN HVINS

   21.97     6.19   1396.69      .00     .00   1397.48       .80      .42       .34   1394.00
   5500.     198.     5302.       0.     50.     729.        0.     173.       33.   1400.00
     .35     4.00      7.27      .00    .035     .035      .035     .000   1390.50   9909.02
 .003156      80.       80.      60.       4         0         0      .00    161.02  10070.04

*SECNO 21.980

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   21.98     3.71   1397.71   1397.71      .00   1397.36      1.65      .11       .43   1401.00
   5500.       2.     5502.       0.       0.     532.        0.     173.       33.   1401.50
     .35      .00     10.31      .00    .035     .035      .035     .000   1394.00   9917.14
 .012270      20.       20.      20.      20        14         0      .00    163.65  10080.79
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  SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    BANK ELEV
  Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
  TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
  SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

CCHV=    .300 CEHV=    .500
1490 NH CARD USED
*SECNO 22.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   22.00     5.51  1400.01  1400.01      .00  1401.14     1.13      .98      .16  1400.10
   5500.    2916.     2584.       0.     371.     280.       0.     174.      33.   1402.00
     .35     7.36      9.22      .00     .232     .235     .035     .000  1394.50  9549.57
 .009380      70.      100.     100.       20       14        0      .00   275.53 10048.02

1490 NH CARD USED
*SECNO 22.020

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

   22.02     6.54  1401.24      .00      .00  1401.71      .47      .38      .20  1400.02
   5500.    3340.     2160.       0.     628.     370.       0.     176.      34.   1402.00
     .35     5.32      5.83      .00     .031     .035     .035     .000  1394.70  9543.56
 .003013      60.      100.     120.        3        0        0      .00   356.67 10049.18

CCHV=    .100 CEHV=    .300
1490 NH CARD USED
*SECNO 22.065

3265 DIVIDED FLOW

   22.07     5.92  1401.72      .00      .00  1402.62      .89      .78      .12  1404.10
   5500.    4444.     1056.       0.     575.     434.       0.     179.      35.   1402.02
     .36     7.73      6.83      .00     .031     .035     .045     .000  1395.30  9588.67
 .006416      160.      241.     240.        3        0        0      .00   312.04 10026.12
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

1490 NH CARD USED
*SECNO 22.090

3265 DIVIDED FLOW

22.09	7.46	1402.76	.20	.00	1403.28	.52	.63	.04	1401.90
5500.	3307.	2193.	0.	617.	343.	0.	182.	36.	1404.00
.37	5.36	6.40	.00	.031	.035	.045	.000	1395.30	9612.85
.002951	150.	150.	150.	3	0	0	.00	371.92	10042.33