community sciences corporation

ACADEMY / TRAMWAY / EUBANK

SECTOR DEVELOPMENT PLAN

MASTER STORM WATER CONVEYANCE STUDY

Prepared For:

Affiliated Mortgage & Development Company

By:

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SURVEYING
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A. PURPOSE AND SCOPE

Under the leadership of Affiliated Mortgage and Development Company, several Albuquerque Developers have organized their individual land holdings into one large contiguous land area for development plan review by the City of Albuquerque under the Sector Development Plan provisions of the Comprehensive Zoning Ordinance. The purpose of this study is to evaluate the various drainage facilities which will be necessary in order to convey storm flows to the major arroyo systems at locations where street conveyance becomes impractical. This study does not address drainage patterns and facilities which are considered internal to individual platting areas. Where preliminary platting schemes were available, street patterns were taken into account to the extent necessary for basin definition and street capacity evaluation.

B. STUDY AREA

The boundaries of this study are roughly as follows:

1) Eubank Boulevard and Academy Place Subdivision on the West.

2) The northerly ridge line of the Bear Canyon Arroyo on the South.

3) The southerly ridge line of the Pino Arroyo on the North.

4) Tramway Boulevard on the East.

A concurrent study has been conducted by Herkenhoff and Associates for the Pino Basin itself and the reader is referred to that report for the sake of continuity and thorough coverage of the subject matter.

The land within the study area slopes from east to west at an average rate of 3 1/2%. Soils typically consist of fine, granular, decomposed granite and fall into the SP, SM, or SC classifications on the Unified System.

C. DESIGN CRITERIA

1) Engineering Parameters:

In accordance with AMAFCA and City of Albuquerque requirements all hydrological analysis is based on 100 year frequency accumulated rainfall figures as presented in NOAA Atlas #2. Volume calculations utilize the 6-hour rainfall figure of 2.8". Rate calculations are based on the 1 hour rainfall figure since this results in higher peak rates of runoff than the 6 hour figure in the hydrograph procedure used.

Runoff coefficients were estimated by calculation of composite values based on the typical plot plan shown in Plate 1. For areas where rear yard ponding will be employed a $C_{COMP.}$ value of 0.8 was calculated for the portion of the lot draining to the streets. Rear yard ponding was assumed applicable to all areas except D & F. (Proposed treatment for Areas D & F will be discussed later in the Report) The $C_{COMP.}$ value of 0.8 was also assumed applicable for all commercial and high density development above 6 du/acre. For those basins in standard R-1 development where it is proposed to allow uncontrolled runoff to street systems and other conveyances a $C_{COMP.}$ of 0.67 was calculated for the entire lot area as shown in Plate 1.

In order to comply with the City Engineer's requirements regarding stability of earthen channels the procedure for determination of maximum allowable velocity as outlined in SCS Technical Release #25 was employed. This procedure relates the D_{75} and Plasticity Index values of the channel soils to the maximum allowable average channel velocity. Consultation with Albuquerque Testing Laboratories resulted in acquisition of the following data from their files regarding D_{75} for soils testing in various NE heights locations:

Location	D Value
Sta 149+00 Juan Tabo Boulevard (Test #1)	1.75 mm
Sta 149+00 Juan Tabo Boulevard (Test #2)	1.10 mm
Lomas Boulevard East of Juan Tabo Boulevard	1.20 mm
Subgrade of Juan Tabo Boulevard	2.40 mm
Wyoming Boulevard 500' South of Candelaria	0.80 mm
Los Angeles Boulevard at North Diversion Channel	1.30 mm
Sample Average	1.43 mm

In addition A.T.L. advised that plasticity indexes for northeast Albuquerque soils average 12-15 with a value of 20 being safe as an assumed maximum. Using these values in the SCS procedure yields a maximum allowable velocity in earthen channels of 3.3 fps for the study area with maximum allowable channel sideslopes of 5:1.

Hydraulic stability becomes a consideration in concrete lined channels running in an east-west direction. Since bottom widths must be kept to a minimum of 10' for maintenance purposes and since flow depths are relatively low at the grades available, the depth-to-bottom width ratios in most east-west concrete channels is much less than 1. This coupled with high Froude numbers leads to inherent stability problems due to the tendency to form surface waves and the sensitivity to obstructions and transitions. The approach taken to this problem in this study is to provide a minimum freeboard in concrete lining of 0.2 times the flow depth on all concrete channels. In addition, those east-west channels with flows greater than 200 cfs and having flows within the unstable range shall have additional freeboard provided in earthen embankments such that the conjugate depth of the supercritical flow mode would be contained within the overall concrete and earth section. An illustration of this concept in cross section is presented on Plate 3. An inherently stable channel on the steep gradients occurring from east to west within the study area would be much more costly to construct than those using the approach outlined above. Hydraulic stability in channels carrying less than 200 cfs is not considered significant.

All channels designed to flow supercritically must have turns designed in spiral curves with the appropriate superelevation throughout the turn.

Energy Dissipators have been recommended for all high velocity conveyance discharge points. An illustration of the design being recommended is shown on Plate 3. This design is presented as a somewhat less effective but much more economical construction than the standard concrete impact basins in common use for very high volume, high velocity dissipators. The design, if employed, should undoubtedly be laboratory modeled for flows greater than 1000 cfs. Since proposed discharge points on the Pino and Bear Basins are safely removed from residential areas an allowable discharge velocity of 5 fps rather than 3.3 fps was selected for these locations. The slight difference in velocities results in a more than 50% savings in the cost of the smaller dissipator over the larger one.

An allowable discharge velocity of 7 fps was selected for the Bear Tributary Dissipator at Eubank Boulevard.

All computations are based on the construction of a planned diversion facility immediately east of Tramway Boulevard. This diversion will protect basins C, B, and G from all offsite flows occurring east of Tramway Boulevard by diverting them into the Bear Canyon Arroyo.

2) Flood Control Regulations:

The drainage plan presented in this report has been developed assuming compliance with the 1972 AMAFCA Resolution in regard to rate and volume of runoff leaving the site. That Resolution has been interpreted to say that the rate and volume of runoff allowed to leave the site after development shall be no greater than the rate and volume running off prior to development.

These regulations were taken into account in two ways:

a) Basin areas were adjusted in hydrological calculations to compensate for portions of the land area draining into ponds.
b) Required ponding volumes were calculated for those areas where central ponding is being anticipated or considered.

D. COMPUTATIONAL PROCEDURES

1) Hydrology:

Based on anticipated (or existing) land uses runoff ratios were assigned to each watershed. These ratios are adjustment factors to account for the use of onsite ponding and represent the portion of overall land area expected to drain to streets and conveyances. It was decided that this approach would present a more realistic representation of what will actually occur physically after development than would be attained if ponding effects were absorbed in the runoff coefficient. Based on the plot plan shown in Plate 1, areas employing rear yard ponding have been assigned runoff ratios of 0.52. Examination of grading plans for Academy Place Unit 5A resulted in assignment of 0.75 runoff ratio to that area. Composite runoff ratios were calculated for areas having multiple land uses and for combinations of sub-basins. Composite C factors were also calculated for these areas.

For the purpose of developing runoff hydrographs the Bureau of Reclamation Triangular Hydrograph Method was used. This method, available on computer at Herkenhoff and Associates, simulates the runoff characteristics of a watershed by development of a series of short duration triangular hydrographs at short intervals relative to storm duration - finally summing the individual hydrographs into one "curve" for the entire duration of the storm. The equivalent to the runoff coefficient in the BoR procedure is a parameter called the Curve Number (Cn). Based of percents of rainfall actually running off for a given Cn value an equation was developed to convert $C_{COMPOSITE}$ into Cn. This equation is written:

Cn = 87 + 29.68 (C-0.5)

Times of concentration were estimated based on the following travel velocities for street and channel flow:

1) Street @ 0.5%	-	3.4 fps
2) Street @ 1.0%	-	4.8 fps
3) Street @ 2.0%	-	6.8 fps
4) Street @ 3.0%	-	8.3 fps
5) Street @ 4.0%	-	9.5 fps
6) Street @ 6.0%	-	12.1 fps
7) East-West Channel	-	26.0 fps
8) North-South Channel	-	10.0 fps

Examination of the hydraulics of the flow rates generated with this input showed a reasonable correlation to the estimated travel times and deviations are not expected to have any significant effect upon the analysis as presented.

The hydrographs developed by the computer are shown in Appendix A and Table 1 gives a summary of input data and the peak flow rates derived.

2) Hydraulics:

Street, pipe, and channel capacities were calculated based on the Manning equation for uniform flow. Hydraulic jump conjugate depths were calculated by means of a tabular solution for trapezoidal sections as presented in the "Handbook of Hydraulics" by King and Brater. Drop inlets were sized by means of the orifice equation with a net/gross grate area ratio of 80% as provided by Irving bridge deck type grates. Dissipators were sized by means of extrapolations from the broad crested weir equations and those relationships are shown in the detail illustrated on Plate 3.

E. COST COMPARISONS

An economic evaluation was made for two alternate improvement plans for each of two separate comparative circumstances with regards to conveyance of the Bear Canyon Tributary Arroyo. The first, itemized in Appendix B, presents a cost comparison between those improvements required both with and without a proposed diversion which would transfer flows occurring in the Bear Tributary just east of Tramway Boulevard into the newly constructed Pino Dam. As the figures indicate, the plan employing the diversion will cost nearly one half of the required improvement costs without it.

Therefore, the diversion plan is adopted as a "given" for the remainder of this report, and all subsequent analysis of the Bear Canyon Tributary is based on the implementation of the plan.

The second comparison is outlined in Appendix C. It evaluates the cost effectiveness of an improved earth/ drop structure conveyance versus a conventional concrete lined channel. This analysis indicates the earth channel to be roughly twice as costly as the hard lined alternate. This analysis is based on the velocity and geometric restrictions discussed under item C1 for earth sections, and would undoubtedly need to be re-evaluated in the event these restrictions are relaxed. The analysis is judged to be relatively applicable to all basins under study and consequently earth sections are not considered cost effective throughout the remainder of the report.

Elements included in cost comparisons are only those necessary for the comparison. Structures such as bridge crossings required under each comparison plan are not included in the cost figures. Land costs are also included only where needed for comparison. No figures are shown for channel fencing since it is assumed that normal yard block wall construction will fill this need by in large.

F. DRAINAGE NETWORKS

1) General:

Plate 2 outlines the drainage basins under study. Basin boundaries were established through a dual consideration of both topography and anticipated conveyance optimization. Each overall basin has been given a letter designation which is followed by a number designation indicating appropriate sub-basin divisions where applicable. The basin/sub-basin designations are also placed on the map at flow confluence locations. Improvements keyed to a given basin/sub-basin refer to those improvements beyond normal street construction required to manage the flows through and/or out of the basin in a controllable manner.

The requirement on the part of the City to maintain one lane dry in each direction on all collectors and arterials during the 100 year storm is virtually impossible to meet. Assuming a 2% crown this would allow a flow depth of 0.25' on a 4 lane facility with a resultant capacity of as little as 6 cfs. The standard both recommended and widely used in the past permits flows to attain a depth of 0.2' above top of curb. This standard is recommended for adoption as applicable to the study area and the hydraulic analysis of the report are based on it. Table 2 summarizes the flow capacitites of various street sections. Spain Road is assumed to be a 50' arterial section @ 3% while Chelwood is assumed to be a 44' section @ 0.5%. Academy Road will be an arterial section at no less than 1% at peak flow points.

Cost estimates for storm sewer improvements are based on use of riser type manholes wherever possible. A sketch of this type of construction is shown on Plate 3. Plate 3 also illustrates the assumed geometry for special design inlets which are considered for several locations as discussed below.

Table 3 summarizes the improvements evaluated for basins under study while Appendix D itemizes cost estimates for these improvements. In some cases alternate plans were considered for single basin/sub-basin areas. It is suggested that the reader refer to this material throught the remainder of the report.

2) Individual Networks:

a) It is assumed that street patterns within sub-basin A1 will carry all flows to the western boundary. At that point two alternatives are considered. One would incorporate a channel running along the western boundary with culverts beneath Spain Road. The other would employ a north-south street to convey flows to Spain Road with a special design drop inlet and culverts to carry the runoff beneath Spain Road. The second alternative is more cost effective and is recommended.

Flows from sub-basin A1 join those from A2 South of Spain Road. Street patterns currently proposed for sub-basin A2 will convey flows to a planned 70' wide drainage easement extending along the west boundary and into the Bear Canyon Arroyo. A concrete channel and dissipator are recommended for this easement. In addition a cost analysis of a pipe diversion to the Bear Canyon Arroyo for basin B proved to be uneconomical. It is therefore recommended that flows from Basin B be allowed to flow down Spain Road to point A1 where a pair of 2'x40' special design drop inlets will collect the flows, divert them into a reinforced concrete junction box, and discharge them into the channel recommended for sub-basin A2. Plate 4 illustrates this scheme in plan view.

b) Basin B boundaries appear unorthodox at first glance. This is due to the fact that a preliminary plat has already been filed establishing proposed street patterns for sub-basins B2 as well as C1. The sub-basin boundaries reflect these proposed patterns. Areas and runoff coefficients for both B2 and C1 are based on a Drainage Management Plan for Peppertree Subdivision, prepared for Dale Bellamah Corporation by Community Sciences Corporation submitted in November of 1977 and revised in June of 1978. Sub-basin B1 must drain to Spain Road. B2 will drain through internal street patterns to Chelwood Boulevard which in turn will drain to Spain Road. As explained under the discussion for Basin A above, a pipe diversion scheme considered for Basin B proved to be uneconomical. Flows reaching Spain will ultimately be intercepted by the sub-basin A2 channel and carried to the Bear Canyon Arroyo.

Since lands south of Spain are currently being platted, street patterns have already been established for this area. A preliminary investigation revealed that these streets will be taxed to near capacity conveying internal flows. For this reason discharge of basin B flows into the street systems of basins A & G was discounted as infeasible.

c) Basin C1 is part of a preliminary platted area as explained above. It is recommended that drop inlets be provided at the flow confluence point to intercept the 10 year storm runoff and carry it beneath Chelwood Boulevard into a proposed channel. The 100 year flows above the 10 year rate would be allowed to flow across Chelwood, join flows from sub-basin C2 and spill into that same channel. Said channel would continue to the west, increase in capacity at point C3, and finally terminate at a dissipator at point C7. Flows from the dissipator will cross Eubank Boulevard and enter the Park/Drainage Way already provided immediately west of the pavement.

Two alternatives were considered for sub-basin C5. The first is a special design drop inlet and storm sewer combination. The second is a road embankment spillway and channel combination. Both would empty flows into the aforementioned channel between points C7 & C2. The pipe/inlet alternate is slightly less costly than the spillway/channel alternate and is therefore recommended. Some of the ponding requirements for sub-basin C5 could be met by diversion of flows in Academy Boulevard into a golf course retention pond located on fairway 17. Should this approach be elected once a development plan for the sub-basin has been prepared, it should have little effect upon the analysis presented herein.

d&e) All flows from basins D & E will be directed into fairway retention ponds along fairways 16 & 18. These ponds will provide 100% retention for the 100 year runoff from these basins.

f) Sub-basin F1 will drain onto Eubank Boulevard and central ponding is recommended to provide retention for the difference between developed and natural runoff volumes. A portion of sub-basin F2 will be diverted northward directly into the Pino Basin by means of regrading, parallel street patterns, and interceptor swales. The area which is anticipated to be included under this catagory is shaded on Plate 2.

It is desirable to allow the remaining flows from sub-basin F2 to drain uncontrolled to Academy Boulevard since space for onsite yard ponding will be scarce in this high density development area. It is proposed to compensate for the lack of retention in sub-basin F2 by providing a corresponding retention volume in the Pino Basin within golf course fairway areas. This compensating volume has been included in the volume requirements listed in the aforementioned Herkenhoff Report.

Flows from sub-basins F1 & F2 converge at F3 where two alternate conveyance plans have been considered. The first would employ a special design inlet and pipe system with dissipator to convey the flows northward into the Pino Arroyo. The second plan would incorporate special design curbs, 1.0' high, along Eubank Boulevard north of Academy Road. With these curbs the street section will have the capacity to carry the total flow rate to a spillway and dissipator at the crossing point of the Pino Arroyo. Since this section of Eubank Boulevard will have no accesses connecting into it, and since the economics are much more favorable for alternate #2 than for alternate #1, alternate #2 is recommended.

g) Flows from basin G will be collected by a street pattern currently under design and conveyed directly into the Bear Canyon Arroyo.

One approach which could significantly increase both the efficiency and effectiveness of on-site ponding is central retention ponding on a subdivision by subdivision basis. In employing this approach, the developer constructs a central retention basin into which all runoff from his development is directed. The facility is usually equipped with a controlled release outlet which can be designed to simulate various frequency storm hydrographs rather than the 100 year storm only. The pond and improvements are dedicated to the City as public improvements just as street, water, and sewer improvements are dedicated. This approach has the added advantage of not being subject to the whims of individual property owners as are lot ponds. This has been used successfully in other municipalities for drainage control.

TABLE 2

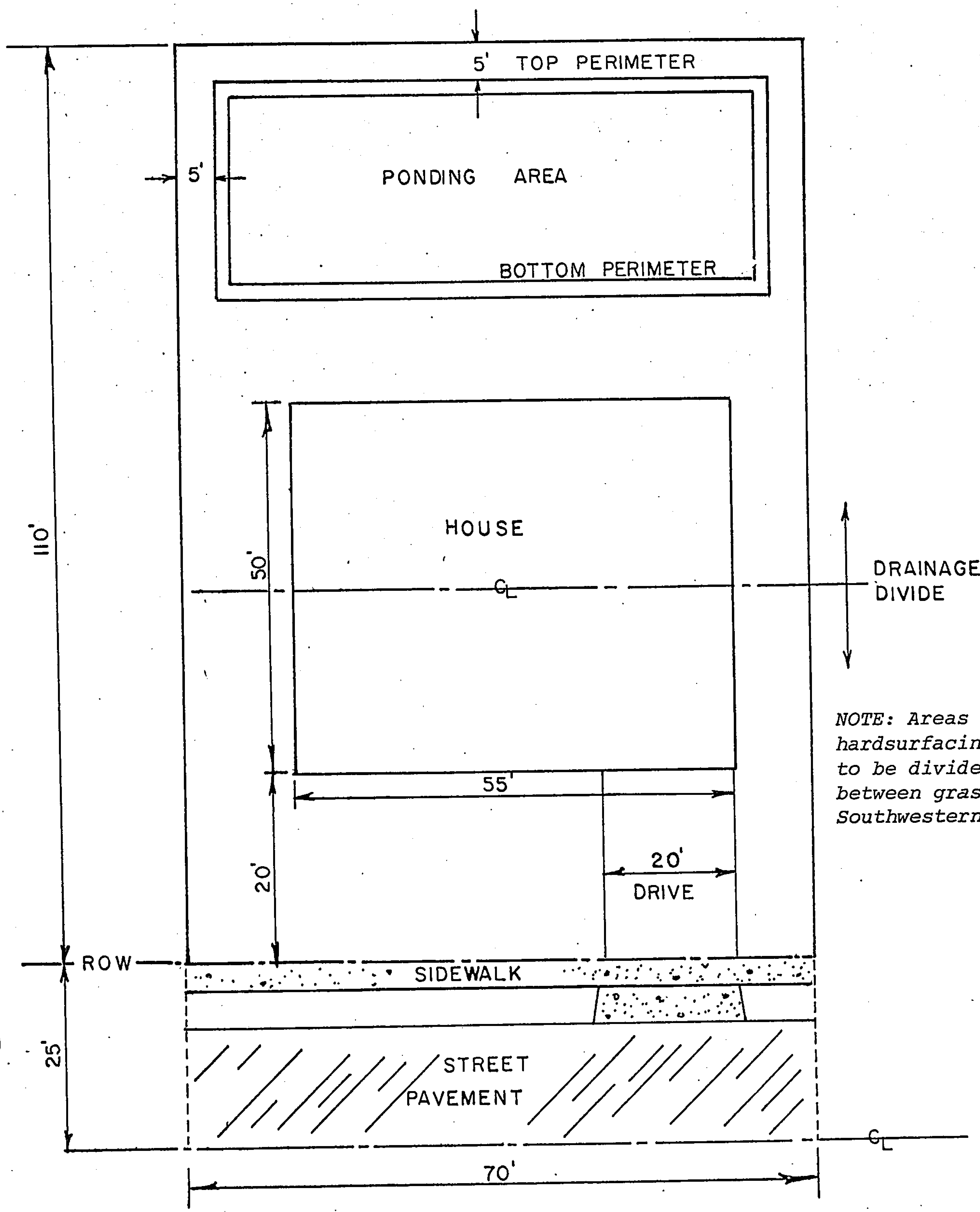
STREET CAPACITIES AT 0.2' DEPTH ABOVE CURB

slope / pavement width	0.5%	1%	2%	3%
32	Q = 121 V = 5.4 Ve = .45	Q = 171 V = 7.6 Ve = .89	Q = 242 V = 10.7 Ve = 1.79	Q = 297 V = 13.2 Ve = 2.69
40	Q = 137 V = 5.2 Ve = .42	Q = 194 V = 7.3 Ve = .83	Q = 274 V = 10.4 Ve = 1.67	Q = 336 V = 12.0 Ve = 2.50
44	Q = 136 V = 5.0 Ve = .38	Q = 192 V = 7.0 Ve = .77	Q = 271 V = 10.0 Ve = 1.54	Q = 332 V = 12.2 Ve = 2.31
50 (arterial with median)	Q = 155 V = 5.0 Ve = .39	Q = 219 V = 7.1 Ve = .77	Q = 309 V = 10.0 Ve = 1.55	Q = 379 V = 12.2 Ve = 2.32

NOTE: Q = Flow in cfs
V = Velocity in fps
Ve = Velocity head in feet

PLATE I

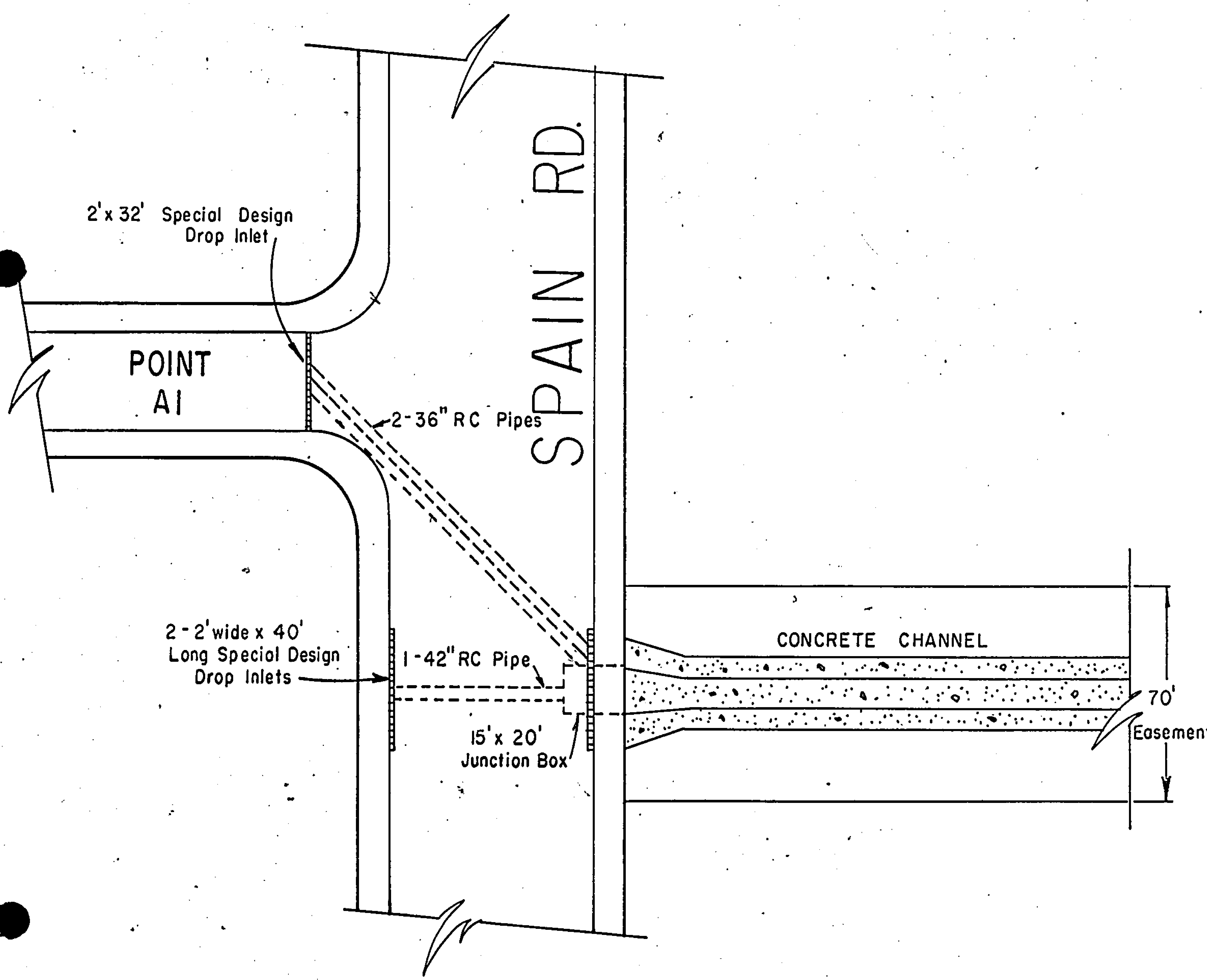
TYPICAL PLOT PLAN



NOTE: Areas not in hardsurfacing assumed to be divided equally between grass and Southwestern Landscaping

PLATE 4

DETAIL OF RECOMMENDED IMPROVEMENTS- SPAIN ROAD



APPENDIX "A"

HYDROGRAPH PRINTOUTS

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS

SECTOR MASTER CONVEYANCE   A-1   25.6 Ac?

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.04(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.04(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.10(HRS)
TIME TO PEAK .... 0.19(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.44	13.929	0.144
0.69	48.283	0.787
0.94	119.536	2.520
1.19	49.762	4.269
1.44	5.460	4.840
1.69	0.000	4.896

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS

SECTOR MASTER CONVEYANCE: A-2

1 HR POINT RAINFALL .... 2.30(IN) 3840
DRAINAGE AREA .... 0.06(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.06(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.13(HRS)
TIME TO PEAK .... 0.20(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.45	18.983	0.196
0.70	67.302	1.087
0.95	167.826	3.516
1.20	79.661	6.073
1.45	10.496	7.005
1.70	0.000	7.113

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS

SECTOR MASTER CONVEYANCE: B-1

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.03(SQ-MI) 19.20
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.03(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.20(HRS)
TIME TO PEAK .... 0.25(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.50	6.448	0.067
0.75	23.626	0.377
1.00	59.510	1.236
1.25	33.196	2.194
1.50	5.151	2.590
1.75	0.000	2.643

SECTOR MASTER CONVEYANCE: B-2

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.05(SQ-MI)
CN FACTOR 92.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 92.00
TOTAL DRAINAGE AREA .... 0.05(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.15(HRS)
TIME TO PEAK .... 0.22(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.47	4.596	0.047
0.72	33.350	0.439
0.97	106.721	1.886
1.22	56.044	3.568
1.47	8.072	4.230
1.72	0.000	4.314

SECTOR MASTER CONVEYANCE: B-3

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.05(SQ-MI)
CN FACTOR 92.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 92.00
TOTAL DRAINAGE AREA .... 0.05(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.20(HRS)
TIME TO PEAK .... 0.25(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.50	4.382	0.045
0.75	32.178	0.423
1.00	104.377	1.834
1.25	61.338	3.546
1.50	9.860	4.281
1.75	0.000	4.383

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS PAGE 1

SECTOR MASTER CONVEYANCE: B-4

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.08(SQ-MI)
CN FACTOR 94.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 94.00
TOTAL DRAINAGE AREA .... 0.08(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.20(HRS)
TIME TO PEAK .... 0.25(HRS)

TIME (HRS)	COMPOSITE HYDROGRAPH FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.50	11.569	0.120
0.75	59.013	0.849
1.00	168.872	3.203
1.25	96.655	5.946
1.50	15.254	7.102
1.75	0.000	7.260

SECTOR MASTER CONVEYANCE: C-1

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.06(SQ-MI)
CN FACTOR 91.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 91.00
TOTAL DRAINAGE AREA .... 0.06(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.12(HRS)
TIME TO PEAK .... 0.20(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.45	4.632	0.048
0.70	41.244	0.522
0.95	138.767	2.381
1.20	66.199	4.499
1.45	8.400	5.269
1.70	0.000	5.356

MASTER CONVEYANCE C-2

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.03(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.03(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.15(HRS)
TIME TO PEAK .... 0.22(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.47	8.259	0.085
0.72	29.555	0.476
0.97	73.911	1.545
1.22	36.915	2.690
1.47	5.152	3.124
1.72	0.000	3.178

SECTOR MASTER CONVEYANCE: C-3

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.14(SQ-MI)
CN FACTOR 94.00
WEIGHTED RAINFALL 2.29
WEIGHTED CN 94.00
TOTAL DRAINAGE AREA .... 0.14(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.18(HRS)
TIME TO PEAK .... 0.23(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.48	22.699	0.234
0.73	115.318	1.660
0.98	329.020	6.251
1.23	182.258	11.532
1.48	27.935	13.704
1.73	0.000	13.992

SECTOR MASTER CONVEYANCE: C-5

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.07(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.07(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.28(HRS)
TIME TO PEAK .... 0.29(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.29	2.068	0.021
0.54	21.766	0.268
0.79	72.831	1.245
1.04	147.344	3.519
1.29	88.542	5.956
1.54	14.906	7.025
1.79	0.000	7.179

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS

SECTOR MASTER CONVEYANCE: C-7

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.34(SQ-MI)
CN FACTOR 95.00
WEIGHTED RAINFALL 2.29
WEIGHTED CN 95.00
TOTAL DRAINAGE AREA .... 0.34(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.31(HRS)
TIME TO PEAK .... 0.31(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.31	10.090	0.104
0.56	92.057	1.159
0.81	335.243	5.574
1.06	664.002	15.896
1.31	418.788	27.082
1.56	89.327	32.331
1.81	4.649	33.302
2.06	0.000	33.350

SECTOR MASTER CONVEYANCE: D

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.06(SQ-MI)
CN FACTOR 92.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 92.00
TOTAL DRAINAGE AREA .... 0.06(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.10(HRS)
TIME TO PEAK .... 0.19(HRS)

TIME (HRS)	COMPOSITE HYDROGRAPH FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.44	6.908	0.071
0.69	49.371	0.653
0.94	155.074	2.765
1.19	67.814	5.067
1.44	7.627	5.847
1.69	0.000	5.926

SECTOR MASTER CONVEYANCE: E

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.01(SQ-MI)
CN FACTOR 92.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 92.00
TOTAL DRAINAGE AREA .... 0.01(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.04(HRS)
TIME TO PEAK .... 0.15(HRS)

TIME (HRS)	COMPOSITE HYDROGRAPH FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.40	1.169	0.012
0.65	8.118	0.108
0.90	24.638	0.446
1.15	6.749	0.771
1.40	0.000	0.840

SECTOR MASTER CONVEYANCE: F-1

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.01(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.01(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.04(HRS)
TIME TO PEAK .... 0.15(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.40	5.051	0.052
0.65	16.556	0.275
0.90	40.227	0.862
1.15	10.505	1.386
1.40	0.034	1.495
1.65	0.000	1.495

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS PAGE 1

SECTOR MASTER CONVEYANCE: F-2

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.08(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.08(SQ-MI)

c ≈ .01
via DPM

** PASS 1 **
TIME OF CONCENTRATION ...... 0.19(HRS)
TIME TO PEAK .... 0.24(HRS)

TIME (HRS)	COMPOSITE HYDROGRAPH FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.49	20.586	0.213
0.74	75.150	1.202
0.99	189.095	3.931
1.24	103.551	6.955
1.49	15.811	8.188
1.74	0.000	8.351

10-year ≈ 123 cfs
peak

SECTOR MASTER CONVEYANCE: F-3

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.09(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.30
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.09(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.19(HRS)
TIME TO PEAK .... 0.24(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.49	23.742	0.245
0.74	86.686	1.386
0.99	218.134	4.535
1.24	119.455	8.023
1.49	18.239	9.445
1.74	0.000	9.633

'SMALL DAM' UNIT HYDROGRAPH ANALYSIS PAGE 1

MASTER CONVEYANCE A-2 REVISED

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.14(SQ-MI)
CN FACTOR 95.00
WEIGHTED RAINFALL 2.29
WEIGHTED CN 95.00
TOTAL DRAINAGE AREA .... 0.14(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.28(HRS)
TIME TO PEAK .... 0.29(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.29	3.321	0.034
0.54	35.685	0.437
0.79	133.505	2.185
1.04	280.375	6.461
1.29	171.265	11.126
1.54	29.200	13.197
1.79	0.000	13.499

MASTER CONVEYANCE C-O, WO DIVERSION

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.66(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.27
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.66(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.33(HRS)
TIME TO PEAK .... 0.32(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.32	28.571	0.295
0.57	220.732	2.871
0.82	714.757	12.535
1.07	1308.444	33.436
1.32	838.061	55.610
1.57	215.048	66.489
1.82	19.176	68.909
2.07	0.000	69.107

MASTER CONVEYANCE C-3 WO DIVERSION

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 0.81(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.27
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 0.81(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.51(HRS)
TIME TO PEAK .... 0.43(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.43	48.202	0.498
0.68	274.190	3.828
0.93	842.810	15.368
1.18	1307.759	37.584
1.43	958.280	60.994
1.68	438.243	75.421
1.93	72.943	80.702
2.18	0.000	81.455

MASTER CONVEYANCE C-7 WO DIVERSION

1 HR POINT RAINFALL .... 2.30(IN)
DRAINAGE AREA .... 1.00(SQ-MI)
CN FACTOR 96.00
WEIGHTED RAINFALL 2.26
WEIGHTED CN 96.00
TOTAL DRAINAGE AREA .... 1.00(SQ-MI)

** PASS 1 **
TIME OF CONCENTRATION ...... 0.64(HRS)
TIME TO PEAK .... 0.51(HRS)

COMPOSITE HYDROGRAPH

TIME (HRS)	FLOW (CFS)	ACCUM VOL (ACRE-FT)
0.26	2.118	0.022
0.51	67.963	0.746
0.76	338.925	4.949
1.01	978.542	18.559
1.26	1424.780	43.387
1.51	1110.955	69.583
1.76	621.851	87.484
2.01	216.896	96.148
2.26	29.433	98.693
2.51	0.000	98.997

APPENDIX "B"

COST COMPARISON
BETWEEN BASIN C IMPROVEMENTS
WITH AND WITHOUT
BEAR TRIBUTARY DIVERSION

A. Improvement Cost without Diversion:

100 cy structural concrete @ $280.00	$28,000.00
125 cy excavation and backfill @ $9.00	1,125.00
182 LF 36" Asho Bridge Beam @ $33.00	6,006.00
232,915 cy excavation and grading @ $3.00	698,745.00
220,610 SF 6" concrete channel lining @ $2.50	551,525.00
22,432 SF 4" concrete channel lining @ $2.00	44,864.00
800 cy wire enclosed rip rap @ $70.00	56,000.00
21,316 SF filter blanket @ $0.15	3,197.00
Subtotal Improvement Cost	1,389,462.00
10% Contingency	138,946.00
10% Engineering	152,841.00
Total Improvement Cost	1,681,249.00
Land Value (100'x 8600' and 20'x1550' easements @ $20,000.00/ acre)	409,090.00
TOTAL ESTIMATED COST	$2,090,339.00

B. *Improvement Cost with Diversion:*

Total Estimated Cost of Improvements West of Tramway (from Appendix C)	*$609,598.00*
Construction Cost of Diversion (from Bovay Engineers)	*30,000.00*
Land Cost for Diversion (8 acres @ $15,000.00)	*120,000.00*
TOTAL ESTIMATED COST	*$759,598.00*

APPENDIX "C"

COST COMPARISON BETWEEN
EARTH AND CONCRETE CHANNELS
ON BEAR TRIBUTARY ARROYO
BETWEEN POINTS C1 AND C7

A. Cost Earth Channel:

77,333 cy earth excavations and grading @ $3.00	$231,999.00
50 Concrete/Gabion Drop structures @ $10,000.00	500,000.00
Subtotal Improvement Costs	$731,999.00
10% Contingency	73,200.00
10% Engineering	80,520.00
Total Improvement Cost	885,719.00
Land Cost (110'x5800' easement @ $20,000.00/acre)	292,929.00
TOTAL ESTIMATED COST	$1,178,648.00

B. Cost Concrete Channel:

Total Improvement Cost (from Appendix A-Items C3 & C7)	$471,168.00
Land Cost (60'x2700' and 45'x3100' easements @ $20,000.00/acre)	138,430.00
TOTAL ESTIMATED COST	$609,598.00

APPENDIX "D"

COST ESTIMATES FOR BASIN IMPROVEMENTS

BASIN A1

Alternate #1 - Concrete Channel with Culverts

20,050 SF 4" thick concrete channel lining @ $2.00	$40,100.00
1,300 cy earth excavation and grading @ $6.00	7,800.00
200 LF 36" RCP @ $36.00	7,200.00
5.2 cy structural concrete headwalls @ $280.00	1,456.00
Subtotal Improvement Cost	$56,556.00
10% Contingency	5,656.00
10% Engineering	6,221.00
Total Improvement Cost	$68,433.00
Estimated Land Value (20'x1200' easement @ $20,000.00/acre)	11,019.00
TOTAL ESTIMATED COST	$79,452.00

Alternate #2 - Street Flow with Drop Inlet

10 cy structural concrete @ $280.00	$ 2,800.00
18 cy excavation and backfill @ $9.00	162.00
64 SF of steel frame and grating @ $15.00	960.00
280 LF 36" RCP @ $36.00	10,080.00
Subtotal Improvement Cost	$14,002.00
10% Contingency	1,400.00
10% Engineering	1,540.00
TOTAL ESTIMATED COST	$16,942.00

BASIN A2

Concrete Channel with Dissipator

18,944 SF 4" thick concrete channel lining @ $2.00	*$37,888.00*
6,500 cy mass earth cut @ $1.50	*9,750.00*
1,600 cy earth excavation and grading @ $6.00	*9,600.00*
100 cy wire enclosed rip rap @ $70.00	*7,000.00*
2,600 SF filter blanket @ $0.15	*390.00*
Subtotal Improvement Cost	*$64,628.00*
10% Contingency	*6,463.00*
10% Engineering	*7,109.00*
TOTAL ESTIMATED COST	*$78,200.00*

BASINS B1, B3, and B4

Alternate #1 - Drop Inlets with Pipe

8 cy structural concrete @ $280.00	$ 2,240.00
14 cy excavation and backfill @ $9.00	126.00
40 SF of steel frame and grating @ $15.00	600.00
108 SY concrete pavement @ $10.00 (above asphalt cost)	1,080.00
1 - type A inlet	1,300.00
1 - type C inlet	1,100.00
65 LF 27" RCP @ $28.00	1,820.00
100 LF 36" RCP @ $36.00	3,600.00
1,400 LF 54" RCP @ $66.00	92,400.00
1 - 8" Ø junction M.h.	2,000.00
3 - 36" Ø riser M.h.s. @ $800.00	2,400.00
100 cy wire enclosed rip rap @ $70.00	7,000.00
2,600 SF filter blanket @ $0.15	390.00
Subtotal Improvement Cost	$116,056.00
10% Contingency	11,605.00
10% Engineering	12,766.00
TOTAL ESTIMATED COST	$140,427.00

BASINS B1, B3, and B4

Alternate #2 - Flow Down Spain with Drop Inlets into A1 - A2 Channel

Note: The following are additional costs above those stated for improvements outlined for reach A2

50 CY structural concrete @ $280.00	$14,000.00
334 CY excavation & backfill @ $9.00	3,006.00
160 SF steel frame & grating @ $15.00	2,400.00
55 LF 42" RCP @ $49.00	2,695.00
4,572 SF 4" thick concrete channel lining @ $2.00	9,144.00
340 CY wire enclosed rip rap @ $70.00	23,800.00
6,425 SF filter blanket @ $0.15	964.00
Subtotal Improvement Cost	56,009.00
10% Contingency	5,600.00
10% Engineering	6,160.00
TOTAL ESTIMATED COST	$67,769.00

BASIN C1

Drop Inlets for 10 Year Flows with Dip Section Across Chelwood

2 - double C inlets @ $1,250.00	$ 2,500.00
40 LF 30" RCP @ $29.00	1,660.00
1 - 6' Ø junction M.h.	1,500.00
200 LF 42" RCP @ $49.00	9,800.00
264 SY concrete pavement @ $10.00 (above asphalt cost)	2,640.00
Subtotal Improvement Cost	$18,100.00
10% Contingency	1,810.00
10% Engineering	1,991.00
TOTAL ESTIMATED COST	$21,901.00

BASIN C3

Concrete Channel

16,734 CY earth excavation and grading @ $3.00	$ 50,202.00
58,730 SF 4" concrete channel lining @ $2.00	117,460.00
Subtotal Improvement Cost	$167,662.00
10% Contingency	16,766.00
10% Engineering	18,443.00
TOTAL ESTIMATED COST	$202,871.00

BASIN C5

Alternate #1 - Drop Inlet with Pipe

8 CY structural concrete @ $280.00	$ 2,240.00
25 CY excavation and backfill @ $9.00	225.00
67 SF of steel frame and grating @ $20.00	1,340.00
573 SY concrete pavement @ $10.00 (above asphalt cost)	5,730.00
800 LF 48" RCP @ $54.00	43,200.00
2 - 36" Ø riser M.h.s. @ $800.00	1,600.00
Subtotal Improvement Cost	$54,335.00
10% Contingency	5,434.00
10% Engineering	5,977.00
TOTAL ESTIMATED COST	$65,746.00

BASIN C5

Alternate #2 - Dip Section with Channel

573 SY concrete pavement @ $10.00 (above ashalt cost)	$ 5,730.00
17,945 SF 4" concrete channel lining @ $2.00	39,890.00
1,400 CY earth excavation and grading @ $6.00	8,400.00
Subtotal Improvement Cost	$54,020.00
10% Contingency	5,402.00
10% Engineering	5,942.00
Total Improvement Cost	$65,364.00
Estimated Land Value (20'x900' easement @ $20,000/acre)	8,264.00
TOTAL ESTIMATED COST	$73,628.00

BASIN C7

Concrete Channel

27,200 CY earth excavation and grading @ $3.00	$ 81,600.00
63,224 SF 4" concrete channel lining @ $2.00	126,448.00
185 CY wire enclosed rip rap @ $70.00	12,950.00
4,900 SF filter blanket @ $0.15	735.00
Subtotal Improvement Cost	$221,733.00
10% Contingency	22,173.00
10% Engineering	24,391.00
TOTAL ESTIMATED COST	$268,297.00

BASIN F3

Alternate #1 - Drop Inlet on East Side of Intersection with Pipe

17.5 CY structural concrete @ $280.00	*$ 4,900.00*
31 CY excavation and backfill @ $9.00	*279.00*
80 SF steel frame and grating @ $15.00	*1,200.00*
210 SF concrete pavement @ $10.00 (above asphalt cost)	*2,100.00*
1,200 LF 66" RCP @ $85.00	*102,000.00*
1 - 8' Ø junction M.h. @ $2,000.00	*2,000.00*
2 - 36" Ø riser M.h.s. @ $800.00	*1,600.00*
230 CY wire enclosed rip rap @ $70.00	*16,100.00*
6,084 SF filter blanket @ $0.15	*913.00*
Subtotal Improvement Cost	*$131,092.00*
10% Contingency	*13,109.00*
10% Engineering	*14,420.00*
TOTAL ESTIMATED COST	*$158,621.00*

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BASIN F3

Alternate #2 - Special Design Curbs 1.2' High on Eubank

2,000 LF of special design curbs (1.0' high) @ $4.00 (above normal curb cost)	$ 8,000.00
650 SY concrete pavement @ $10.00 (above asphalt cost)	6,500.00
2,280 SF 4" concrete channel lining @ $2.00	4,560.00
50 CY wire enclosed rip rap @ $70.00	3,500.00
1,332 SF filter blanket @ $0.15	200.00
Subtotal Improvement Cost	$22,760.00
10% Contingency	2,276.00
10% Engineering	2,504.00
TOTAL ESTIMATED COST	$27,540.00

TABLE I

SUMMARY OF HYDROLOGICAL PARAMETERS AND PEAK FLOW RATES

Area/Point Designation	Area (acres)	Individual Runoff Ratio	Individual C	Areas Contributing	Gross Area (acres)	Overall Runoff Ratio	Total Area Running Off (acres)	C Composite	Ch	Tc (hr.)	Q c.f.s.	Required Ponding Volume (acre ft.)
ANALYSIS WITH BEAR TRIBUTARY DIVERSION												
A1	50.2	0.52	0.8	A1	50.2	0.52	26.1	0.8	96	0.10	120	-
A2	25.6	0.52	0.8	A1, A2	75.8	0.52	39.4	0.8	96	0.13	168	-
B1	30.7	0.52	0.8	B1	30.7	0.52	16.0	0.8	96	0.20	60	-
B2	35.3	1.0	0.67	B2	30.2	1.0	30.2	0.67	92	0.15	107	-
B3	2.6	1.0	0.8	B2, B3	32.8	1.0	32.8	0.68	92	0.20	107	-
B4	NA	NA	NA	B1-3	63.5	0.77	48.9	0.72	94	0.20	169	-
C1	38.0	1.0	0.65	C1	38.0	1.0	38.0	0.65	91	0.12	139	-
C2	34.6	0.52	0.8	C2	34.6	0.52	1.8	0.8	96	0.15	74	-
C3	69.3	0.52	0.8	C1-3	141.9	0.65	92.2	0.74	94	0.18	329	-
C4	37.7	0.75	0.8	-	-	-	-	-	-	-	-	-
C5	71.2	0.62	0.8	C5	71.2	0.62	44.1	0.8	96	0.28	147	4.5
C6	26.2	0.75	0.8	-	-	-	-	-	-	-	-	-
C7	60.4	0.52	0.8	C1-7	337.4	0.64	215.9	0.77	95	0.31	664	-
D	39.1	1.0	0.67	D	39.1	1.0	39.1	0.67	92	0.10	155	6.10
E	5.3	1.0	0.67	E	5.3	1.0	5.3	0.67	92	0.04	25	0.83
F1	13.5	0.57	0.8	F1	13.5	0.57	7.7	0.8	96	0.04	40	1.26
F2	49.7	1.0	0.8	F2	49.7	1.0	49.7	0.8	96	0.19	189	-
F3	NA	NA	NA	F1, F2	63.2	0.91	57.4	0.8	96	0.19	218	-
ANALYSIS WITH A & B WATERSHED JOINED												
A2	25.6	0.52	0.8	B1-4, A1-2	139.3	0.63	87.8	0.76	95	0.28	280	-
ANALYSIS WITHOUT BEAR TRIBUTARY DIVERSION												
C0	814.0	0.52	0.8	C0	814.0	0.52	423.0	0.8	96	0.33	1308	-
C3	-	-	-	C0-3	955.9	0.54	515.5	0.79	96	0.51	1308	-
C7	-	-	-	C0-7	1151.4	0.56	639.2	0.79	96	0.64	1424	-