TECHNICAL MEMORANDUM

CH2M HILL

PREPARED FOR: Grays Harbor County

PREPARED BY: Steven J Wasson P.E.

DATE: April 26, 1994

SUBJECT: Vance Creek Drainage Evaluation

PROJECT: SEA34056.A0.A1

Background

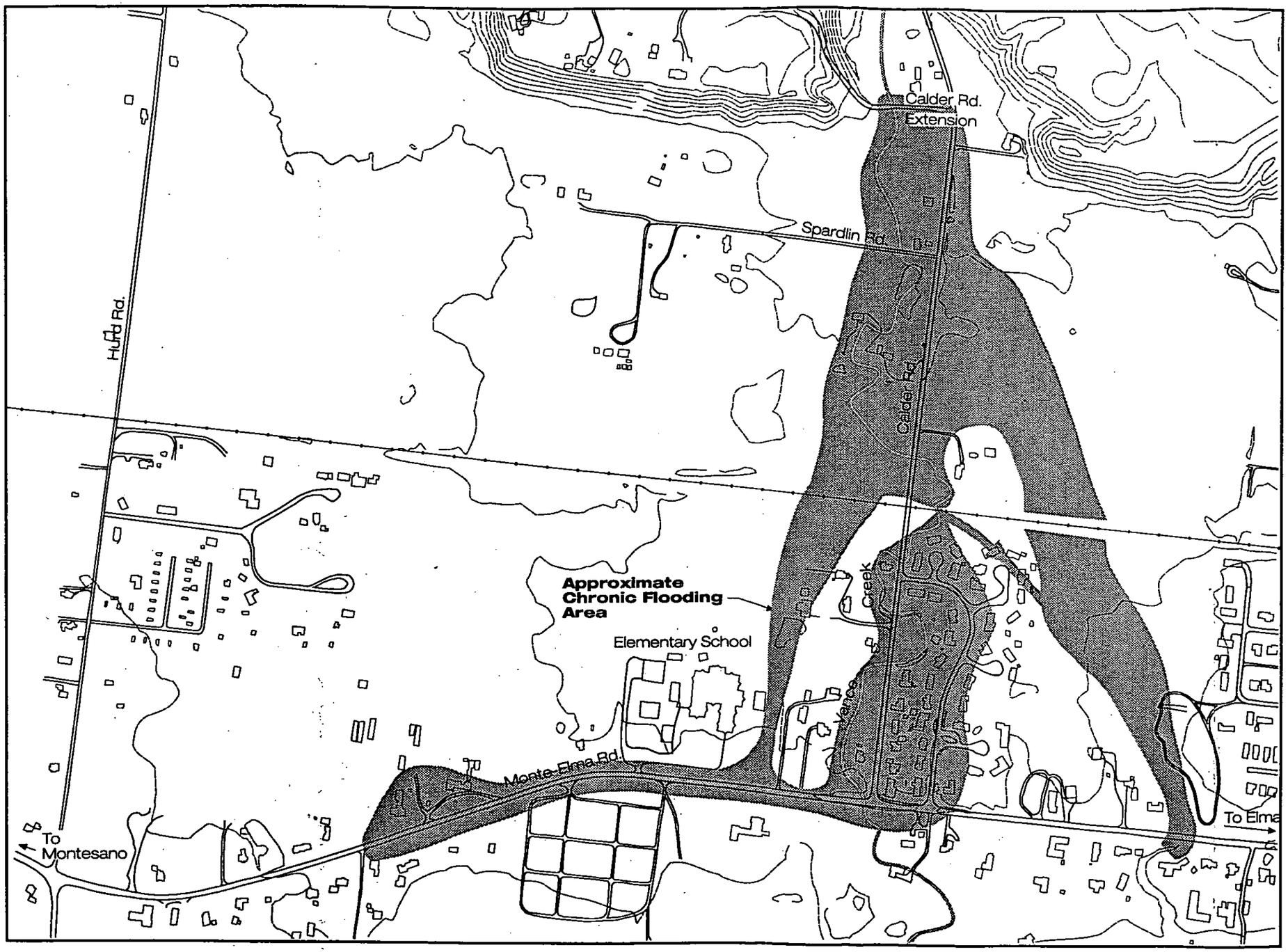
Vance Creek has a history of flooding a residential area in and around the City of Elma. Residents state that Flooding has be come progressively worse over the past 20 years. To address this situation, Grays Harbor County has retained CH2M HILL to investigate the flooding problems, propose alternative solutions, and recommend a strategy to reduce these occurrences. This memorandum outlines the extent of the flooding, defines the design storm flow rates, and presents alternative solutions for the county's review and input.

Problem Definition

As identified in Figure 1, the Vance Creek flooding area is located adjacent to Calder Road just north of the Montesano-Elma Road. Creek flooding frequently impacts a residential area located immediately northeast of this intersection, and ranchettes located on the west side of Calder Road. On occasion the creek overtops its banks and crosses the railroad tracks west of Calder Road and flows through the school grounds and disperses in both directions along the Monte-Elma Road. The area of inundation as highlighted in Figure 1 encompasses approximately 70 acres, susceptible to property damage and utility disruption.

In natural streams the main channel generally has capacity for up to the 2-year storm event. This condition is reflected in the lower portion of Vance Creek which has an average channel capacity of 200 cfs and a predicted 2-year, 24-hour peak runoff of 150 cfs. Larger and less frequent events overflow the stream banks and seek overland channels.

Topographic mapping of the area suggests that historically flood flows would have been passed to the east towards the existing Dry Creek channel, and west following the ground contours toward the present location of Hurd Road. Currently Vance Creek has no well defined flood channel. Construction of roads and the railroad appear to have blocked the historic overland flow paths. Generally flooding now occurs behind manmade constrictions



N

0 250 500
Scale in Feet

Figure 1
Vance Creek Flooding Areas

to the natural channel, forcing excess water on to the surrounding land surfaces and into the local residential areas. Culvert crossings under Calder Road and the Montesano-Elma Road create the majority of the backwater problems.

Calder Road and the adjoining access roads cross Vance Creek 6 times in approximately 0.6 mile. The capacity of each culvert crossing is less than the flood flows generated by the upstream basin. As outlined in the Hydrology/Hydraulics section, the average capacity of these culvert crossings are roughly equivalent to the natural stream channel capacity, while the runoff rates produced by design storm events are much greater. This situation creates a broad and widespread flooding pattern along this portion of the creek channel.

Criteria and Methods

To define the extent of the flooding issues in the Vance Creek basin and recommend solutions to alleviate them, base criteria for evaluation purposes must be established. This criteria is needed to target the type, size and duration of rainfall events to be contained by the creek system.

The analysis of the Vance creek basin has been based on the requirements of the *Stormwater Management Manual for the Puget Sound Basin* (Ecology, 1992)(Stormwater Manual). This manual provides criteria and methods for the control of stormwater runoff that are widely accepted in Western Washington. Analysis methods included in the manual are well suited for the study of developing rural watersheds such as the Vance Creek basin.

The Ecology Manual stipulates the following requirements for stormwater conveyance.

Runoff event. Culverts and conveyance systems shall be sized to convey the 25-year, 24-hour rainfall event without overtopping. This event has a rainfall depth of 5.5 inches in the vicinity of Elma. Runoff has also been analyzed for the 100-year, 24-hour event with a rainfall depth of 7.0 inches.

Storm type. A Soil Conservation Service Type IA rainfall distribution will be used for design storm hyetograph development.

Hydrologic modelling technique. An SCS based unit hydrograph method shall be used to model hydrologic response. Runoff Curve Numbers shall be based on SCS runoff curve numbers as developed for Western Washington for use with Type IA storm distributions.

Hydrologic and Hydraulic Analysis

A computer model has been used to predict the hydrologic response of the Vance Creek system. Peak runoff rates and quantities have been predicted using the Army Corps of Engineers program HEC-1. Estimates of the capacity of the existing culverts under Calder Road and the existing creek channel have been developed based on a backwater analysis of the culvert and channel characteristics.

The Vance Creek drainage basin upstream of the Montesano-Elma Road covers an area of approximately 4 square miles of diverse use. The upper portion of the basin above the Calder Road Extension is composed primarily of 10 to 20 year old second growth forest. The topography in this section of the basin is generally steep above the stream channel with hillside slopes averaging about 30 percent. A large forested wetland area is located along the creek channel through much of this upper basin area.

Downstream of Calder Road Extension the area adjacent to the creek is a mixture of open pasture area with scattered ranchettes and residential housing. The ranchettes are generally located on the west side of Calder Road and north of the railroad tracks. The residential area is located on the east of Calder Road near the Montesano-Elma Road. This lower basin area encompasses 0.26 square miles and is where culverts intercept Vance Creek 6 times in approximately 0.6 mile.

The HEC-1 model of the Vance Creek basin has been developed to predict the runoff response of the basin to design storm events. The model incorporates the SCS curve numbers and the Snyder unit hydrograph to calculate runoff rates. A copy of the input file is attached in Appendix A.

Table 1 provides a summary of the HEC-1 model results for the Vance Creek basin upstream of the Montesano-Elma Road These flow rates compare reasonably to bulk estimates of flow using area weighted parameters as outlined in *TR-55*, and estimations using historical information from the *Magnitude and Frequency of Floods in Washington*.

Information on the culvert crossings of Vance Creek has been gathered from two primary sources. Plans from a 1976 Asphalt surfacing project for Calder Road included information on the Vance Creek culverts. The plans provided invert elevations, road crown elevations, culvert diameters, and plan view lengths for the culverts under Calder Road. The information on these culverts was supplemented with data collected during a field investigation conducted by CH2M HILL. Information on two additional culverts and the railroad trestle across Vance Creek was also collected during that field investigation.

Table 1
Vance Creek
HEC-1 Summary Results

Location	25-year Peak Runoff (25-year, 24-hour event)	100-year Peak Runoff (100-year, 24-hour event)
Culvert Crossing #1 Calder Road Extension	530 cfs	920 cfs
Culvert Crossing #2 Spardlin Rd.	540 cfs	940 cfs
Culvert Crossing #3 Calder Rd. Sta 16+45	540 cfs	950 cfs
Culvert Crossing #4 Calder Rd. Sta 11+64	550 cfs	960 cfs
Culvert Crossing #5 Calder Rd. Sta 8+84	550 cfs	960 cfs
Culvert Crossing #6 Calder Rd. Sta 6+59	560 cfs	970 cfs
Culvert Crossing #7 Montesano-Elma Rd.	560 cfs	970 cfs

Findings from the recent field investigations indicate that the culvert crossings of Vance Creek have been expanded since the 1976 asphalt project. The 1976 plans show two parallel culverts at each of the Vance Creek crossings along Calder Road and the Montesano-Elma Road. Currently each of the crossings have three parallel culverts carrying flow. Asphalt patching of the road surface at the culvert crossing indicates that an additional culvert was installed at each crossings subsequent to the 1976 asphalt resurfacing project. No plans outlining the installation of these culverts have been made available. County staff members recall these culverts were installed in the 1980s to address previous flooding concerns.

The information on the culvert crossings has been used to develop peak discharge estimates for each of the culverts and the creek channel. The results of the backwater analysis are attached in Appendix B. These results show that the maximum capacity of both the channel and the culverts are substantially less than the 25-year predicted peak flow rates for Vance Creek.

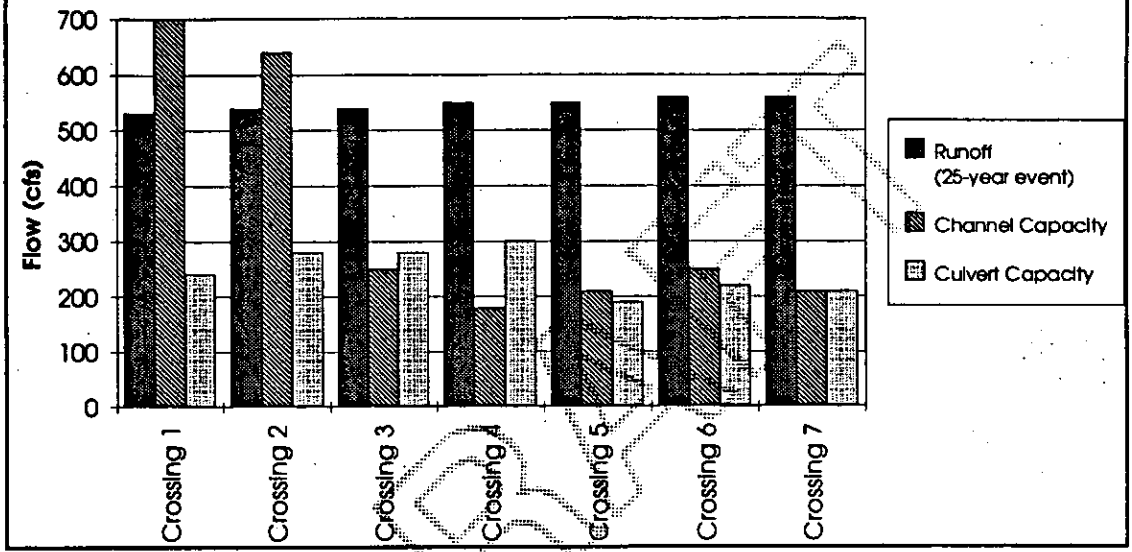
Table 2 summarizes the results of the capacity analysis for the culvert crossings and the creek channel.

Table 2
Vance Creek
Culvert Capacity Analysis Summary Results

Location	Estimated Total Culvert Capacity	Estimated Minimum D/S Channel Capacity
Culvert Crossing #1 Calder Road Extension	240 cfs	700 cfs
Culvert Crossing #2 Spardlin Rd.	280 cfs	640 cfs
Culvert Crossing #3 Calder Rd. Sta 16+45	280 cfs	250 cfs
Culvert Crossing #4 Calder Rd. Sta 11+64	300 cfs	180 cfs
Culvert Crossing #5 Calder Rd. Sta 8+84	190 cfs	210 cfs
Culvert Crossing #6 Calder Rd. Sta 6+59	230 cfs	250 cfs
Culvert Crossing #7 Montesano-Elma Rd.	200 cfs	210 cfs

Figure 2 has been developed to graphically depict the difference between the capacity of the existing culverts and the predicted 25-year, 24-hour peak flow rate in Vance Creek. Figure 2 indicates that all of the existing culvert crossings and most of the channel reaches have less capacity than the design storm event flow rates.

Figure 2
Vance Creek
Flow versus Capacity



As identified in Figure 2 the Estimated runoff rates for the 25-year event are significantly higher than the capacity of both the culvert system and in most cases the creek channel. These results indicate that to provide the needed capacity to pass design storm events, the channel would need to be expanded throughout the Calder road area and likely downstream of the Montesano-Elma Road.

Conveyance Solutions

A range of alternative conveyance concept solutions has been developed to address the flooding problems along Vance Creek. The solutions have been developed at a concept level to provide a reference for discussions on a preferred alternative. These alternatives provide a wide range of solutions to convey flood flows around the problem areas. The benefits and costs of each should be considered in reference to the goal of the project.

Three Common Improvements are included with each of the alternatives (unless otherwise noted). These improvements are basic modifications to the stream channel which must be addressed by each of the presented alternatives.

COMMON IMPROVEMENT 1: Expand Culvert Capacity at Calder Road Extension
Concept: Install a new box culvert or additional roadway culverts to pass the design storm peak runoff rate.

COMMON IMPROVEMENT 2: Expand Culvert Capacity at Spardlin Road Extension
Concept: Install a new box culvert or additional roadway culverts to pass the design storm peak runoff rate.

COMMON IMPROVEMENT 3: Expand Channel Capacity D/S of Monte-Elma Rd.
Concept: Widen existing channel for approximately 500 feet downstream of the Montesano-Elma Road. Create channel capacity to handle the design storm runoff rate without backwater effect on the upstream channel or flooding of the residence adjacent to Vance Creek south of the Monte-Elma Rd.

The alternative solutions presented here offer solutions which range from modest improvements to reduce the most frequent flooding problems, to full scale alternatives which seek to eliminate flooding situations up to the design event runoff rates. Figures 3 through 7 included in Appendix C present these alternatives on a map of the area. Detailed cost opinions have been included in Appendix D.

ALTERNATIVE 1: Formalize Existing Flood Way
Concept: Formalize existing overflow channel which flows around greenhouses and into swale system at the school property. Enlarge size of equalizer pipe under the railroad west of Calder Road, construct broad and shallow channel (40 feet wide by 3 ft deep) through fields north and east of green house structures, expand/improve swale system on east side of school, install multiple culverts under the Monte-Elma Road, and expand ditch on south side of Monte-Elma to creek channel.
Advantages
o Maximizes use of existing drainage network o Minimizes the disruption of Calder Rd and driveways o Construction proposed in undeveloped areas o Channel area could be used for grazing and other low impact uses o Will control base flooding problem west of school site.
Disadvantages
o Permanent drainage easement required across private property o Need for new drainage crossing under railroad tracks o Flood water is directed out of natural channel o Flood channel located near school will require fencing/security measures o Does not address annual flooding issues in residential area adjacent to creek o Due to grades, overflow culverts under Monte-Elma Rd. would not have sufficient capacity for design storm events.
Cost $425,000

ALTERNATIVE 2: Construct Overflow Channel Adjacent to Calder Rd

Concept: Route flood flows through new channel on west side of Calder Rd. New channel could begin at location of existing restricted culvert north of railroad tracks, flow south under railroad, along the edge of Calder Road to the Monte-Elma Road. Replace the existing (3) 48 inch diameter Montesano-Elma Road culverts with box culverts. The overflow channel would cross the existing stream channel at three locations.

Advantages

- Locates overflow channel near road alignment, utilizing part of the existing R/W
- Location allows for easy construction and maintenance access
- Allows for multiple overflow points.
- Potential to utilize existing culvert crossing at Monte-Elma Rd

Disadvantages

- Required width of channel may impact 2 to 3 existing structures
- Will necessitate some utility relocations (power poles, water, and electrical)
- Property acquisitions necessary from several land owners.
- Locates deep fast flowing channel near residences and roadway (during overflows)
- Need for new drainage crossing under railroad tracks

Cost $600,000

ALTERNATIVE 3: Expand Existing Stream Channel

Concept: Structurally expand constricted portions of the existing stream channel from the Calder Rd crossing north of the railroad tracks to the Montesano-Elma Road. Replace/expand existing culvert crossings as needed. Provide bioengineered structural bank stabilization to simulate the existing channel conditions.

Advantages

- Utilizes existing channel capacity and alignment
- Minimum property taking required
- Does not require construction of additional channel
- Addresses overflow problem at its source
- Existing Channel can be stabilized concurrent with the overflow design

Disadvantages

- Requires significant excavation adjacent to existing homes with tight working conditions
- Could require direct, extended, and difficult in-stream construction
- Would require a lengthy environmental permitting process
- Construction permits required from multiple landowners
- May not be allowed if impacts to habitat cannot be addressed

Cost $1,200,000

ALTERNATIVE 4: Construct Overflow Pipeline in Calder Rd

Concept: Install an overflow structure adjacent to the existing overflow point at the Calder Road culvert north of the railroad tracks. Route overflows into an 8 foot diameter drainage pipeline installed under Calder Rd. Route overflow pipeline approximately 1700 feet south along Calder Rd to a discharge at Vance Creek south of the Monte-Elma Rd.

Advantages

- Utilizes the existing R/W and limits property acquisition needs
- Maximizes safety through closed conduit conveyance
- Reduced maintenance requirements (less litter, and debris accumulation)
- Confined construction zone
- Limited need for construction easements
- Potential to reduce minor event impact on existing channel

Disadvantages

- Expensive construction costs associated with pipeline
- Conflict with existing culvert crossings, and underground utilities very likely
- Potential for severe traffic disruption
- Limited depth of cover available for pipeline construction
- Substantial outfall protection likely required at downstream discharge (for safety and erosion control)

Cost $1,250,000

ALTERNATIVE 5: Construct Detention Basin to Attenuate Peak Flows

Concept: Install detention in fields upstream of existing creek overflow point north of the railroad tracks and east of Calder Road. Store peak run off flows in excess of downstream system capacity. Discharge detention basin back into stream channel as capacity allows.

Advantages

- Concentrates construction in one location
- Potential to restore creek flows during smaller events to historic levels (limits erosion, improves habitat)
- Potential for summer grazing use of basin area
- Would allow partial sedimentation of silt laden runoff thus enhancing downstream water quality
- Control of flows at detention basin eliminates the need for Common Improvement 3.

Disadvantages

- Huge land acquisition required (40 to 50 acres) from multiple owners
- Potentially high construction costs related to haul and disposal of excavated soil
- Removal of 2 to 4 homes and displacement of residents
- Likely need to resurface Calder Rd due to truck traffic impact on existing pavement

Cost 2,800,000 (does not include land acquisition)

Alternatives 1 through 5 presented above provide methods to reduce the occurrence of flooding and therefore prevent property damage. The basic goal of each alternative is to direct flood waters into a defined channel or storage area and route the flows to a discharge point downstream of the existing flooding areas. While these alternatives would reduce the frequency of flooding to varying degrees, they each require substantial capital investments. A second approach to controlling property damage is to reduce the impacts of flooding on the affected properties. Alternatives presented below outline methods to prevent damage to the existing residences.

Flood Hazard Reduction Alternatives

Alternatives to reduce damage from flooding include preservation of historic flood channels and structural protection of individual structures or groups of structures. This combined approach will have a greatly reduced capital cost and is likely to be the only alternative that is financially feasible.

For this alternative to be successful, historic flood channels must be protected and improved to accommodate flood flows. Specifically, the minimum overland flow channels that must be protected are:

- under the north end of Calder Road to the east and down through Dry Creek, and
- west, under the railroad tracks and south along the eastern edge of the elementary school property.

Even minor alteration of grades in these channels can reduce their capacity and divert flood flows onto other properties. Therefore, it will be important to identify these channels to the County's Planning Department permit staff so that building or other permits are not issued in these areas. These areas are included in the FEMA Flood Insurance Rate Map. However, since the area is not within the floodplain of a major river it may be worthwhile to draw the flood channels onto the County's zoning maps at the permit counter to prevent an oversight. If the channels are not protected their capacity to pass flows would be lost. Flooding would get worse as a result. Protecting these channels may be difficult since property owners often perform minor grading and filling of their property without permits. Grading in these areas could affect drainage patterns and fall below the thresholds for permits. Flooding can be expected to slowly increase even more as the watershed is logged or as the area develops and runoff increases.

To accommodate the historic flows in these channels it may be necessary to install larger culverts under Calder Road north of the Spardlin Road intersection, and new culverts under Montesano-Elma Road at the school site. Culvert improvements under Montesano-Elma Road in front of the elementary school are planned to occur during 1994.

With historic channels protected, individual property owners could then protect their properties. Due to the shallow, dispersed nature of the flooding, this could best be accomplished by construction of small berms. In particular, the residential area east of Calder Road and north of Monte-Elma Road could be protected with a berm. In most areas, this would be an earthen berm 2 to 3 feet high. Along the several properties closest to the creek, an approach that requires less space will be necessary. Options that require less space include "ecology blocks" backed with soil on one side, gabion baskets lined with fabric and filled with sand, or a wall built in layers with geotextile fabric and soil.

Each option would incorporate natural vegetation such as willows and dogwoods to provide additional stability, reduce flow erosion, and to provide streamside habitat. Figures for flood proofing options are included in Appendix E. Figure 8 shows the location of the proposed berm. Figure 9 shows a typical cross-section for a berm and the options for confined spaces. The estimated capital costs of these options are summarized in Table 3. Each cost estimate assumes construction of 1150 feet of flood proofing berm as indicated in Figure 8.

Table 3
Floodproofing Capital Costs Estimates

Option	Cost
Floodproofing Berm[a]	$86,000
Ecology Block Wall[b]	$40,000
Gabion Basket Wall[a]	$78,000
Geotextile Supported Embankment[a]	$121,000

[a] = 3 foot high embankment
[b] = 2 foot high embankment

Elevating structures (houses and buildings) is not considered feasible due to the large number of homes affected by the shallow flood waters. Similarly, it is not necessary to "buy-out" homes in this area because the flooding is minor (usually below first floor elevations), causes minimal damage, and the damages could be significantly reduced with minor capital expenditures.

Funding Options

The costs to design and construct the improvements necessary to provide flood protection along Vance Creek will be beyond County financial resources. It will be necessary for the property owners to fund a portion of the project. The costs of major capital improvements along Vance Creek are likely to be well beyond the ability and/or willingness of local property owners to pay.

Since there are no existing flood control structures, the project may not be eligible for FCAAP funding, but other funding such as block grants may be available. At best, 50% of the project costs could expected to come from grants. Thus, the other 50% would have to be funded by local residents. This would have to be accomplished through formation of a County Road Improvement District (RID) or other Special District.

An RID could include only those properties that show a direct benefit from the project and most likely would include the neighborhood at the northeast corner of Calder and Monte-Elma Roads. An RID is used to fund major capital projects and is established only for a specific time period. In contrast, a Special District (RCW 85.38), or a stormwater management utility is intended to be a permanent funding structure. These latter options can be managed locally or by the County and can charge properties that contribute to the problem as well as those that benefit. Thus, the costs can be shared by a larger number of property owners.

Recommendations

The highest priorities are to protect the overflow flood channels, relieve flooding of the elementary school and to protect homes along Calder Road from further flooding. Protection of the overflow channels should be accomplished through coordination with the Planning Department. Flooding at the elementary school should be relieved by construction of the new culverts and the return channel this summer. The greatest protection of homes for the least cost will be provided by floodproofing individual homes or groups of homes. Figure 3 shows the locations of the proposed capital improvements.

Specifically we make the following preliminary recommendations;

- Install mechanism to protect overflow channels
- Provision for, or enlargement of culverts for overflow conveyance
- Install ecology block wall for protection of homes and property
- Establishment of local funding mechanism for construction of facilities (RID)

Following construction of the dike, flood patterns should be observed to determine if additional culvert improvements are needed at the following locations;

- Calder Road north of Spardlin Road
- Dry Creek under the Montesano-Elma Road
- Montesano-Elma Road west of the school site

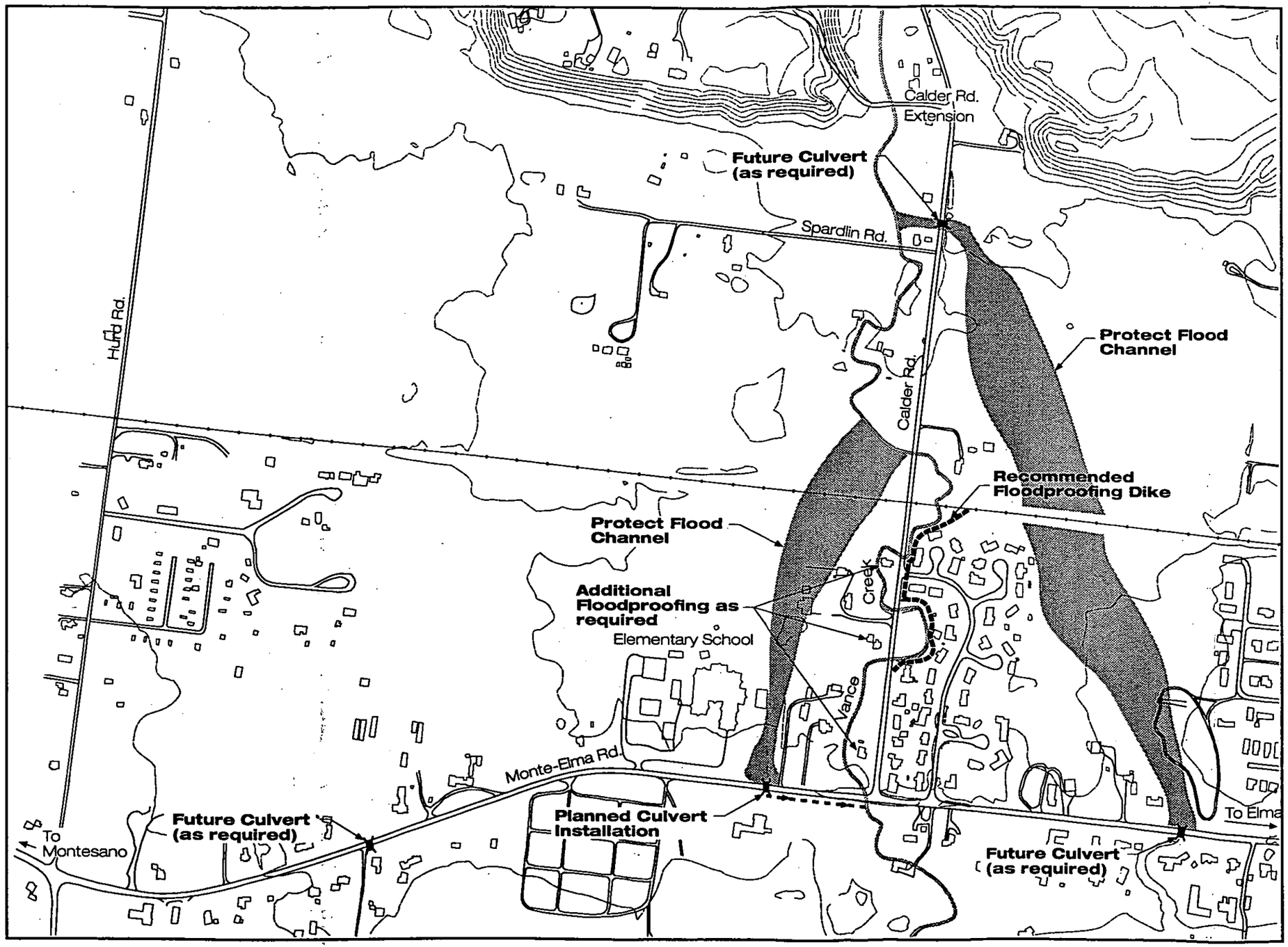


Figure 3
Recommended Plan

Costs

Preliminary estimates of the cost to construct the floodproofing dike have been developed on an order of magnitude basis. Additional costs construction and mitigation not included in Table 3 are outlined here.

Item	Opinion of Cost
1150 LF ecology block dike	$40,000
Roadway regrading at dike crossings	$5,600
Culvert headwall improvements (6)	$6,000
Habitat restoration/mitigation	$5,000 - $10,000
Backfill landscaping (optional)	$3,000 - $6,000
Total (high estimate)	**$68,000**

To initiate action on these recommendations, we suggest that a neighborhood meeting be conducted to present the alternatives and discuss formation of a local funding mechanism. Input from the public process will also provide clarification of the extent of flooding and provide a forum for input from the residents on other problems and potential solutions.

After review and internal discussion of this memorandum, please contact CH2M HILL at your earliest convenience to answer any questions which arise and arrange the community meeting.

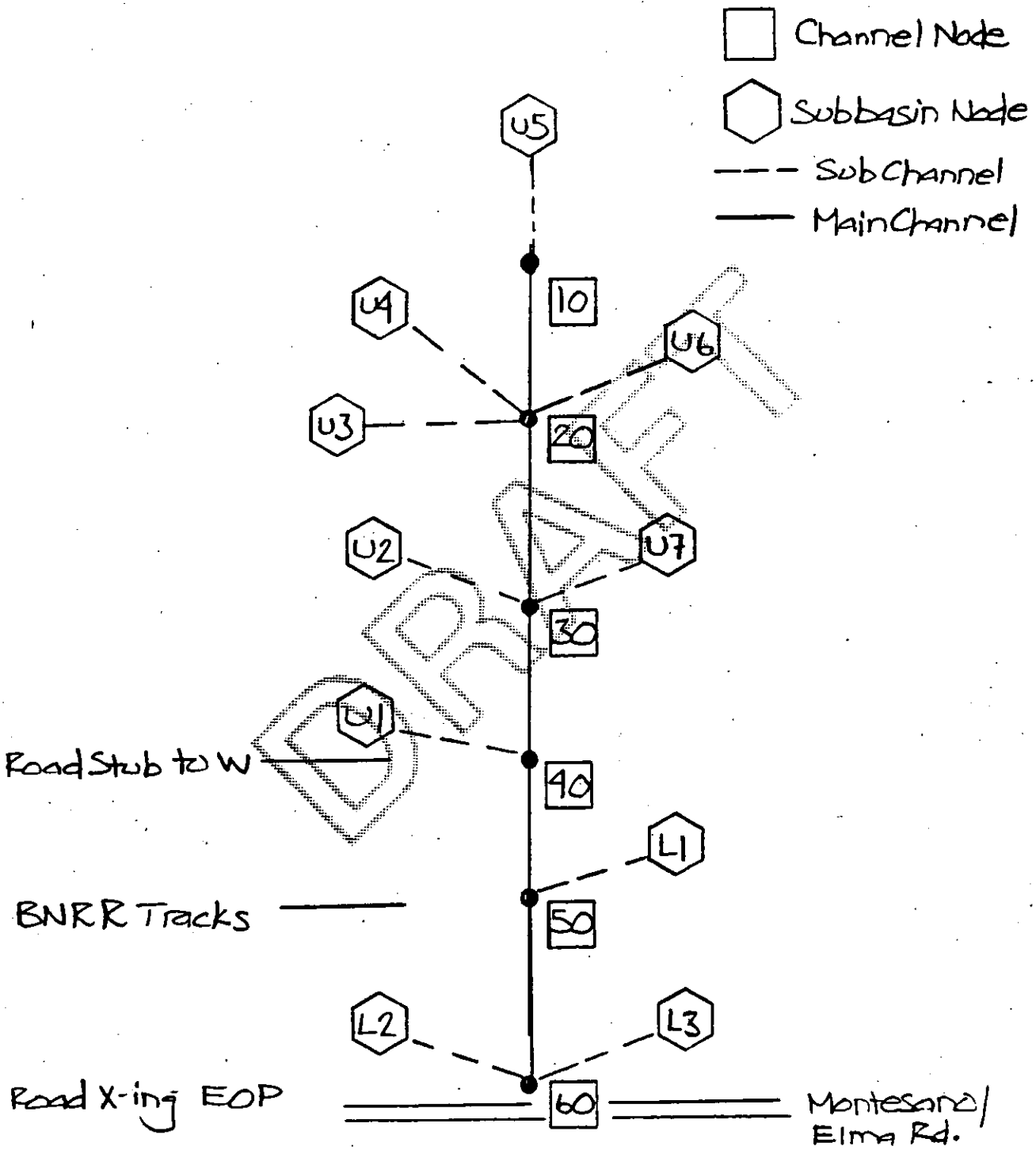
Appendix A

HEC-1
Hydrologic Model Input Tables

CH2MHILL SUBJECT Grays Harbor Vance Crk HEC1 Node

BY S Wasson DATE

PROJECT NO. SHT OF



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ID FILE NAME VANCE25.IN1  REVISED 8-5-93 S WASSON
ID GRAYS HARBOR COUNTY--VANCE CREEK PRELIMINARY DRAINAGE STUDY
ID MODEL OF VANCE CREEK DRAINAGE BASIN ELMA, WA.  ASSUMPTIONS:
*FREE
*DIAGRAM
IT   10 01JAN00     1    150
IO   3
* **********
KK SUBU5
KM Basin runoff calculation for  SUBU5
BA   .82
*  25-YEAR 24-HOUR PRECIPITATION
PB    5.5
*  TYPE IA 24-HOUR STORM
PC .004  .008  .012  .016  .020  .024  .028  .032  .036  .040
PC .045  .050  .055  .060  .065  .070  .076  .082  .088  .094
PC .100  .106  .113  .120  .127  .134  .141  .148  .156  .164
PC .173  .181  .189  .197  .207  .216  .226  .235  .245  .254
PC .268  .281  .294  .312  .330  .364  .418  .445  .463  .477
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PC .660  .667  .674  .681  .688  .696  .701  .707  .713  .718
PC .724  .730  .736  .741  .747  .753  .758  .764  .769  .774
PC .779  .784  .789  .794  .799  .804  .809  .814  .819  .824
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PC .868  .872  .876  .880  .884  .888  .892  .896  .900  .904
PC .908  .912  .916  .920  .924  .928  .932  .936  .940  .944
PC .948  .952  .956  .960  .964  .968  .972  .976  .980  .984
PC .988  .992  .996  1.000
LS    0     66
UD    0.76
* **********
KKROUTE1
KM Muskingum-Cunge channel routing from      10 to      20
RD     5300  .015  .040  0  TRAP  7  2
* **********
KK SUBU3
KM Basin runoff calculation for  SUBU3
BA   .495
LS    0     66
UD    0.76
* **********
KK SUBU3
KM Combining two hydrographs at control point      20
HC    2
* **********
KK SUBU6
KM Basin runoff calculation for  SUBU6
BA   .638
LS    0     66
UD    1.16
* **********
KK SUBU6
KM Combining two hydrographs at control point      20
HC    2
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* **********
KK SUBU4
KM Basin runoff calculation for  SUBU4
BA  .691
LS    0     66
UD    0.86
* **********
KK SUBU4
KM Combining two hydrographs at control point      20
HC    2
* **********
KKROUTE2
KM Muskingum-Cunge channel routing from      20 to      30
RD    3500  .005  .080  0  trap  150.0  4.0
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KM Combining two hydrographs at control point      30
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* **********
KK SUBU7
KM Basin runoff calculation for  SUBU7
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LS    0     66
UD    0.65
* **********
KK SUBU7
KM Combining two hydrographs at control point      30
HC    2
* **********
KKROUTE3
KM Muskingum-Cunge channel routing from      30 to      40
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* **********
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KM Basin runoff calculation for  SUBU1
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UD    0.89
* **********
KK SUBU1
KM Combining two hydrographs at control point      40
HC    2
* **********
KKROUTE4
KM Muskingum-Cunge channel routing from      40 to      50
RD   2000  .005  .04  0  TRAP  8.0  3
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KK SUBL1
KM Basin runoff calculation for  SUBL1
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BA .141
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UD    0.73
* **********
KK SUBL1
KM Combining two hydrographs at control point      50
HC   2
* **********
KKROUTE5
KM Muskingum-Cunge channel routing from      50 to      60
RD   2000 .005 .04 0 TRAP 9.0 3
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KM Basin runoff calculation for  SUBL2
BA .112
LS   0    70
UD    0.49
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KK SUBL2
KM Combining two hydrographs at control point      60
HC   2
* **********
KK SUBL3
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BA .048
LS   0    72
UD    0.17
* **********
KK SUBL3
KM Combining two hydrographs at control point      60
HC   2
* **********
ZZ
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ID FILE NAME VANCE100.DAT  REVISED 8-12-93 S WASSON
ID GRAYS HARBOR COUNTY--VANCE CREEK PRELIMINARY DRAINAGE STUDY
ID MODEL OF VANCE CREEK DRAINAGE BASIN ELMA, WA.  ASSUMPTIONS:
*FREE
*DIAGRAM
IT   10 01JAN00     1    150
IO   3
* **********
KK SUBU5
KM Basin runoff calculation for  SUBU5
BA   .82
*  100-YEAR 24-HOUR PRECIPITATION
PB    7.0
*  TYPE IA 24-HOUR STORM
PC .004  .008  .012  .016  .020  .024  .028  .032  .036  .040
PC .045  .050  .055  .060  .065  .070  .076  .082  .088  .094
PC .100  .106  .113  .120  .127  .134  .141  .148  .156  .164
PC .173  .181  .189  .197  .207  .216  .226  .235  .245  .254
PC .268  .281  .294  .312  .330  .364  .418  .445  .463  .477
PC .490  .504  .512  .521  .530  .539  .548  .556  .565  .574
PC .583  .592  .600  .609  .616  .624  .631  .638  .645  .652
PC .660  .667  .674  .681  .688  .696  .701  .707  .713  .718
PC .724  .730  .736  .741  .747  .753  .758  .764  .769  .774
PC .779  .784  .789  .794  .799  .804  .809  .814  .819  .824
PC .828  .832  .836  .840  .844  .848  .852  .856  .860  .864
PC .868  .872  .876  .880  .884  .888  .892  .896  .900  .904
PC .908  .912  .916  .920  .924  .928  .932  .936  .940  .944
PC .948  .952  .956  .960  .964  .968  .972  .976  .980  .984
PC .988  .992  .996  1.000
LS    0     66
UD    0.76
* **********
KKROUTE1
KM Muskingum-Cunge channel routing from     10 to      20
RD     5300  .015  .040  0  TRAP  7  2
* **********
KK SUBU3
KM Basin runoff calculation for  SUBU3
BA  .495
LS    0     66
UD    0.76
* **********
KK SUBU3
KM Combining two hydrographs at control point      20
HC    2
* **********
KK SUBU6
KM Basin runoff calculation for  SUBU6
BA  .638
LS    0     66
UD    1.16
* **********
KK SUBU6
KM Combining two hydrographs at control point      20
HC    2
```

```
* **********
KK SUBU4
KM Basin runoff calculation for  SUBU4
BA  .691
LS    0     66
UD    0.86
* **********
KK SUBU4
KM Combining two hydrographs at control point      20
HC    2
* **********
KKROUTE2
KM Muskingum-Cunge channel routing from      20 to      30
RD    3500  .005  .080  0  trap  150.0  4.0
* **********
KK SUBU2
KM Basin runoff calculation for  SUBU2
BA  .697
LS    0     66
UD    0.63
* **********
KK SUBU2
KM Combining two hydrographs at control point      30
HC    2
* **********
KK SUBU7
KM Basin runoff calculation for  SUBU7
BA  .138
LS    0     66
UD    0.65
* **********
KK SUBU7
KM Combining two hydrographs at control point      30
HC    2
* **********
KKROUTE3
KM Muskingum-Cunge channel routing from      30 to      40
RD    3200  .0035  .08  0  TRAP  150.0  4.0
* **********
KK SUBU1
KM Basin runoff calculation for  SUBU1
BA  .239
LS    0     66
UD    0.89
* **********
KK SUBU1
KM Combining two hydrographs at control point      40
HC    2
* **********
KKROUTE4
KM Muskingum-Cunge channel routing from      40 to      50
RD  2000  .005  .04  0  TRAP  8.0  3
* **********
KK SUBL1
KM Basin runoff calculation for  SUBL1
```

```
BA .141
LS   0   68
UD   0.73
* **********
KK SUBL1
KM Combining two hydrographs at control point      50
HC   2
* **********
KKROUTE5
KM Muskingum-Cunge channel routing from      50 to      60
RD   2000 .005 .04 0 TRAP 9.0 3
* **********
KK SUBL2
KM Basin runoff calculation for  SUBL2
BA .112
LS   0   70
UD   0.49
* **********
KK SUBL2
KM Combining two hydrographs at control point      60
HC   2
* **********
KK SUBL3
KM Basin runoff calculation for  SUBL3
BA .048
LS   0   72
UD   0.17
* **********
KK SUBL3
KM Combining two hydrographs at control point      60
HC   2
* **********
ZZ
```

Appendix B

Culvert Backwater Analysis

Vance Creek Culvert Crossings Capacity Checks

Culvert Description	Flow Rate (cfs)	Mannings Coeff. n	Culvert Diameter (ft)	Culvert Length (ft)	Culvert Slope (ft/ft)	Full Flow Area (sf)	Full Flow Velocity (fps)	Velocity Head (ft)	Entrance Loss Coeff. Ke	Entrance Loss (ft)	Friction Loss (ft)	Total Head Loss HW - TW (ft)	Allowable HW - TW (ft)	Allowable Head above u/s crown (ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Culvert Crossing #1			(*)		(s)									(s)
Calder Rd. Extension	240	0.024	8.4	50.7	0.004	55.42	4.33	0.291	0.7	0.204	0.092	0.6	0.6	0.4
Culvert Crossing #2					(s)									(s)
Spardlin County Rd.- #1	120	0.024	6.0	30.7	0.003	28.27	4.24	0.280	0.9	0.252	0.084	0.6	0.6	0.5
Spardlin County Rd.- #2	160	0.024	6.0	30.3	0.003	28.27	5.66	0.497	0.9	0.448	0.147	1.1	1.1	1.0
Culvert Crossing #3					(s)									(s)
Calder Rd. Sta 16+45- #1	90	0.024	4.5	40.6	0.006	15.90	5.66	0.497	0.9	0.448	0.288	1.2	1.2	1.0
Calder Rd. Sta 16+45- #2	95	0.024	4.5	40.6	0.006	15.90	5.97	0.554	0.9	0.499	0.321	1.4	1.4	1.2
Calder Rd. Sta 16+45- #3	93	0.024	4.5	40.6	0.006	15.90	5.85	0.531	0.9	0.478	0.308	1.3	1.3	1.1
Culvert Crossing #4					(m)									(m)
Calder Rd. Sta 11+64- #1	115	0.024	4.5	40	0.008	15.90	7.23	0.812	0.7	0.568	0.464	1.8	1.8	1.5
Calder Rd. Sta 11+64- #2	115	0.024	4.5	40	0.008	15.90	7.23	0.812	0.7	0.568	0.464	1.8	1.8	1.5
Calder Rd. Sta 11+64- #3	73	0.024	4.5	40	0.008	15.90	4.59	0.327	0.9	0.294	0.187	0.8	0.8	0.5
Culvert Crossing #5					(m)									(m)
Calder Rd. Sta 8+84- #1	68	0.024	4.5	40	0.003	15.90	4.28	0.284	0.7	0.199	0.162	0.6	0.6	0.5
Calder Rd. Sta 8+84- #2	68	0.024	4.5	40	0.003	15.90	4.28	0.284	0.7	0.199	0.162	0.6	0.6	0.5
Calder Rd. Sta 8+84- #3	55	0.024	4.5	40	0.003	15.90	3.46	0.186	0.9	0.167	0.106	0.5	0.5 (a)	-0.5
Culvert Crossing #6					(m)									(m)
Calder Rd. Sta 6+59- #1	85	0.024	4.5	41	0.012	15.90	5.34	0.444	0.7	0.310	0.260	1.0	1.0	0.5
Calder Rd. Sta 6+59- #2	85	0.024	4.5	41	0.012	15.90	5.34	0.444	0.7	0.310	0.260	1.0	1.0	0.5
Calder Rd. Sta 6+59- #3	55	0.024	4.5	41	0.012	15.90	3.46	0.186	0.9	0.167	0.109	0.5	0.5 (a)	-0.5
Culvert Crossing #7														(s)
Monte-Elma Rd.- #1	75	0.012	4.0	55	Unk.	12.57	5.97	0.553	0.7	0.387	0.127	1.1	1.1	1.1
Monte-Elma Rd.- #2	82	0.012	4.0	55	Unk.	12.57	6.53	0.661	0.7	0.463	0.152	1.3	1.3	1.3
Monte-Elma Rd.- #3	50	0.024	4.0	55	Unk.	12.57	3.98	0.246	0.7	0.172	0.226	0.6	0.6	0.6

NOTES:

This spreadsheet calculates headwater on a culvert assuming full pipe flow conditions with TW @ d/s crown elevation.
Flow rate is iterated upon until: Total head loss (13) = Allowable HW-TW (14).

Column (2): Iterated to give maximum allowable HW (14) = Total head loss (13)
Column (11): Entrance Loss = Ke*(V*V/2g) [(9)*(10)]
Column (12): Friction Loss = (V*V/2g)*(29*n*n*L)/(D/4)^1.33 [(9)*29*(3)*(3)*(5)/(((4)/4)^1.33)]
Column (13): Total Head Loss = Entrance loss + Exit loss + Friction loss [(11)+(9)+(12)]
Column (14): Allowable HW - TW = Allowable head above u/s crown + L*So [(15)+(5)*(6)]
Column (15): Allowable head set to 1.0' below surveyed top of road elevation minus u/s crown elevation.

(*) - approximate equivalent diameter for 11.5' x 7.3' elliptical culvert
(s) - field surveyed by differentials, 1993
(m) - map survey information, Calder Rd. profile, Grays Harbor County Dept. of Public Works
(a) - actual conditions not full flow. From adjacent culverts flow condition is HW-TW = 0.5.

Appendix C

Conveyance Alternatives Figures

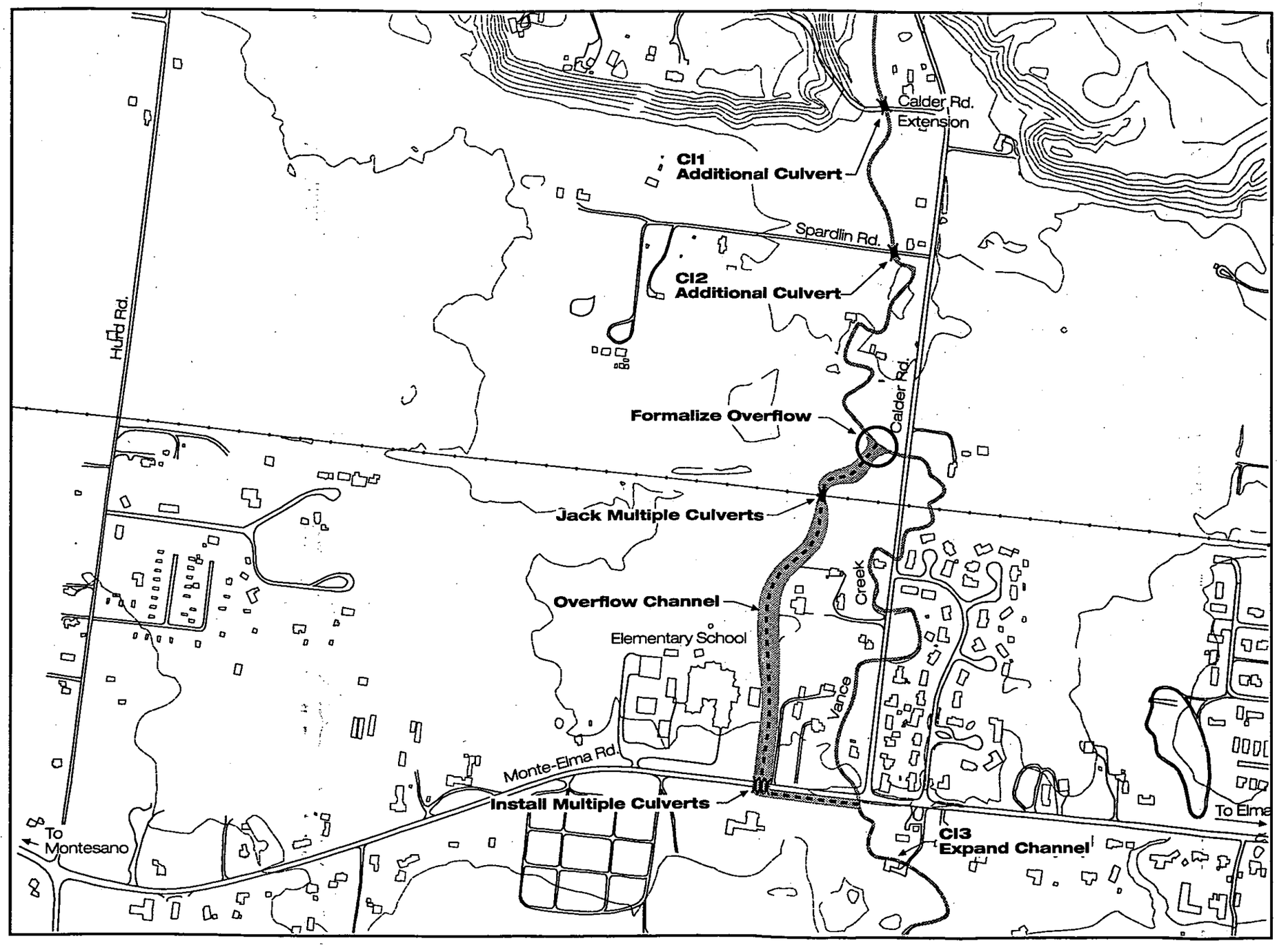

Figure 4
Alternative 1
Formalize Existing Floodway

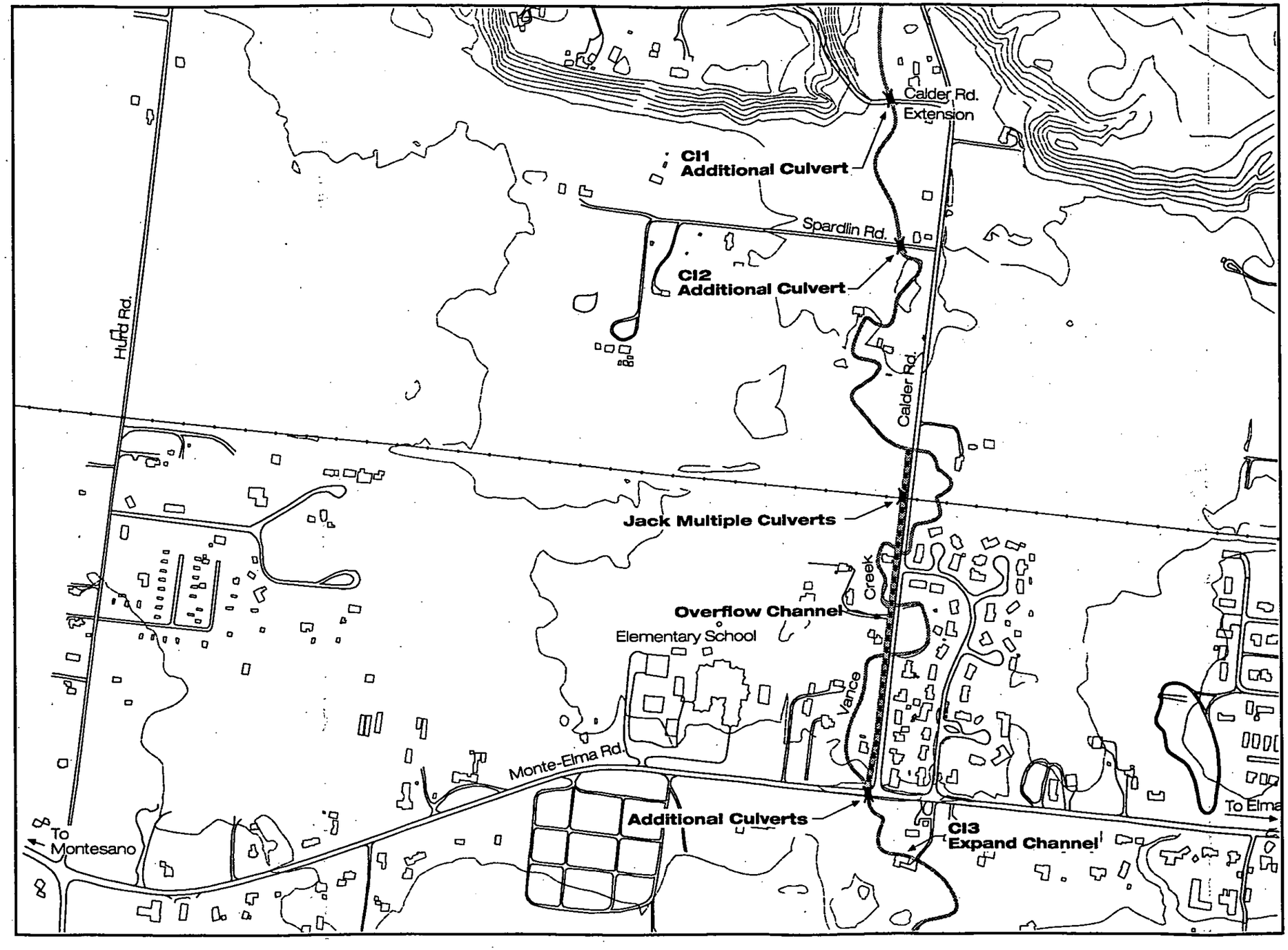

Figure 5
Alternative 2
Construct Overflow Channel

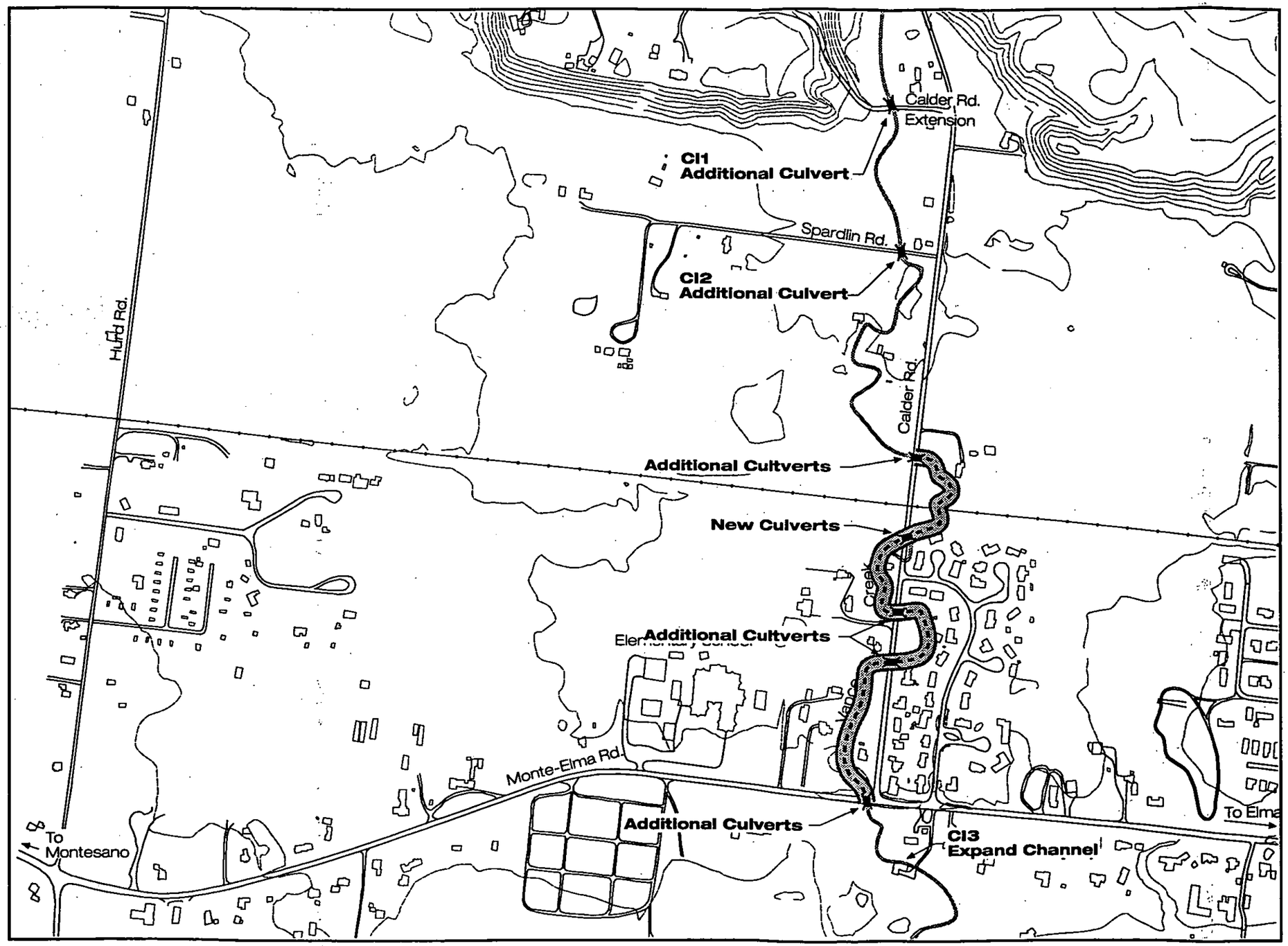

Figure 6
Alternative 3
Expand Existing Stream Channel

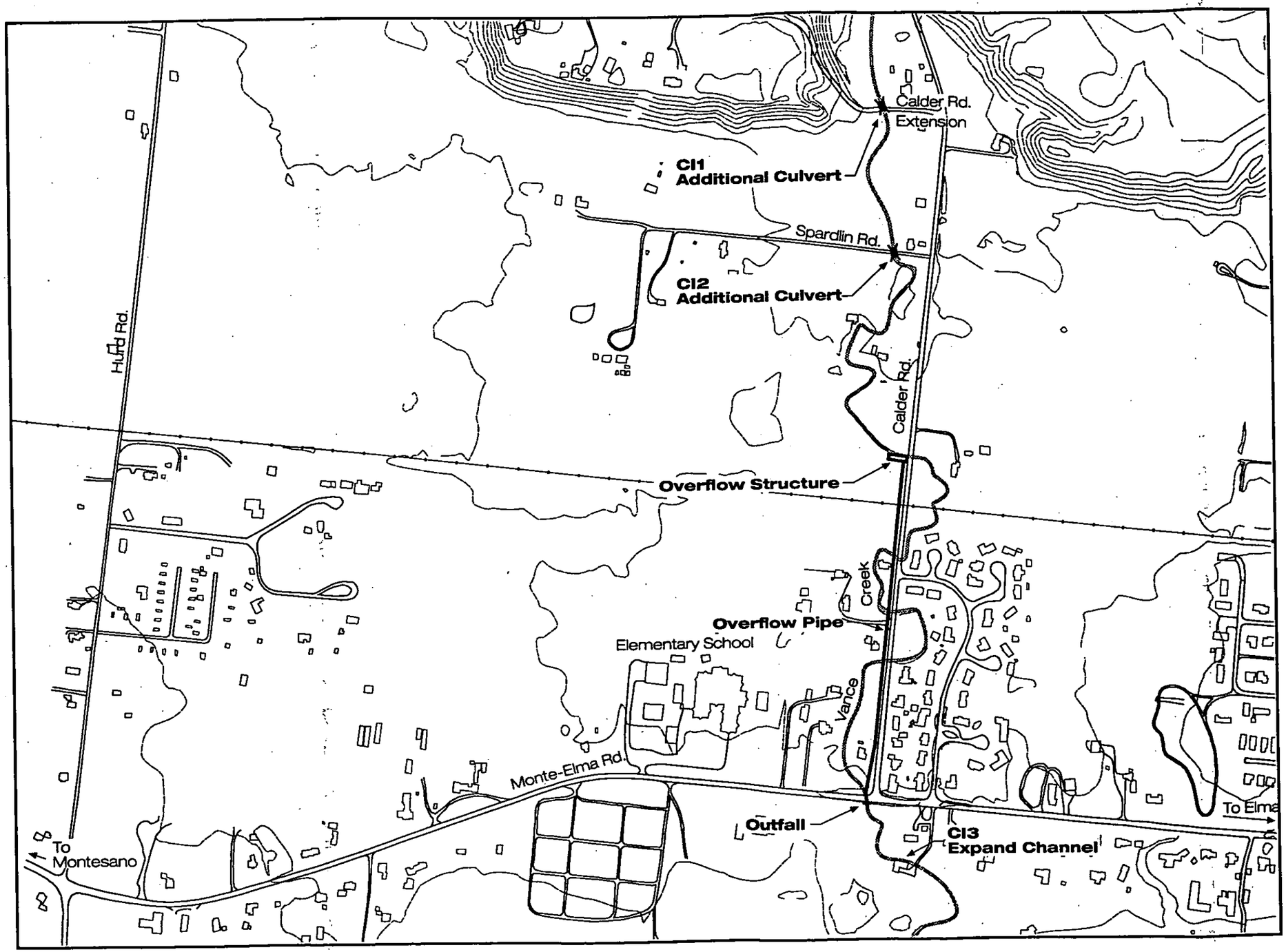

Figure 7
Alternative 4
Construct Overflow Pipeline

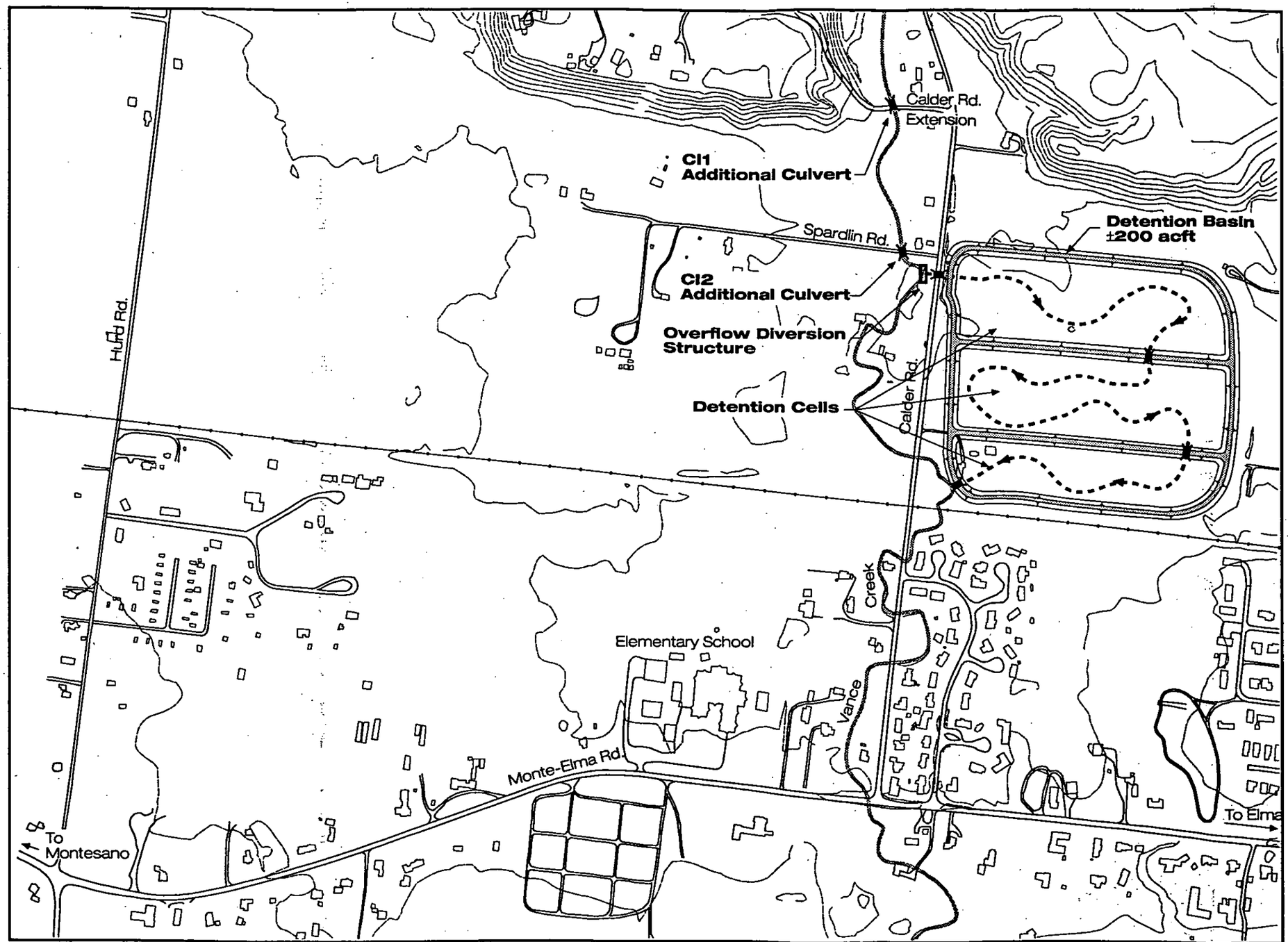

Figure 8
Alternative 5
Construct Detention Basin

Appendix D

Opinions of Cost

PROJECT: GRAYS HARBOR VANCE CREEK
ORDER OF MAGNITUDE COST ESTIMATE

DATE: 03/14/94
PROJECT NO.: NPW34056.A0
FILE: VANCE.XLS

Alternative 1:
Formalize Existing Floodway

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
CI#1: (2) 60" CMP Culverts (80'L) @ Calder Road				
Excavation	CY	712	$3.00	$2,136
Imported Bed & Zone	CY	404	$18.00	$7,272
Native Backfill	CY	192	$4.00	$768
Waste	CY	520	$3.00	$1,560
Gravel Surface Restoration	CY	88	$18.00	$1,584
60" CMP	LF	160	$100.00	$16,000
TOTAL CI#1				$29,320
CI#2: (2) 60" CMP Culverts (60'L) @ Spardlin Road				
Excavation	CY	390	$3.00	$1,170
Imported Bed & Zone	CY	260	$18.00	$4,680
Native Backfill	CY	44	$4.00	$176
Waste	CY	346	$3.00	$1,038
Gravel Surface Restoration	CY	44	$18.00	$792
60" CMP	LF	120	$100.00	$12,000
TOTAL CI#2				$19,856
CI#3: Widen Creek Channel				
Excavation & Waste	CY	2,100	$6.00	$12,600
Fish Gravel	CY	800	$21.00	$16,800
Quarry Spalls	CY	1,000	$20.00	$20,000
Live Willow Stakes	EA	750	$2.00	$1,500
Filter Fabric	SY	750	$1.20	$900
Logs, Stumps, Big Rocks	LS	1	$2,000.00	$2,000
Creek Diversion	LS	1	$50,500.00	$50,500
TOTAL CI#3				$104,300
Alternative 1:				
Flood Channel Excavation & Waste	CY	9,200	$6.00	$55,200
Hydroseeding	SY	3,700	$0.35	$1,295
Ditch Excavation & Waste	CY	1,400	$6.00	$8,400
Quarry Spall Lining	CY	400	$21.00	$8,400
(4) 48" CMP Culverts (80'L)				
Sawcut ACP	LF	776	$1.00	$776
Remove ACP	SY	400	$1.50	$600
Remove Base Course	CY	400	$2.00	$800
Dispose of ACP	CY	400	$10.00	$4,000
Excavation	CY	748	$3.00	$2,244
Imported Bed & Zone	CY	504	$18.00	$9,072
Native Backfill	CY	96	$4.00	$384

Alternative 1: (Cont.)
Formalize Existing Floodway

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
Waste	CY	652	$3.00	$1,956
Surface Restoration Base	CY	100	$20.00	$2,000
Surface Restoration ACP (Patch)	TN	104	$60.00	$6,240
48" CMP Culvert	LF	320	$50.00	$16,000
TOTAL ALTERNATIVE #1				$117,367
SUBTOTAL				$270,843
ALLOWANCE	10%			$27,084
SUBTOTAL				$297,927
CONTINGENCY	30%			$89,378
SUBTOTAL				$387,305
MOBILIZATION	10%			$38,731
TOTAL				$426,036

ASSUMPTIONS:

- Trench safety accounted for by 1:1 slope
- Dewatering is not substantial; therefore, not accounted for
- Permits and scheduling conflicts are the responsibility of the owner

NOTE:

The above cost opinion is in March 1994 dollars and does not include escalation, construction management, engineering, sales tax, financial costs or operation and maintenance costs. In addition, there are no costs for the mitigation or remediation associated with the potential discovery of hazardous materials. The order of magnitude cost opinion shown has been prepared for guidance in project evaluation at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule and other variable factors. As a result, the final project costs will vary from the estimate presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

PROJECT: GRAYS HARBOR VANCE CREEK
ORDER OF MAGNITUDE COST ESTIMATE

DATE: 03/14/94
PROJECT NO.: NPW34056.A0
FILE: VANCE.XLS

Alternative 2:
Construct Overflow Channel Adjacent to Calder Rd.

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
CI#1: (2) 60" CMP Culverts (80'L) @ Calder Road				
Excavation	CY	712	$3.00	$2,136
Imported Bed & Zone	CY	404	$18.00	$7,272
Native Backfill	CY	192	$4.00	$768
Waste	CY	520	$3.00	$1,560
Gravel Surface Restoration	CY	88	$18.00	$1,584
60" CMP	LF	160	$100.00	$16,000
TOTAL CI#1				$29,320
CI#2: (2) 60" CMP Culverts (60'L) @ Spardlin Road				
Excavation	CY	390	$3.00	$1,170
Imported Bed & Zone	CY	260	$18.00	$4,680
Native Backfill	CY	44	$4.00	$176
Waste	CY	346	$3.00	$1,038
Gravel Surface Restoration	CY	44	$18.00	$792
60" CMP	LF	120	$100.00	$12,000
TOTAL CI#2				$19,856
CI#3: Widen Creek Channel				
Excavation & Waste	CY	2,100	$6.00	$12,600
Fish Gravel	CY	800	$21.00	$16,800
Quarry Spalls	CY	1,000	$20.00	$20,000
Live Willow Stakes	EA	750	$2.00	$1,500
Filter Fabric	SY	750	$1.20	$900
Logs, Stumps, Big Rocks	LS	1	$2,000.00	$2,000
Creek Diversion	LS	1	$50,500.00	$50,500
TOTAL CI#3				$104,300
Alternative 2:				
(2) 4' Dia. Steel Pipe under RR Tracks	LF	160	$338.00	$54,080
Channel Excavation & Waste	CY	5,000	$6.00	$30,000
Quarry Spall Lining	CY	2,500	$21.00	$52,500
Diversion Structure				
Concrete	CY	15	$400.00	$6,000
Excavation	CY	42	$3.00	$126
Base Course	CY	4	$18.00	$72
Native Backfill	CY	17	$4.00	$68
Waste	CY	25	$3.00	$75
(3) 4'x6' Box Culverts under Monte-Elma Rd.				
Sawcut ACP	LF	624	$1.00	$624
Remove ACP	SY	639	$1.50	$959
Remove Base Course	CY	108	$2.00	$216
Dispose of ACP	CY	54	$10.00	$540
Excavation	CY	1,056	$3.00	$3,168
Base Course	CY	45	$18.00	$810
Native Backfill	CY	771	$4.00	$3,084

Alternative 2: (Cont.)
Construct Overflow Channel Adjacent to Calder Rd.

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
Waste	CY	285	$2.00	$570
Surface Restoration Base	CY	108	$20.00	$2,160
Surface Restoration ACP (Patch)	TN	108	$60.00	$6,480
4'x8' Box Culvert	CY	240	$300.00	$72,000
TOTAL ALTERNATIVE #2				**$233,532**
SUBTOTAL				**$387,008**
ALLOWANCE	10%			$38,701
SUBTOTAL				**$425,708**
CONTINGENCY	30%			$127,712
SUBTOTAL				**$553,421**
MOBILIZATION	10%			$55,342
TOTAL				**$608,763**

ASSUMPTIONS:

- Trench safety accounted for by 1:1 slope
- Dewatering is not substantial; therefore, not accounted for
- Permits and scheduling conflicts are the responsibility of the owner

NOTE:

The above cost opinion is in March 1994 dollars and does not include escalation, construction management, engineering, sales tax, financial costs or operation and maintenance costs. In addition, there are no costs for the mitigation or remediation associated with the potential discovery of hazardous materials. The order of magnitude cost opinion shown has been prepared for guidance in project evaluation at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule and other variable factors. As a result, the final project costs will vary from the estimate presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

PROJECT: GRAYS HARBOR VANCE CREEK
ORDER OF MAGNITUDE COST ESTIMATE

DATE: 03/14/94
PROJECT NO.: NPW34056.A0
FILE: VANCE.XLS

Alternative 3:
Flood Channel Expansion

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
CI#1: (2) 60" CMP Culverts (80'L) @ Calder Road				
Excavation	CY	712	$3.00	$2,136
Imported Bed & Zone	CY	404	$18.00	$7,272
Native Backfill	CY	192	$4.00	$768
Waste	CY	520	$3.00	$1,560
Gravel Surface Restoration	CY	88	$18.00	$1,584
60" CMP	LF	160	$100.00	$16,000
TOTAL CI#1				$29,320
CI#2: (2) 60" CMP Culverts (60'L) @ Spardlin Road				
Excavation	CY	390	$3.00	$1,170
Imported Bed & Zone	CY	260	$18.00	$4,680
Native Backfill	CY	44	$4.00	$176
Waste	CY	346	$3.00	$1,038
Gravel Surface Restoration	CY	44	$18.00	$792
60" CMP	LF	120	$100.00	$12,000
TOTAL CI#2				$19,856
CI#3: Widen Creek Channel				
Excavation & Waste	CY	2,100	$6.00	$12,600
Fish Gravel	CY	800	$21.00	$16,800
Quarry Spalls	CY	1,000	$20.00	$20,000
Live Willow Stakes	EA	750	$2.00	$1,500
Filter Fabric	SY	750	$1.20	$900
Logs, Stumps, Big Rocks	LS	1	$2,000.00	$2,000
Creek Diversion	LS	1	$50,500.00	$50,500
TOTAL CI#3				$104,300
Alternative 3:				
Excavation & Haul	CY	48,000	$6.00	$288,000
Restoration Area (Grass & Erosion Matting)	AC	8	$7,200.00	$57,600
Easements	AC	8	$15,000.00	$120,000
Impact to 4 Structures	LS	1	$50,000.00	$50,000
(5) Culvert Crossings Impacted				
Sawcut ACP	LF	740	$1.00	$740
Remove ACP	SY	665	$1.50	$998
Remove Base Course	CY	110	$2.00	$220
Dispose of ACP	CY	110	$10.00	$1,100
Excavation	CY	1,105	$3.00	$3,315
Base Course	CY	45	$18.00	$810
Native Backfill	CY	645	$4.00	$2,580
Waste	CY	460	$3.00	$1,380
Surface Restoration Base	CY	110	$20.00	$2,200

Alternative 3: (Cont.)
Flood Channel Expansion

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
Surface Restoration ACP (Patch)	TN	110	$60.00	$6,600
5'x9' Box Culvert	CY	220	$300.00	$66,000
TOTAL ALTERNATIVE #3				**$601,543**
SUBTOTAL				**$755,019**
ALLOWANCE	10%			$75,502
SUBTOTAL				**$830,520**
CONTINGENCY	30%			$249,156
SUBTOTAL				**$1,079,676**
MOBILIZATION	10%			$107,968
TOTAL				**$1,187,644**

ASSUMPTIONS:

- Trench safety accounted for by 1:1 slope
- Dewatering is not substantial; therefore, not accounted for
- Permits and scheduling conflicts are the responsibility of the owner

NOTE:

The above cost opinion is in March 1994 dollars and does not include escalation, construction management, engineering, sales tax, financial costs or operation and maintenance costs. In addition, there are no costs for the mitigation or remediation associated with the potential discovery of hazardous materials. The order of magnitude cost opinion shown has been prepared for guidance in project evaluation at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule and other variable factors. As a result, the final project costs will vary from the estimate presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

PROJECT: GRAYS HARBOR VANCE CREEK
ORDER OF MAGNITUDE COST ESTIMATE

DATE: 03/14/94
PROJECT NO.: NPW34056.A0
FILE: VANCE.XLS

Alternative 4:
Construct Overflow Pipeline

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
CI#1: (2) 60" CMP Culverts (80'L) @ Calder Road				
Excavation	CY	712	$3.00	$2,136
Imported Bed & Zone	CY	404	$18.00	$7,272
Native Backfill	CY	192	$4.00	$768
Waste	CY	520	$3.00	$1,560
Gravel Surface Restoration	CY	88	$18.00	$1,584
60" CMP	LF	160	$100.00	$16,000
TOTAL CI#1				$29,320
CI#2: (2) 60" CMP Culverts (60'L) @ Spardlin Road				
Excavation	CY	390	$3.00	$1,170
Imported Bed & Zone	CY	260	$18.00	$4,680
Native Backfill	CY	44	$4.00	$176
Waste	CY	346	$3.00	$1,038
Gravel Surface Restoration	CY	44	$18.00	$792
60" CMP	LF	120	$100.00	$12,000
TOTAL CI#2				$19,856
CI#3: Widen Creek Channel				
Excavation & Waste	CY	2,100	$6.00	$12,600
Fish Gravel	CY	800	$21.00	$16,800
Quarry Spalls	CY	1,000	$20.00	$20,000
Live Willow Stakes	EA	750	$2.00	$1,500
Filter Fabric	SY	750	$1.20	$900
Logs, Stumps, Big Rocks	LS	1	$2,000.00	$2,000
Creek Diversion	LS	1	$50,500.00	$50,500
TOTAL CI#3				$104,300
Alternative 4:				
Headwall @ Outfall for 96" Pipe (Conc.)	EA	1	$8,200.00	$8,200
Manhole (120" x 14' dp)	EA	4	$9,200.00	$36,800
Riprap	CY	45	$30.00	$1,350
Diversion Structure				
Concrete	CY	15	$400.00	$6,000
Excavation	CY	42	$3.00	$126
Base Course	CY	4	$18.00	$72
Native Backfill	CY	17	$4.00	$68
Waste	CY	25	$3.00	$75
1100' 96" dia. Concrete Pipe, 10' dp				
Excavation	CY	8,148	$3.00	$24,444
Imported Bed & Zone	CY	5,500	$18.00	$99,000
Native Backfill	CY	601	$4.00	$2,404
Waste	CY	7,547	$3.00	$22,641
Surface Restoration (Seeding)	SY	3,911	$0.35	$1,369
96" Concrete Pipe	LF	1,100	$200.00	$220,000
600' 96" dia. Concrete Pipe, 14' dp				
Excavation	CY	7,467	$3.00	$22,401
Imported Bed & Zone	CY	3,000	$18.00	$54,000
Native Backfill	CY	3,350	$4.00	$13,400

Alternative 4: (Cont.)
Construct Overflow Pipeline

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
Waste	CY	4,117	$3.00	$12,351
Surface Restoration (Seeding)	SY	2,667	$0.35	$933
96" Concrete Pipe	LF	600	$200.00	$120,000
TOTAL ALTERNATIVE #4				**$645,634**
SUBTOTAL				**$799,110**
ALLOWANCE	10%			$79,911
SUBTOTAL				**$879,021**
CONTINGENCY	30%			$263,706
SUBTOTAL				**$1,142,728**
MOBILIZATION	10%			$114,273
TOTAL				**$1,257,001**

ASSUMPTIONS:

- Trench safety accounted for by 1:1 slope
- Dewatering is not substantial; therefore, not accounted for
- Permits and scheduling conflicts are the responsibility of the owner

NOTE:

The above cost opinion is in March 1994 dollars and does not include escalation, construction management, engineering, sales tax, financial costs or operation and maintenance costs. In addition, there are no costs for the mitigation or remediation associated with the potential discovery of hazardous materials. The order of magnitude cost opinion shown has been prepared for guidance in project evaluation at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule and other variable factors. As a result, the final project costs will vary from the estimate presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

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Alternative 5:
Construct Detention Basin

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
CI#1: (2) 60" CMP Culverts (60'L) @ Calder Road				
Excavation	CY	712	$3.00	$2,136
Imported Bed & Zone	CY	404	$18.00	$7,272
Native Backfill	CY	192	$4.00	$768
Waste	CY	520	$3.00	$1,560
Gravel Surface Restoration	CY	88	$18.00	$1,584
60" CMP	LF	160	$100.00	$16,000
TOTAL CI#1				**$29,320**
CI#2: (2) 60" CMP Culverts (60'L) @ Spardlin Road				
Excavation	CY	390	$3.00	$1,170
Imported Bed & Zone	CY	260	$18.00	$4,680
Native Backfill	CY	44	$4.00	$176
Waste	CY	346	$3.00	$1,038
Gravel Surface Restoration	CY	44	$18.00	$792
60" CMP	LF	120	$100.00	$12,000
TOTAL CI#2				**$19,856**
CI#3: Widen Creek Channel				
Excavation & Waste	CY	2,100	$6.00	$12,600
Fish Gravel	CY	800	$21.00	$16,800
Quarry Spalls	CY	1,000	$20.00	$20,000
Live Willow Stakes	EA	750	$2.00	$1,500
Filter Fabric	SY	750	$1.20	$900
Logs, Stumps, Big Rocks	LS	1	$2,000.00	$2,000
Creek Diversion	LS	1	$50,500.00	$50,500
TOTAL CI#3				**$104,300**
Alternative 5:				
Excavation (w/15 mile roundtrip haul)	CY	160,000	$8.00	$1,280,000
Berm Embankment	CY	20,000	$4.00	$80,000
Surface Preparation & Hydroseed	AC	25	$2,000.00	$50,000
Silt Fence	LF	2,000	$3.00	$6,000
(3) Concrete Outlet Control Weirs	CY	39	$400.00	$15,600
ACP	TN	808	$60.00	$48,480
Diversion Structure				
Concrete	CY	15	$400.00	$6,000
Excavation	CY	42	$3.00	$126
Base Course	CY	4	$18.00	$72
Native Backfill	CY	17	$4.00	$68
Waste	CY	25	$3.00	$75
(2) 200' 72" dia. Concrete Pipe, 8' dp (side by side)				
Excavation	CY	1,718	$3.00	$5,154
Imported Bed & Zone	CY	1,030	$18.00	$18,540
Native Backfill	CY	163	$4.00	$652
Waste	CY	1,555	$3.00	$4,665

Alternative 5: (Cont.)
Construct Detention Basin

DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
Surface Restoration (Seeding)	SY	822	$0.35	$288
72" Concrete Pipe	LF	400	$120.00	$48,000
200' 4'x6' Box Culvert Outlet				
Excavation	CY	778	$3.00	$2,334
Imported Bed & Zone	CY	30	$18.00	$540
Native Backfill	CY	570	$4.00	$2,280
Waste	CY	208	$3.00	$624
Surface Restoration (Gravel)	CY	81	$18.00	$1,458
Riprap	CY	30	$30.00	$900
4'x6' Box Culvert Outlet	CY	119	$300.00	$35,700
TOTAL ALTERNATIVE #5				**$1,607,556**
SUBTOTAL				**$1,761,032**
ALLOWANCE	10%			$176,103
SUBTOTAL				**$1,937,135**
CONTINGENCY	30%			$581,140
SUBTOTAL				**$2,518,275**
MOBILIZATION	10%			$251,828
TOTAL				**$2,770,103**

ASSUMPTIONS:

- Trench safety accounted for by 1:1 slope
- Dewatering is not substantial; therefore, not accounted for
- Permits and scheduling conflicts are the responsibility of the owner

NOTE:

The above cost opinion is in March 1994 dollars and does not include escalation, construction management, engineering, sales tax, financial costs or operation and maintenance costs. In addition, there are no costs for the mitigation or remediation associated with the potential discovery of hazardous materials. The order of magnitude cost opinion shown has been prepared for guidance in project evaluation at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule and other variable factors. As a result, the final project costs will vary from the estimate presented above. Because of these factors, funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

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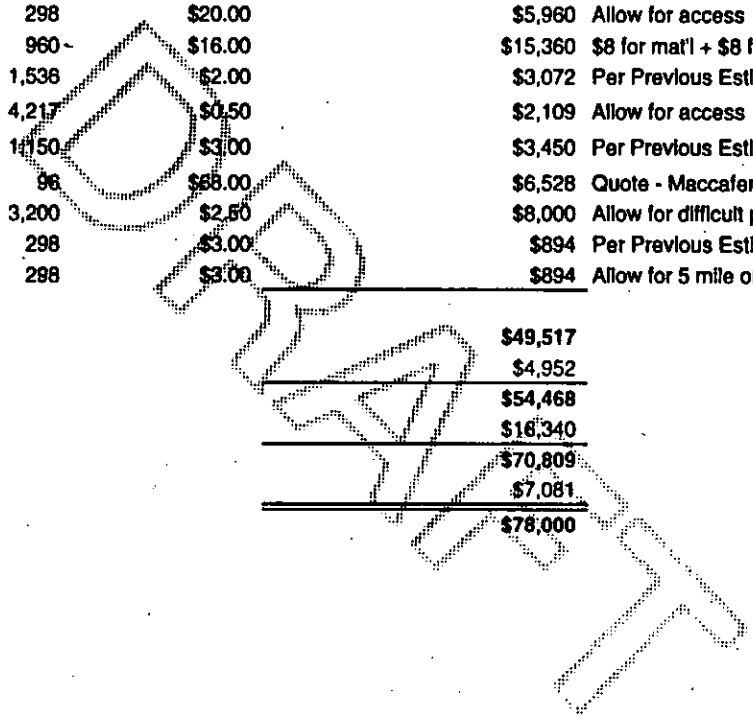
ALTERNATIVE #1:
GABION BASKET WALL

DESCRIPTION	UNIT	QTY	UNIT PRICE	TOTAL	COMMENTS
Clear & Grub	AC	0.65	$5,000.00	$3,250	Per Previous Estimate (North Lake Tapps)
Compact Subgrade	CY	298	$20.00	$5,960	Allow for access
Select Backfill	CY	960	$16.00	$15,360	$8 for mat'l + $8 for placement
Live Stakes	EA	1,536	$2.00	$3,072	Per Previous Estimate (Vance)
Permanent Seeding	SY	4,217	$0.50	$2,109	Allow for access
Erosion & Sediment Control (Silt Fence)	LF	1150	$3.00	$3,450	Per Previous Estimate (Vance)
Gabion Basket (3'x3'x12')	EA	96	$68.00	$6,528	Quote - Maccaferri $17 cy X 4cy=$68 ea
Geotextile	SY	3,200	$2.50	$8,000	Allow for difficult placement
Excavation	CY	298	$3.00	$894	Per Previous Estimate (Vance)
Waste	CY	298	$3.00	$894	Allow for 5 mile one-way, no fee
SUBTOTAL				**$49,517**	
ALLOWANCE	10%			$4,952	
SUBTOTAL				**$54,468**	
CONTINGENCY	30%			$16,340	
SUBTOTAL				**$70,809**	
MOBILIZATION	10%			$7,081	
TOTAL (ROUNDED)				**$78,000**	



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ALTERNATIVE #2:
GEOTEXTILE SUPPORTED EMBANKMENT

DESCRIPTION	UNIT	QTY	UNIT PRICE	TOTAL	COMMENTS
Clear & Grub	AC	0.60	$5,000.00	$3,000	Per Previous Estimate (North Lake Tapps)
Compact Subgrade	CY	511	$20.00	$10,220	Allow for Access
Select Backfill	CY	1,610	$18.00	$28,980	$8 for mat'l + $10 for placement
Live Stakes	EA	2,300	$2.00	$4,600	Per Previous Estimate (Vance)
Permanent Seeding	SY	5,367	$0.50	$2,684	Allow for access
Erosion & Sediment Control (Silt Fence)	LF	1,150	$3.00	$3,450	Per Previous Estimate (Vance)
Geotextile	SY	10,350	$2.00	$20,700	Allow for difficult placement
Excavation	CY	511	$3.00	$1,533	Per Previous Estimate (Vance)
Waste	CY	511	$3.00	$1,533	Allow for 5 mile one-way, no fee
SUBTOTAL				$76,700	
ALLOWANCE	10%			$7,670	
SUBTOTAL				$84,369	
CONTINGENCY	30%			$25,311	
SUBTOTAL				$109,680	
MOBILIZATION	10%			$10,968	
TOTAL (ROUNDED)				$121,000	

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ALTERNATIVE #3:
ECOLOGY BLOCK WALL

DESCRIPTION	UNIT	QTY.	UNIT PRICE	TOTAL	COMMENTS
Clear & Grub	AC	0.50	$5,000.00	$2,500	Per Previous Estimate (North Lake Tapps)
Compact Subgrade	CY	298	$20.00	$5,960	Allow for access
Select Backfill	CY	269	$16.00	$4,304	$8 for mat'l + $8 for placement
Live Stakes	EA	576	$2.00	$1,152	Per Previous Estimate (Vance)
Permanent Seeding	SY	4,983	$0.50	$2,492	Allow for access
Erosion & Sediment Control (Silt Fence)	LF	1,150	$3.00	$3,450	Per Previous Estimate (Vance)
Ecology Block	EA	192	$20.00	$3,840	Quote - $17 + $3 placement
Excavation	CY	298	$3.00	$894	Per Previous Estimate (Vance)
Waste	CY	298	$3.00	$894	Allow for 5 mile one-way, no fee
SUBTOTAL				**$25,486**	
ALLOWANCE	10%			$2,549	
SUBTOTAL				**$28,034**	
CONTINGENCY	30%			$8,410	
SUBTOTAL				**$36,444**	
MOBILIZATION	10%			$3,644	
TOTAL (ROUNDED)				**$40,000**	

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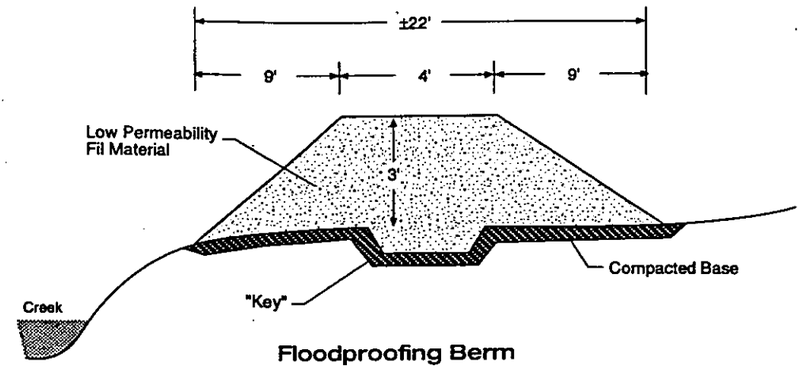
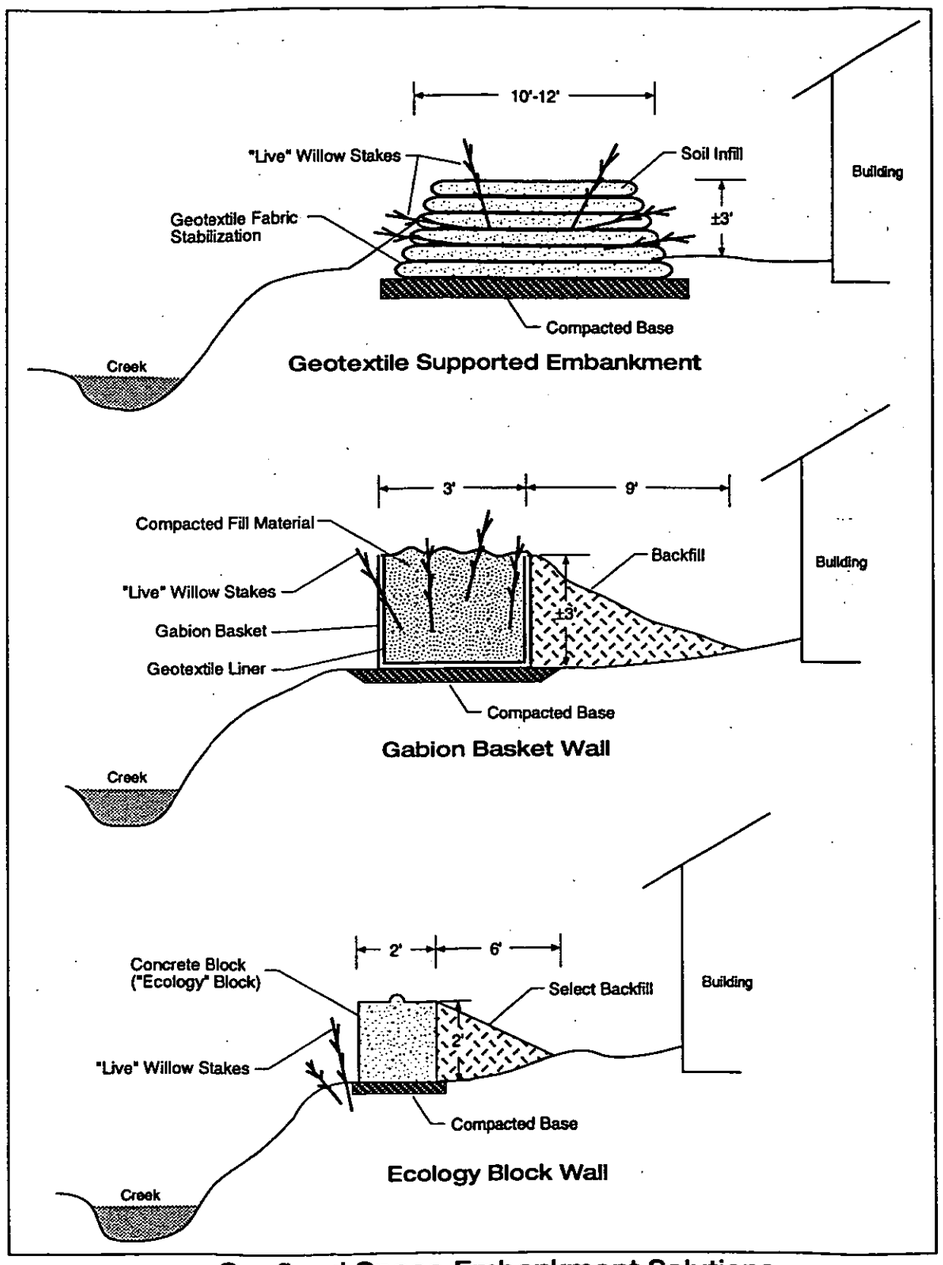
DESCRIPTION	UNIT	QTY	UNIT PRICE	TOTAL	COMMENTS
ALTERNATIVE #4: FLOOD PROOFING BERM					
Clear & Grub	AC	0.85	$5,000.00	$4,250	Per Previous Estimate (North Lake Tapps)
Low Permeability Fill	CY	1,725	$16.00	$27,600	$10 for mat'l + $6 for placement
Permanent Seeding	SY	6,644	$0.50	$3,322	Allow for access
Erosion & Sediment Control (Silt Fence)	LF	1,150	$3.00	$3,450	Per Previous Estimate (Vance)
Quarry Spalls	CY	690	$20.00	$13,800	Per Previous Estimate (Vance)
Excavation	CY	341	$3.00	$1,023	Per Previous Estimate (Vance)
Waste	CY	341	$3.00	$1,023	Allow for 5 mile one-way, no fee
SUBTOTAL				$54,468	
ALLOWANCE	10%			$5,447	
SUBTOTAL				$59,915	
CONTINGENCY	30%			$17,974	
SUBTOTAL				$77,889	
MOBILIZATION	10%			$7,789	
TOTAL (ROUNDED)				$86,000	

Appendix E

Floodproofing Options Figures



Floodproofing Berm



Confined Space Embankment Solutions

Figure 10
Floodproofing Alternatives

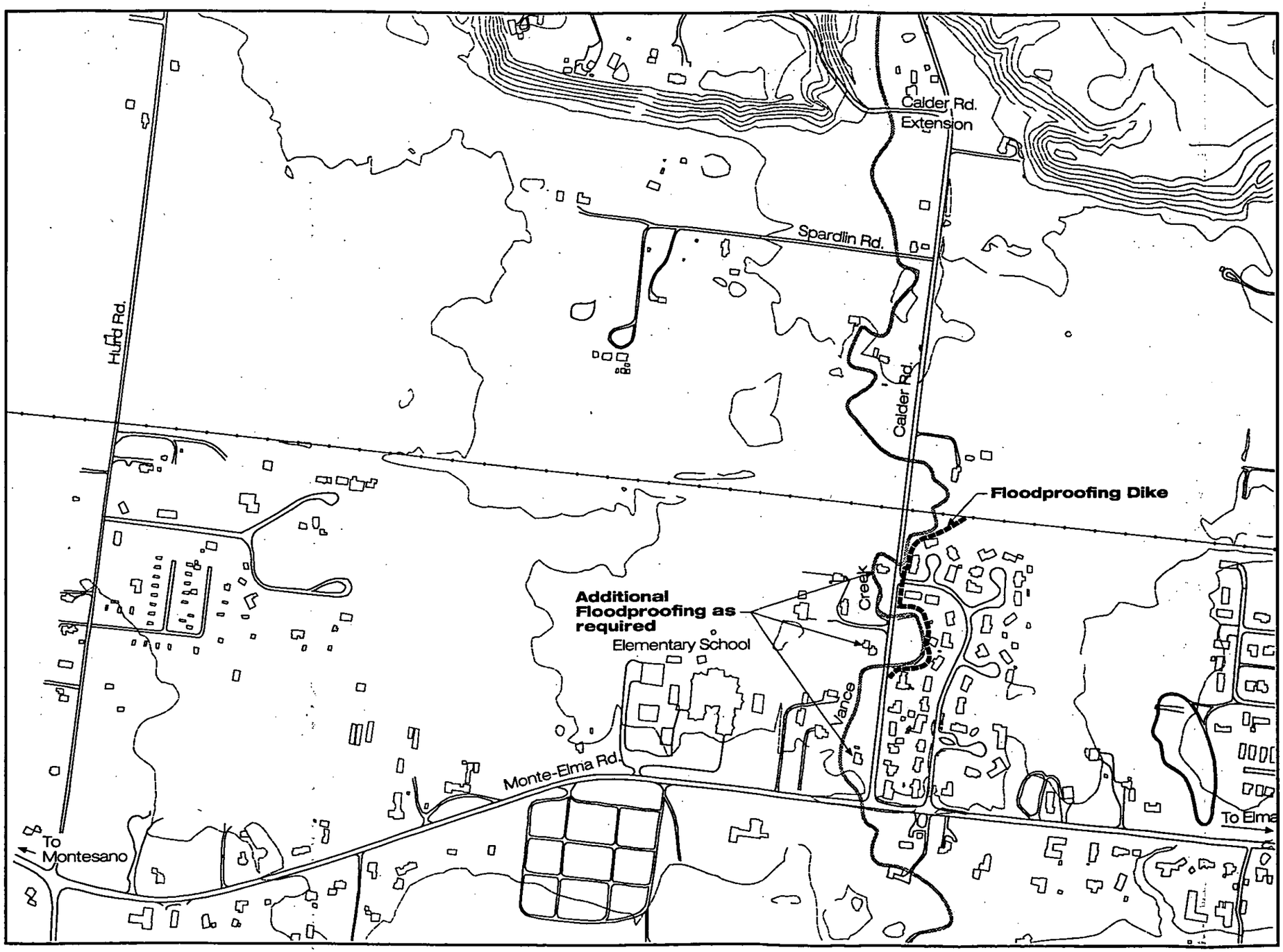


Figure 9
Alternative 6
Floodproofing