FINAL DRAINAGE REPORT

WINDSOR PARK SUBDIVISION

18 ROAD AND J.6 ROAD

FRUITA, CO

PREPARED FOR:

CASA TIARA DEVELOPMENT, INC.
P.O. Box 1083
Grand Junction, CO 81502

November 2001

JMK & Associates
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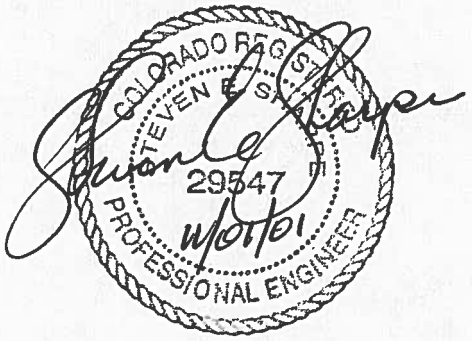
PREPARED BY:

JMK & ASSOCIATES, INC.
2764 Compass Drive, #200
Grand Junction, CO 81506

CERTIFICATION

I hereby certify that this Final Drainage Report for **Windsor Park Subdivision** was prepared by me or under my direct supervision. The report was prepared in accordance with the Stormwater Management Manual, adopted by the City of Grand Junction in May 1996.



Steven E. Sharpe
Registered Professional Engineer
State of Colorado, #29547

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FINAL DRAINAGE REPORT
WINDSOR PARK SUBDIVISION

I. GENERAL LOCATION AND DESCRIPTION

SITE LOCATION

The proposed Windsor Park Subdivision is located in the southeast corner of 18 Road (Pine) and J.6 Road (Aspen) as illustrated on the Vicinity Map included in Appendix A, which shows the project limits in relation to the area. Single-family residences exist to the north and a large parcel exists to the east, with a single-family dwelling present. This eastern parcel is currently utilized for farming operations. Grace Park lies to the south and contains 4-plex condominium units. Single-family and multiple-family housing is adjacent to this site on the west.

Surrounding zoning consists of County AFT to the north and east, County AFT and Fruita PUD to the south and Fruita Community Residential to the west. Access to the site will be provided from 18 Road (one access point) and J.6 Road (two access points). Windsor Park Drive is stubbed to the east to allow an alternate access through this site upon future development of the east adjacent property.

SITE AND MAJOR BASIN DESCRIPTION

The approximately 20-acre parcel that makes up Windsor Park Subdivision currently is covered with sparse to moderate alfalfa and weed growth, with bare ground under-story and historically was utilized for crop growth and farming operations. The parcel has not been irrigated for approximately one year, in an attempt to lower the water table elevation for anticipated construction activities. A single-family structure also currently exists on the parcel, in the southwest region, and served as the historic residence of this site. In researching the soil types at this location, reference was made to the Soil Survey of the Grand Junction Area as issued by the U.S. Department of Agriculture, Soil Conservation Service, 1955 and updated in 1997. The soil type on this parcel, as shown on the geologic map in Appendix A, was found to be Billings silty clay loam (Bc) and Ravola very fine sandy loam (Ra), as described also in Appendix A of this report. These soil types can be generally categorized as hydrologic soil type "C", having low infiltration rates when thoroughly wetted.

II. EXISTING DRAINAGE CONDITIONS

MAJOR BASIN

The existing major drainage basin is delineated by Little Salt Wash on the north and west, Adobe Creek on the east, and the Colorado River on the south. The general direction of drainage within the basin is from northeast to southwest.

In researching the floodplain hazard for the area, reference was made to the Flood Insurance Rate Map for Mesa County as produced by the Federal Emergency Management Agency (FEMA), revised July 1992. This site does not lie within the 100-year flood boundary as identified by this map. A portion of the FEMA map for this area is included in Appendix A.

SITE

Historically, and as stated on the previous page, the site was utilized for crop production and farming operations although is currently made up of bare ground and weeds. The site is comprised of two distinct, separate drainage basins. The East drain basin encompasses approximately 13.7 acres of the parcel and drains from east to west at a slope of 0.5 – 1.5%. Runoff is discharged near the southwest corner of the property at a rate of 2.2 cfs for the 2-year storm and 11.0 cfs for the 100-year storm event. There is no runoff introduced from the north due to the presence of J.6 Road, which runs the entire length of the northern boundary. An irrigation ditch runs along the entire length of the eastern boundary and prevents runoff from being introduced from the east. Existing topography and grading of the parcel prevents runoff from being introduced from the south and west.

The West drain basin encompasses approximately 6.3 acres and drains generally from north to south at a slope of 0.5 – 1.4%. Runoff is discharged from the site approximately 150' north of the southwest corner at a rate of 1.2 cfs for the 2-year storm and 5.8 cfs for the 100-year storm event. No runoff is introduced from the north due to the presence of J.6 Road. An earthen irrigation ditch runs along the entire length of the eastern boundary and prevents runoff from being introduced from the east. There is no runoff introduced from the west or south due to the natural topography of the land sloping to the west and south.

Both the East and West drainage basins discharge runoff directly into an 18" storm drain, which runs parallel with 18 Road on the west side. The site drainage basins are shown on the Historic Conditions Drainage Map included in Appendix B.

III. PROPOSED DRAINAGE CONDITIONS

CHANGES IN DRAINAGE PATTERNS

No change in drainage patterns is proposed for the lands adjacent to and surrounding Windsor Park Subdivision. A Major Basin Drainage Map is included in Appendix B that illustrates the existing drainage basin. Proposed drainage patterns within the site will be modified, as is customary, to accommodate development. A Developed Conditions Drainage Map is also included in Appendix B illustrating the grading of the site along with the time of concentration flow paths. Supporting documentation for time of concentration determinations appear in Appendix C. Upon development, stormwater runoff is proposed to essentially follow current drainage routes.

Runoff from the West basin will be conveyed in street curb and gutter sections, westward in Inverness Way to Kent Street, then south to storm inlets near the intersection of Windsor Park Drive. Drainage from this basin will be discharged directly into a storm sewer system that will transport water to the proposed 36" RCP pipe in 18 Road. The 36" RCP pipeline will be installed as part of this project. Runoff from the East basin will also be conveyed in street curb and gutter sections, westward in Windsor Park Drive to a low point prior to the intersection of Kent Street. Drainage will cross Windsor Park Drive, via an 8' wide v-pan, and be transported to the detention pond located in the southwest region of the site. Here drainage will be stored and released at approximately 75% of Historic release rates for both the 2-year and 100-year storm events. Drainage released from the detention pond will be transported in an 18" PVC pipe westward, within a 20' easement, to the east side of 18 Road and also into the proposed 36" RCP storm sewer. From here, drainage is conveyed south and ultimately transported to the Colorado River.

The historic and developed runoff rates, for the two respective drainage basins, are illustrated in tabular form in Section V of this report. Developed runoff from the West basin will be discharged at the historic release rate. Runoff from the developed East drain basin will be discharged below the historic release rate, as shown.

MAINTENANCE ISSUES

Access to the detention pond and outlet structure (Tract F) will be provided directly from the Tract H private drive. A Homeowners Association will be formed for this development and will be responsible for maintaining the drainage improvements to insure proper performance and to avoid potential impacts to neighboring areas.

IV. DESIGN CRITERIA & APPROACH

GENERAL CONSIDERATIONS

It is understood that a preliminary master plan has been completed to determine the necessity for large-scale drainage improvements required for the immediate region. The preliminary master plan study suggests that future development in this region attempt to detain and release stormwater accumulations at approximately 48% of the historic release rates. This project proposes to detain and release stormwater and drainage below the historic rates, however per design, 75% release rate was achieved.

For each surrounding development that has been approved and constructed, an individual Drainage Report has been prepared which identifies the proposed improvements for each development. These reports discuss how stormwater will be conveyed so as to prevent adverse impacts to adjoining properties. Since the location of the proposed detention basin is very near the natural collection point under existing conditions, adjacent lands should be unaffected by drainage improvements to this site.

HYDROLOGY

Hydrology calculations were based on the 2-year and 100-year rainfall events and precipitation based on the Intensity-Duration-Frequency (IDF), Table A-1a, as obtained from the City of Grand Junction Stormwater Management Manual, May 1996 and adopted by Mesa County. Runoff calculations were performed using the Rational Method, on Eagle Point software, for historic and developed flow release rates and Modified Rational Method, also on Eagle Point software, for detention pond sizing.

Parameter selection and design procedures were based on using a composite Coefficient, the largest time of concentration (T_c) obtained for each of the drainage basins, and the respective basin areas obtained by use of a computer.

HYDRAULICS

Hydraulic calculations were accomplished by utilizing Eagle Point computer software, Haestad Methods hydrology software, and Manning's equation. Parameter selection was determined by the various surfaces utilized, and the corresponding coefficients from the City of Grand Junction and Mesa County Stormwater Management Manual, May 1996.

V. RESULTS AND CONCLUSIONS

RUNOFF RATES

Historic & developed runoff rates for Windsor Park Subdivision are tabulated below:

	STORM EVENT			
BASIN	2-yr (H)	2-yr (D)	100-yr (H)	100-yr (D)
Historic				
West	1.2 cfs	NA	5.8 cfs x.48 = 2.784	NA
East	2.2 cfs	NA	11.0 cfs x.48 = 5.28	NA
Developed				
West	NA	1.4 cfs	NA	5.9 cfs
East	NA	1.8 cfs	NA	7.7 cfs

Calculations to support the above release rates are included in Appendix C.

CONCLUSIONS

In developing this area into Windsor Park Subdivision, it is nearly impossible not to increase the amount of runoff. However, with proper design and construction of the proposed drainage system little, if any, impacts to the Murray Drainage system are anticipated. The general concept of the drainage plan is to follow historic patterns of flow toward the west and southwest regions of the site. In the southwest location, the proposed detention pond outlet structure will control and convey stormwater releases below the historic rate. As mentioned earlier, the conveyance and release of stormwater from the west drain basin will be at, or very near, historic rates.

The designed amount of over-detention of stormwater accumulations proposed within Windsor Park Subdivision will certainly help minimize the impact on the proposed downstream storm sewer conveyance system (Murray Drain).

This Drainage Report has been prepared to address site-specific drainage concerns in accordance with the requirements of the City of Fruita. The appendices of this report include criteria, exhibits and calculations used in the design and analysis of this project. Finish floor elevations for housing structures in the detention pond vicinity and throughout the subdivision will be set at least one foot higher than the 100-year flood elevation, to comply with City of Fruita standards.

VI. REFERENCES

1. Stormwater Management Manual, City of Grand Junction and County of Mesa, Colorado, Adopted May 1996.

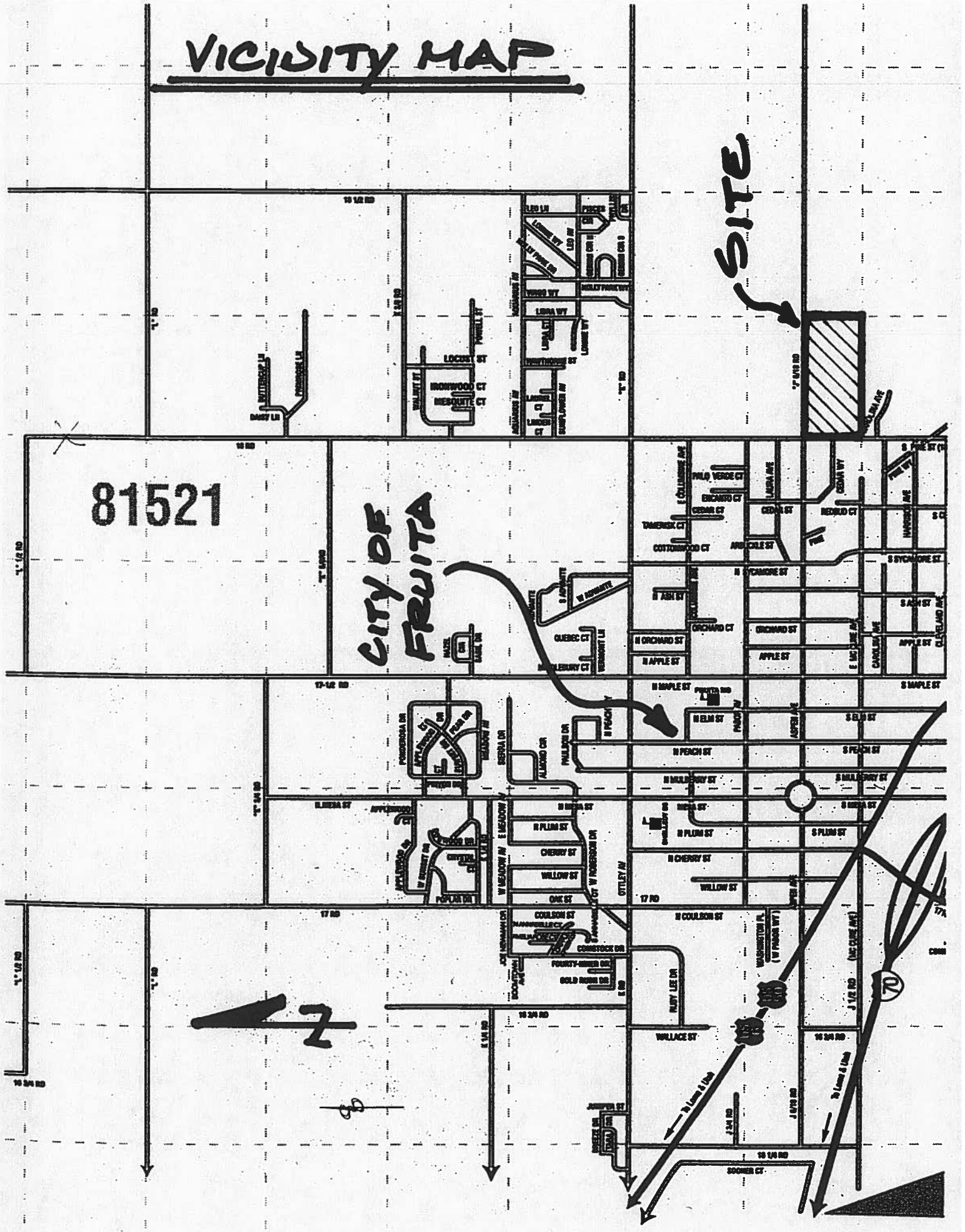
2. Flood Insurance Rate Map, National Flood Insurance Program, Federal Emergency Management Agency, Mesa County, Revised July 1992.

3. Soil Survey, Grand Junction Area, Colorado, U.S. Department of Agriculture, Soil Conservation Service, 1955 and updated in 1997.

4. Eagle Point Civil/Survey 2001, Civil Engineering Software, Eagle Point, Dubuque, Iowa.

5. Flowmaster Professional Edition, Version 5.13, Haestad Methods Hydrology Software, Haestad Methods, Waterbury, CT.

APPENDIX A


VICINITY MAP
SITE
81521
CITY OF FRUITA


SOILS
CLASSIFICATION
SITE
EVERGREEN CEMETERY
Little
MAIN
Fruita
PREC.
SOUTH FRUITA
COLORADO
RIVER
DENVER
INDEPENDENT

The C and Cy horizons have hues of 10YR to 5Y, value of 5 to 7 dry, and 4 to 6 moist, and chromas of 2 to 4. Textures are silty clay loam, silt loam, clay loam, and very fine sandy loam. Gypsum is in crystals and nodules that amount to 0.5 to 10 percent of the horizon by volume.

COMPETING SERIES: These are Fivemile (WY), Ravola, Slaw (NV), and Tours (AZ). Fivemile soils have hues of 10YR or redder, are highly stratified and do not contain gypsum crystals. Ravola soils contain 18 to 27 percent clay in the particle-size control section. Slaw soils have a mean annual soil temperature of 53 to 57 degrees F., lack gypsum accumulations, and have a calcium carbonate equivalent of less than 5 percent. Tours soils have 5YR or redder hue and have visible carbonates at depths of 10 inches.

GEOGRAPHIC SETTING: These soils are on valley floors, flood plains and a few narrow alluvial fans. Parent material is alluvium from alkaline marine shales and mixed sedimentary rocks containing gypsum. Slopes range from 0 to 10 percent. The climate is semiarid. Elevation ranges from 4000 to 6500 feet. Mean annual air temperature is 46 to 54 degrees F. and the freeze-free period ranges from 110 to 160 days. Mean annual precipitation ranges from 5 to 11 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Cache, Killpack, Libbings, Mayfield, Salt Lake, Skumpah and the competing Ravola series. Cache and Libbings soils have more than 2 percent salt in the layers above 20 inches. Killpack soils are 20 to 40 inches deep over shale. Mayfield soils have more than 40 percent carbonates in the particle-size control section. Salt Lake soils have fine particle-size control sections and aquic moisture regimes. Skumpah soils have a natric horizon.

DRAINAGE AND PERMEABILITY: Well and moderately well drained; Runoff is medium to rapid; permeability is moderately slow to slow.

USE AND VEGETATION: Where irrigated and not too saline, alfalfa, small grains, sugar beets, and beans are grown. Potential vegetation is mainly shadscale, Indian ricegrass, galleta, and greasewood.

DISTRIBUTION AND EXTENT: The semiarid and arid parts of Montana, Wyoming, Colorado, and Utah. MLRA 34,35,28A. The series is extensive.

MLRA OFFICE RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Billings Area, Montana, 1902.

REMARKS: The pH values given are of soil paste.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface of the soil to 11 inches (Ap1, Ap2 horizons)

Gypsum feature - the zone of gypsum accumulation from 42 to 60 inches (Cy horizon)

Particle-size control section - the zone from 10 to 40 inches.

National Cooperative Soil Survey
U.S.A.

LOCATION RAVOLA UT+NM

Established Series
Rev. RLM/DKR/SSP
4/98

RAVOLA SERIES

The Ravola series consists of very deep, well drained soils that formed in alluvium derived from shale, siltstone, and sandstone. Ravola soils are on alluvial fans and flood plains. Slopes range from 0 to 10 percent. Mean annual precipitation is about 7 inches and the mean annual temperature is about 50 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, active, calcareous, mesic Typic Torrifluvents

TYPICAL PEDON: Ravola loam under cultivation. (Colors are for dry soil unless otherwise noted.)

Ap1--0 to 6 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure parting to weak fine subangular blocky; slightly hard, friable, slightly plastic; many fine roots, few coarse roots; common fine and medium pores; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary. (2 to 6 inches thick)

Ap2--6 to 9 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; strongly compacted plowpan layer; weak coarse subangular blocky structure parting to weak coarse granular; hard, friable, slightly sticky and slightly plastic; many fine roots; common fine pores; few medium pores; strongly effervescent; slightly alkaline (pH 7.7); clear smooth boundary. (0 to 3 inches thick).

C1--9 to 18 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak thin platy structure parting to weak very thin platy; hard, friable, slightly sticky and slightly plastic; few coarse and many fine roots; many medium and common fine pores, strongly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (9 to 24 inches thick)

C2--18 to 45 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; few medium and many fine roots; common medium pores; strongly effervescent; slightly alkaline (pH 7.9); gradual irregular boundary. (6 to 30 inches thick)

C3--45 to 60 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; massive; soft, very friable; few fine roots; few fine pores; strongly effervescent; moderately alkaline (pH 7.9).

TYPE LOCATION: Emery County, Utah; about 1 1/2 miles south and 1/2 mile east of Huntington; located about 2,000 feet west and 600 feet north of the southeast corner of sec. 31, T. 17 S., R. 9 E.

RANGE IN CHARACTERISTICS:

Mean annual soil temperature: 49 to 56 degrees F

Particle-size control section: 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand

A horizon:

Hue: 10YR to 5Y

Value: 5 to 7 dry, 4 or 5 moist

Chroma: 2 or 4 dry or moist

Texture: loam or clay loam

Calcium carbonate equivalent: 5 to 25 percent

Reaction: slightly to strongly alkaline

C horizon:

Hue: 10YR to 5Y

Value: 5 to 7 dry, 4 or 5 moist

Chroma: 2 to 4 dry or moist

Texture: stratified loamy sand to clay loam

Calcium carbonate equivalent: 5 to 25 percent

Reaction: slightly to strongly alkaline

COMPETING SERIES: The Slaw series is the only current competitor. Previous competitors prior to the Seventh Edition of the Keys to Soil Taxonomy are the Billings, Fivemile, Slawha, and Tours series.

Slaw and Slawha soils have a xeric moisture pattern.

Billings soils have particle-size control sections with 27 to 35 percent clay, and gypsum nodules below the series control section.

Fivemile soils have moderately slow permeability.

Tours soils hue of 5YR or redder.

GEOGRAPHIC SETTING:

Parent material: alluvium derived from shale, siltstone, and sandstone

Landform: alluvial fans and flood plains

Slopes: 0 to 10 percent

Elevation: 4,500 to 6,000 feet

Mean annual temperature: 47 to 56 degrees F

Mean annual precipitation: 5 to 11 inches

Frost-free period: 110 to 160 days

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Billings soils and the Hunting, Killpack, Mayfield, Saltair, and Skumpah soils. Hunting soils have mottles and a water table at depths between 20 and 40 inches. Killpack soils have a paralithic contact between 20 and 40 inches. Mayfield soils have carbonatic mineralogy. Saltair soils contain calcic horizons. Skumpah soils have a natric horizon.

DRAINAGE AND PERMEABILITY: well drained, negligible to medium runoff, moderate permeability. These soils are subject to occasional brief flooding following high intensity summer thunderstorms.

USE AND VEGETATION: Irrigated areas are used for growing small grains, corn, sugar beets, alfalfa, and pasture. Potential vegetation is shadscale, greasewood, Indian ricegrass, and galleta.

DISTRIBUTION AND EXTENT: Eastern Utah, northwest New Mexico and western Colorado. LRR D, MLRA 28A, 34, 35, 37. This series is of large extent.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado

SERIES ESTABLISHED: Emery and Grand Counties, Utah. 1940. Green River Soil Conservation District.

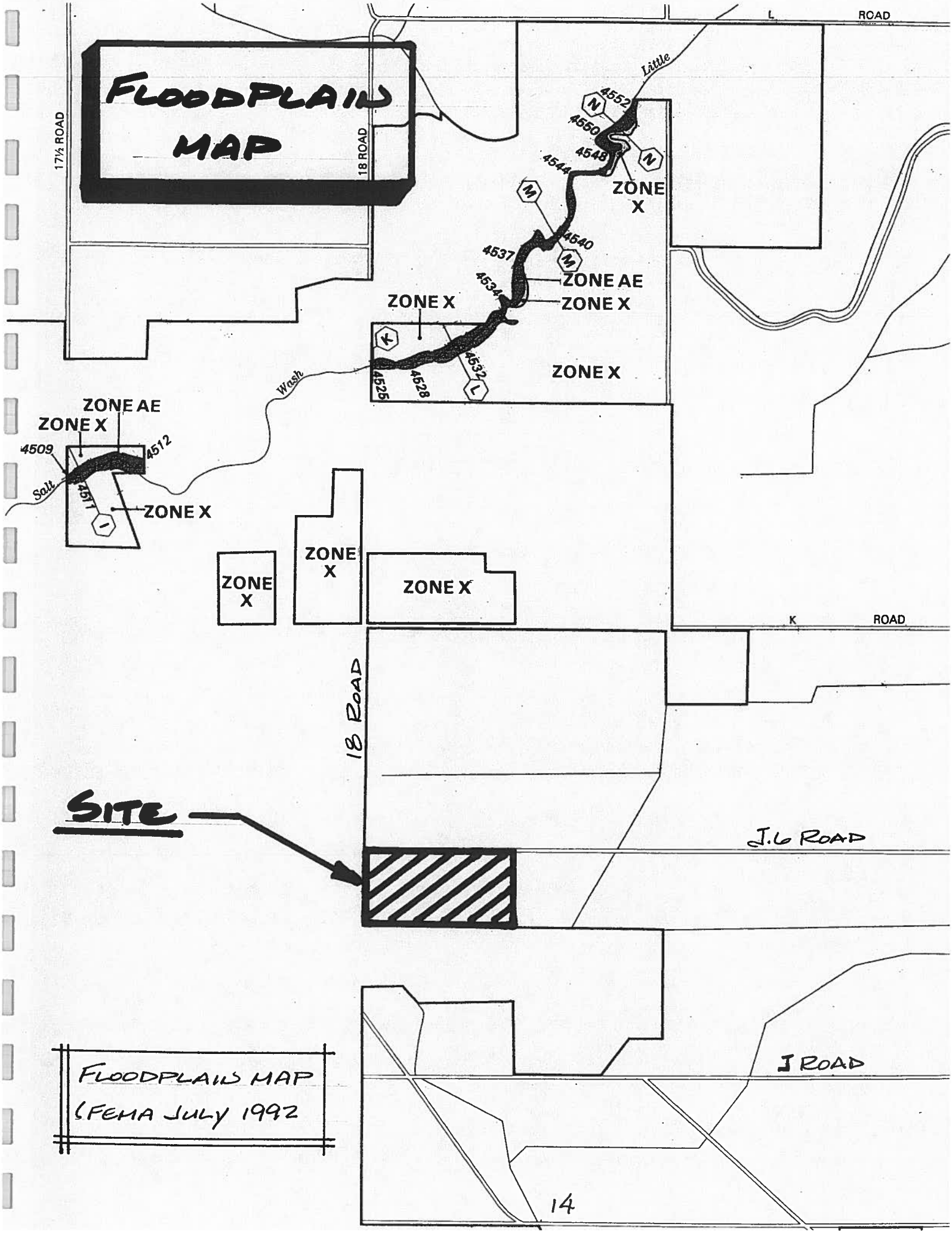
REMARKS: Diagnostic horizons and features recognized in this pedon are:

ochric epipedon: The zone from 0 to 9 inches. (Ap1 and Ap2)

Taxonomy version, 7th Edition 1996

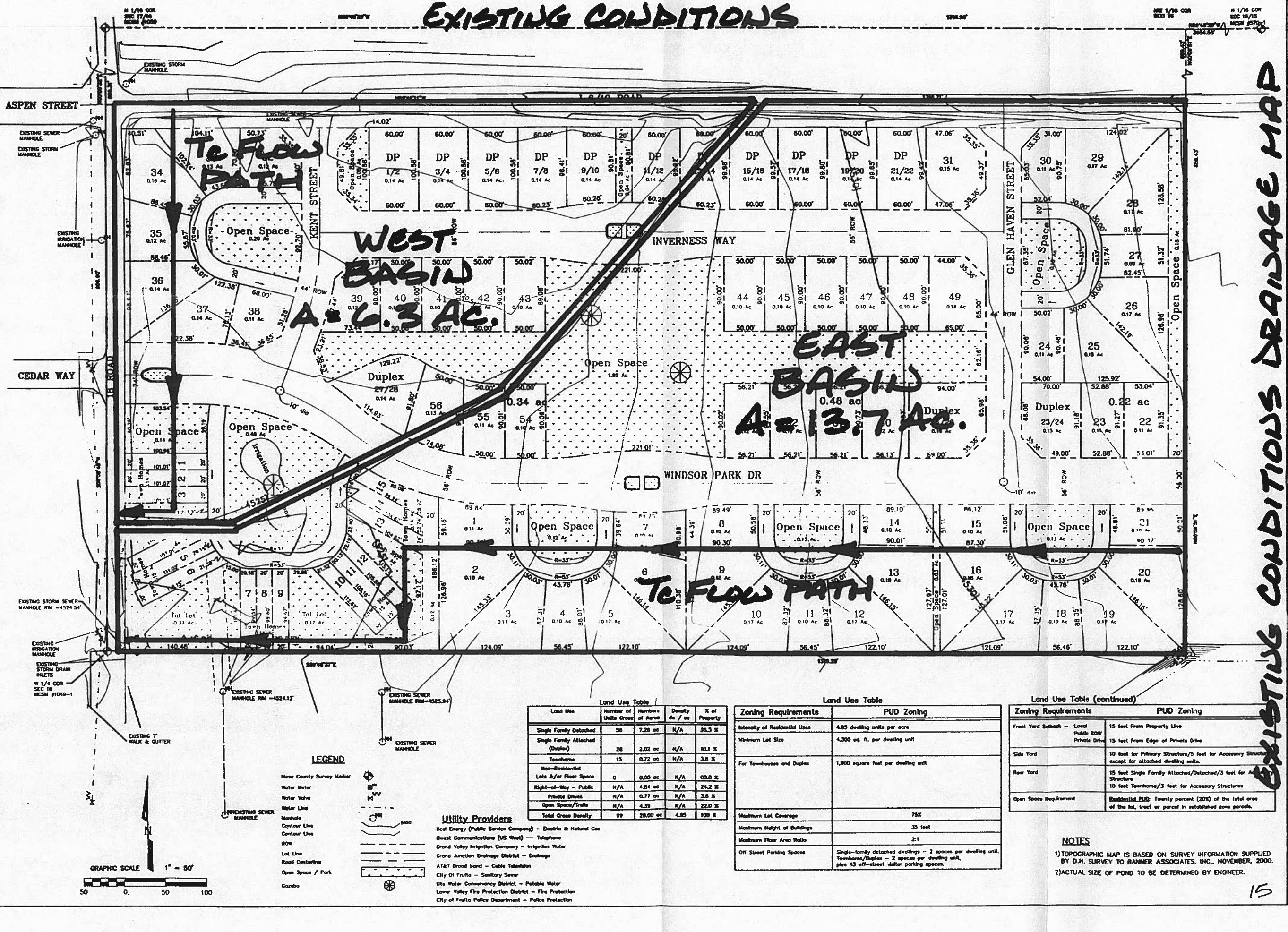
ADDITIONAL DATA: Lab sampled by NSSL in New Mexico. Pedon number S86NM-045-014.

National Cooperative Soil Survey
U.S.A.


FLOODPLAIN MAP
17½ ROAD
18 ROAD
L ROAD
K ROAD
J.6 ROAD
J ROAD
Little
Wash
Salt
4552
4550
4548
4544
4540
4537
4534
4532
4528
4525
4512
4509
4511
ZONE X
ZONE AE
ZONE X
ZONE X
ZONE X
ZONE X
ZONE X
ZONE X
ZONE X
ZONE AE
ZONE X
SITE
18 ROAD
FLOODPLAIN MAP
(FEMA JULY 1992

APPENDIX B

EXISTING CONDITIONS



LEGEND

- Mesa County Survey Marker
- Water Meter
- Water Valve
- Water Line
- Manhole
- Contour Line
- Contour Line
- ROW
- Lot Line
- Road Centerline
- Open Space / Park
- Gazebo

Utility Providers

Xcel Energy (Public Service Company) – Electric & Natural Gas
Qwest Communications (US West) — Telephone
Grand Valley Irrigation Company – Irrigation Water
Grand Junction Drainage District – Drainage
AT&T Broad band – Cable Television
City Of Fruita – Sanitary Sewer
Ute Water Conservancy District – Potable Water
Lower Valley Fire Protection District – Fire Protection
City of Fruita Police Department – Police Protection

Land Use Table

Land Use	Number of Units Gross	Numbers of Acres	Density du / ac	% of Property
Single Family Detached	56	7.26 ac	N/A	36.3 %
Single Family Attached (Duplex)	28	2.02 ac	N/A	10.1 %
Townhome	15	0.72 ac	N/A	3.6 %
Non-Residential Lots &/or Floor Space	0	0.00 ac	N/A	00.0 %
Right-of-Way – Public	N/A	4.84 ac	N/A	24.2 %
Private Drives	N/A	0.77 ac	N/A	3.8 %
Open Space/Trails	N/A	4.39	N/A	22.0 %
Total Gross Density	99	20.00 ac	4.95	100 %

Land Use Table

Zoning Requirements	PUD Zoning
Intensity of Residential Uses	4.95 dwelling units per acre
Minimum Lot Size	4,300 sq. ft. per dwelling unit
For Townhouses and Duplex	1,900 square feet per dwelling unit
Maximum Lot Coverage	75%
Maximum Height of Buildings	35 feet
Maximum Floor Area Ratio	2:1
Off Street Parking Spaces	Single-family detached dwellings – 2 spaces per dwelling unit. Townhome/Duplex – 2 spaces per dwelling unit, plus 43 off-street visitor parking spaces.

Land Use Table (continued)

Zoning Requirements		PUD Zoning
Front Yard Setback –	Local	15 feet From Property Line
	Public ROW	15 feet From Edge of Private Drive
	Private Drive	
Side Yard		10 foot for Primary Structure/5 feet for Accessory Structure except for attached dwelling units.
Rear Yard		15 feet Single Family Attached/Detached/3 feet for Accessory Structure 10 feet Townhome/3 feet for Accessory Structures
Open Space Requirement		Residential PUD: Twenty percent (20%) of the total area of the lot, tract or parcel in established zone parcels.

NOTES

1) TOPOGRAPHIC MAP IS BASED ON SURVEY INFORMATION SUPPLIED BY D.H. SURVEY TO BANNER ASSOCIATES, INC., NOVEMBER, 2000.
2) ACTUAL SIZE OF POND TO BE DETERMINED BY ENGINEER.

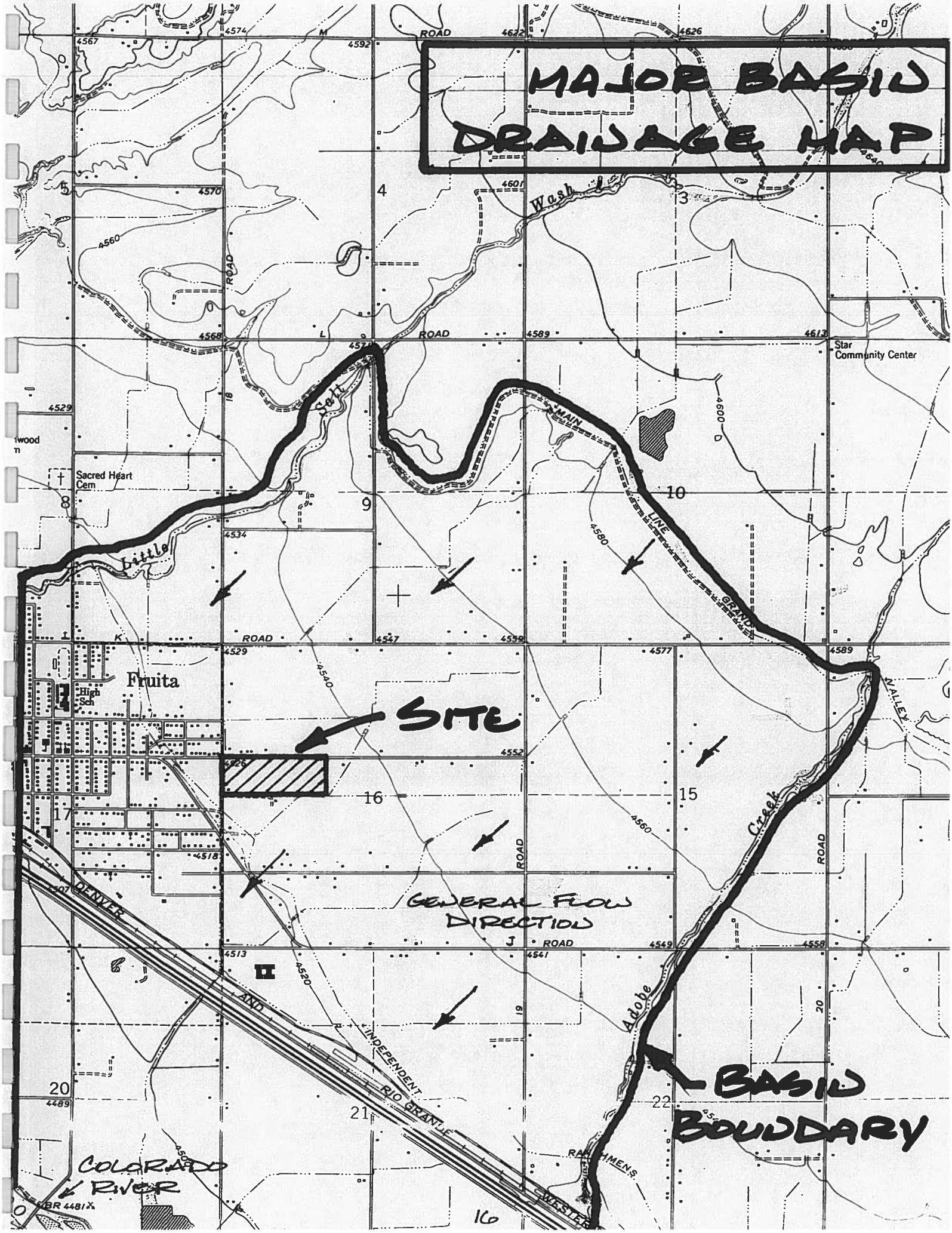
15

EXISTING CONDITIONS DRAINAGE MAP

DEVELOPMENT CONCEPTS, INC.
Planning and Development Services
2764 Compass Drive, Suite 217-1
Grand Junction, CO 81506
Phone (970) 255-1131 Fax (970) 255-1159
E-mail Address - yobubba@gjct.net

WINDSOR PARK
SKETCH PLAN - EXHIBIT 6
FOR: CASA TIARA DEVELOPMENT, INC.
FRUITA, COLORADO

Revision:	1
Scale 1" = 50'	
Date:	04-12-01
Drawn By:	HR
Checked By :	MJ
Designed By:	MJ


MAJOR BASIN DRAINAGE MAP
Wash
Little
Star Community Center
Sacred Heart Cem
Fruita
High Sch
SITE
GENERAL FLOW DIRECTION
Adobe Creek
BASIN BOUNDARY
COLORADO RIVER
DENVER
RIO GRANDE
WESTER
MAIN LINE
GRAND VALLEY
ROAD
4574
4567
4592
4622
4626
4570
4560
4568
4589
4613
4529
4534
4547
4539
4577
4589
4540
4552
4526
4518
4560
4549
4558
4513
4541
4520
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4600
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17
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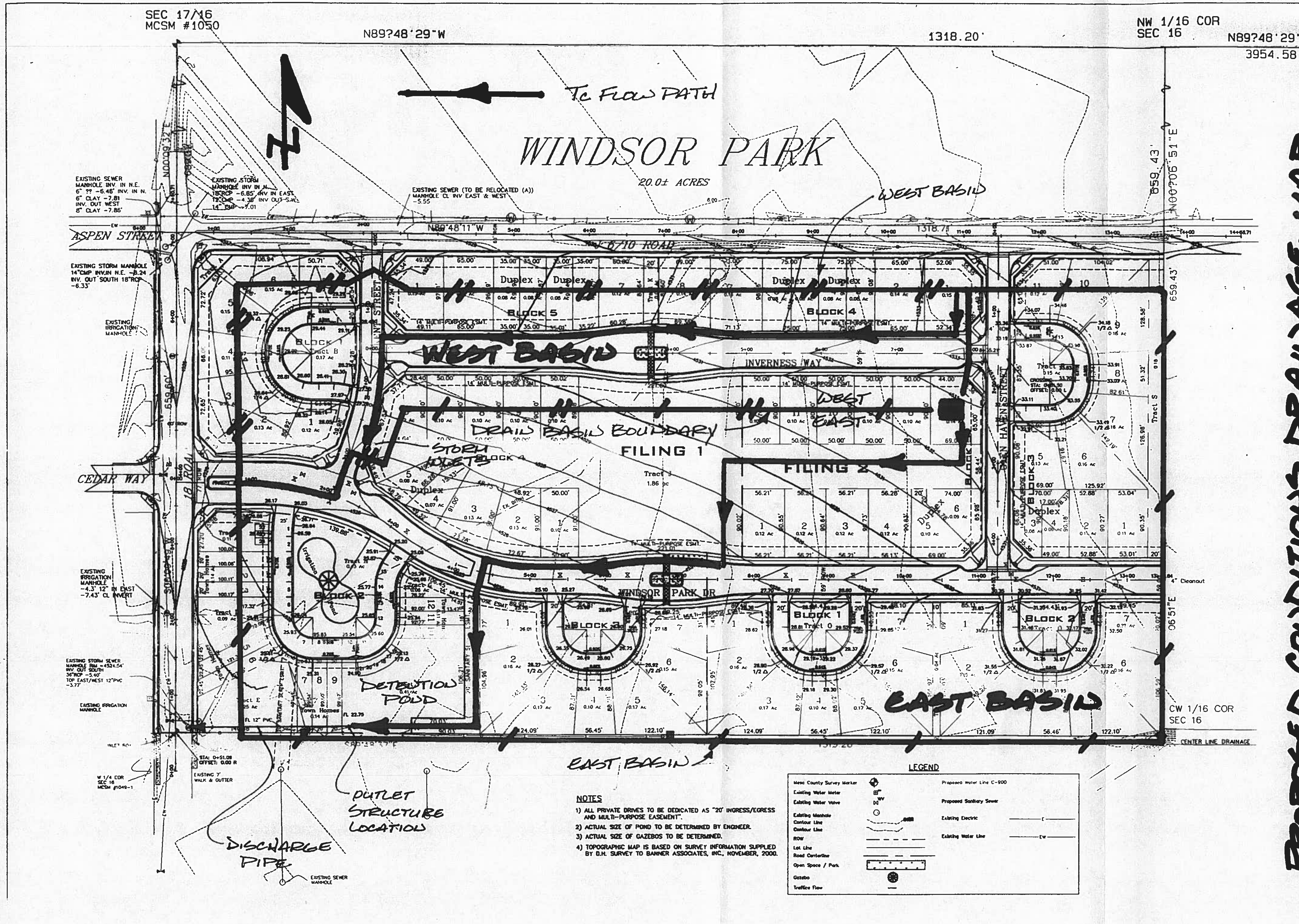

GRADEING AND DRAINAGE PLAN
WINDSOR PARK SUBDIVISION
FRUITA, COLORADO

CASA TIARA DEVELOPMENT, INC.
P. O. BOX 1083
FRUITA, COLORADO
(970) 257-9483

JMK & Associates, Inc.

Date 10/05/01
Scale 1"=50'
Drawn JB
Sheet 17

APPENDIX C

STORM RUNOFF CALCULATIONS

WINDSOR PARK SUBDIVISION

HISTORIC CONDITIONS (WEST BASIN)

Total drain Basin area, A_T = 6.30 acres

Soil types: (B_C) Billings silty clay loam; and (R_A) Ravola very fine sandy loam

Hydrologic soil type "C", predominate land slope 0 - 2%

Basin Description	A_T = 6.30 Ac.	C_2	C_{100}
Bare ground/Agriculture	6.30	0.22	0.28

* See Table "B-1", SWMM on sheet following T_c determination for values used above.

Composite "C" determination:

Cc_2 = 6.30 (0.22) / 6.30 = **0.22**

Cc_{100} = 6.30 (0.28) / 6.30 = **0.28**

INTENSITY: Table "A-1a" (SWMM) @ T_c = 13 min., I_2 = 0.83 in./hr., I_{100} = 3.30 in./hr.

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: Q = CiA

Q_2 = 0.22(0.83)(6.30) = 1.2 cfs **Q_{100} = 0.28(3.30)(6.30) = 5.8 cfs**

for 48% Q_{100} = .48 (5.8) = 2.784 equivalent $C = \frac{2.784}{(3.30)(6.30)} = .134$

Reference: Stormwater Management Manual (SWMM) Adopted May 1996 by the City of Grand Junction and Mesa County.

STORM RUNOFF CALCULATIONS (Cont.)

WINDSOR PARK SUBDIVISION

HISTORIC CONDITIONS (WEST BASIN)

TIME OF CONCENTRATION DETERMINATION:

Sheet flow:

C = 0.95, L = 11 ft., S = 2.0%, flow across half of J.6 Road
Fig. E-2 (SWMM), $T_o = 1.8\,(1.1 - 0.95)(11)^{0.5} / (2.0)^{0.33}$ T = 0.7 min.

Sheet flow:

C = 0.76, L = 3 ft., S = 2.0%, flow across gravel shoulder
Fig. E-2 (SWMM), $T_o = 1.8\,(1.1 - 0.76)(3)^{0.5} / (2.0)^{0.33}$ T = 0.8 min.

Overland flow:

C = 0.28, L = 10 ft., S = 30.0%, flow from shoulder to furrows
Fig. E-2 (SWMM), $T_o = 1.8\,(1.1 - 0.28)(10)^{0.5} / (30.0)^{0.33}$ T = 1.5 min.

Channel flow:

Flow in parabolic field channel: width = 0.5 ft., depth = 0.15 ft.
Flow area = 0.05 s.f., wet perimeter = 0.62 ft., $r_H = 0.05/0.62 = 0.081$ ft.
Manning's n = 0.022 (earth channel), s = 0.0045, L = 480 ft.

$$V = \frac{1.49}{n}(r_H)^{0.67}(s)^{0.5} = \frac{1.49}{0.022}(0.081)^{0.67}(0.0045)^{0.5} = 0.85 \text{ fps}$$

T = L/V = 480 ft./0.85 fps = 565 sec. T = 9.4 min.

Channel flow:

Flow in 12" CMP culvert under 18 Road flowing full:
L = 40 ft., s = 1.0%, Q = 1.93 cfs, V = 2.46 fps

T = L/V = 40 ft./2.46 fps = 16 sec. T = 0.3 min.

Total T_c = 12.7 min.

STORM RUNOFF CALCULATIONS

WINDSOR PARK SUBDIVISION

HISTORIC CONDITIONS (EAST BASIN)

Total drain Basin area, A_T = 13.7 acres

Soil types: (B_C) Billings silty clay loam; and (R_A) Ravola very fine sandy loam

Hydrologic soil type "C", predominate land slope 0 - 2%

Basin Description	A_T = 13.70 Ac.	C_2	C_{100}
Buildings/concrete	0.04	0.93	0.95
Gravel areas	0.26	0.68	0.76
Bare ground/Agriculture	13.40	0.22	0.28

* See Table "B-1", SWMM on sheet following T_c determination for values used above.

Composite "C" determination:

Cc_2 = 0.04 (0.93) + 0.26 (0.68) + 13.40 (0.22) / 13.70 = **0.23**

Cc_{100} = 0.04 (0.95) + 0.26 (0.76) + 13.40 (0.28) / 13.70 = **0.29**

INTENSITY: Table "A-1a" (SWMM) @ T_c = 19 min., I_2 = 0.70 in./hr., I_{100} = 2.77 in./hr.

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: Q = CiA

Q_2 = 0.23(0.70)(13.70) = 2.2 cfs **Q_{100} = 0.29(2.77)(13.70) = 11.0 cfs**

Reference: Stormwater Management Manual (SWMM) Adopted May 1996
by the City of Grand Junction and Mesa County.

STORM RUNOFF CALCULATIONS (Cont.)

WINDSOR PARK SUBDIVISION

HISTORIC CONDITIONS (EAST BASIN)

TIME OF CONCENTRATION DETERMINATION:

Overland flow:

C = 0.76, L = 10 ft., S = 2.1%, east side gravel access road
Fig. E-2 (SWMM), $T_o = 1.8\,(1.1 - 0.76)(10)^{0.5} / (2.1)^{0.33}$ T = 1.5 min.

Channel flow:

Flow in parabolic field channel: width = 0.5 ft., depth = 0.15 ft.
Flow area = 0.05 s.f., wet perimeter = 0.62 ft., $r_H = 0.05/0.62 = 0.081$ ft.
Manning's n = 0.022 (open channel), s = 0.0071, L = 985 ft.

$$V = \frac{1.49}{n}(r_H)^{0.67}(s)^{0.5} = \frac{1.49}{0.022}(0.081)^{0.67}(0.0071)^{0.5} = 1.07 \text{fps}$$

T = L/V = 985 ft./1.07 fps = 921 sec. T = 15.4 min.

Channel flow:

Flow in parabolic irrigation waste ditch: width = 2.0 ft., depth = 1.0 ft.
Flow area = 1.33 s.f., wet perimeter = 3.33 ft., $r_H = 1.33/3.33 = 0.40$ ft.
Manning's n = 0.022 (open channel), s = 0.0049, L = 250 ft.

$$V = \frac{1.49}{n}(r_H)^{0.67}(s)^{0.5} = \frac{1.49}{0.022}(0.40)^{0.67}(0.0049)^{0.5} = 2.57 \text{ fps}$$

T = L/V = 250 ft./2.57 fps = 97 sec. T = 1.6 min.

Channel flow:

Flow in 12" PVC culvert under 18 Road flowing full:
L = 150 ft., s = 2.2%, Q = 7.6 cfs, V = 9.7 fps

T = L/V = 150 ft./9.7 fps = 16 sec. T = 0.3 min.

Total T_c = 18.8 min.

STORM RUNOFF CALCULATIONS

WINDSOR PARK SUBDIVISION

DEVELOPED CONDITIONS (WEST BASIN)

Total drain Basin area, $A_T = 3.90$ acres

Soil types: (B_C) Billings silty clay loam; and (R_A) Ravola very fine sandy loam

Hydrologic soil type "C", predominate land slope 0 - 2%

Basin Description	$A_T = 3.90$ Ac.	C_2	C_{100}
Buildings, concrete	0.40	0.93	0.95
Streets, sidewalks	1.35	0.93	0.95
Landscape areas	2.15	0.24	0.30

Composite "C" determination:

$Cc_2 = (0.40 + 1.35)(0.93) + 2.15\ (0.24) / 3.90 =$ **0.55**

$Cc_{100} = (0.40 + 1.35)(0.95) + 2.15\ (0.30) / 3.90 =$ **0.59**

INTENSITY: Table "A-1a" (SWMM) @ $T_c = 22$ min., $I_2 = 0.65$ in./hr., $I_{100} = 2.57$ in./hr.

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: $Q = CiA$

$Q_2 = 0.55(0.65)(3.90) = 1.4$ cfs **$Q_{100} = 0.59(2.57)(3.90) = 5.9$ cfs**

Reference: Stormwater Management Manual (SWMM) Adopted May 1996 by the City of Grand Junction and Mesa County.

STORM RUNOFF CALCULATIONS (Cont.)

WINDSOR PARK SUBDIVISION

DEVELOPED CONDITIONS (WEST BASIN)

TIME OF CONCENTRATION DETERMINATION:

Sheet flow:

C = 0.95, L = 14.0 ft., S = 25.0%, sheet flow from roof
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.95)(14.0)^{0.5} / (25.0)^{0.33}$ T = 0.3 min.

Overland flow:

C = 0.30, L = 36 ft., S = 2.0%, lawn drainage to sidewalk
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.30)(36)^{0.5} / (2.0)^{0.33}$ T = 6.9 min.

Overland flow:

C = 0.95, L = 4 ft., S = 2.0%, sheet flow over sidewalk
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.95)(4)^{0.5} / (2.0)^{0.33}$ T = 0.4 min.

Overland flow:

C = 0.30, L = 5 ft., S = 2.0%, sheet flow to back of curb
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.30)(5)^{0.5} / (2.0)^{0.33}$ T = 2.6 min.

Concentrated flow:

L = 772 ft., S = 0.56%, Flow in Inverness Way gutter
From Figure "E-3" SWMM (paved area), V = 1.5 fps
T = L/V = 772 ft./1.5 fps = 515 sec. T = 8.6 min.

Concentrated flow:

L = 180 ft., S = 1.04%, Flow in Kent Street gutter
From Figure "E-3" SWMM (paved area), V = 2.0 fps
T = L/V = 180 ft./2.0 fps = 90 sec. T = 1.5 min.

Channel flow:

Flow in 18" ADS storm pipe in Windsor Park Drive discharging into Pine Street storm sewer improvement (36" RCP), full flow
L = 250 ft., s = 0.5%, Q = 8.1 cfs, n = 0.012, V = 4.5 fps
T = L/V = 250 ft./4.5 fps = 56 sec. T = 0.9 min.

Total T_c = 21.2 min.

STORM RUNOFF CALCULATIONS

WINDSOR PARK SUBDIVISION

DEVELOPED CONDITIONS (EAST BASIN)

Total drain Basin area, A_T = 14.40 acres

Upon development of Windsor Park Subdivision, an irrigation pond will be constructed in the southwest region (developed east basin) that will encompass 0.36 acres. Rainfall and drainage within this area will be contained and the pond will act as a stormwater retention basin, therefore this area is subtracted from the total (14.76 – 0.36 = 14.40 acres).

Soil types: (B_C) Billings silty clay loam; and (R_A) Ravola very fine sandy loam

Hydrologic soil type "C", predominate land slope 0 - 2%

Basin Description	A_T = 14.40 Ac.	C_2	C_{100}
Buildings, concrete	1.85	0.93	0.95
Streets, sidewalks	3.45	0.93	0.95
Landscape areas	9.10	0.24	0.30

Composite "C" determination:

Cc_2 = (1.85 + 3.45)(0.93) + 9.10 (0.24) / 14.40 = **0.49**

Cc_{100} = (1.85 + 3.45)(0.95) + 9.10 (0.30) / 14.40 = **0.54**

INTENSITY: Table "A-1a" (SWMM) @ T_c = 31 min., I_2 = 0.53 in./hr., I_{100} = 2.11 in./hr.

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: Q = CiA

Q_2 = 0.49(0.53)(14.40) = 3.7 cfs **Q_{100} = 0.54(2.11)(14.40) = 16.4 cfs**

Reference: Stormwater Management Manual (SWMM) Adopted May 1996 by the City of Grand Junction and Mesa County.

STORM RUNOFF CALCULATIONS (Cont.)

WINDSOR PARK SUBDIVISION

DEVELOPED CONDITIONS (EAST BASIN)

TIME OF CONCENTRATION DETERMINATION:

Sheet flow:

C = 0.95, L = 14 ft., S = 25.0%, sheet flow from roof
Fig. E-2 (SWMM), $T_o = 1.8\,(1.1 - 0.95)(14.0)^{0.5} / (25.0)^{0.33}$ T = 0.3 min.

Overland flow:

C = 0.30, L = 70 ft., S = 1.9%, lawn drainage south to open space
Fig. E-2 (SWMM), $T_o = 1.8\,(1.1 - 0.30)(70)^{0.5} / (1.9)^{0.33}$ T = 9.7 min.

Shallow concentrated flow:

L = 470 ft., S = 0.5%, Flow in grassed open space
From Figure "E-3" SWMM, V = 0.5 fps

T = L/V = 470 ft./0.5 fps = 940 sec. T = 15.7 min.

Concentrated flow:

L = 300 ft., S = 0.85%, Flow in Windsor Park Drive gutter
From Figure "E-3" SWMM (paved area), V = 1.8 fps

T = L/V = 300 ft./1.8 fps = 167 sec. T = 2.8 min.

Concentrated flow:

L = 320 ft., Flow in 6' v-pan to detention pond, side slope = 3:1
D = 0.95 ft., S = 0.5%, Q = 13.0 cfs, V = 4.7 fps

T = L/V = 320 ft./4.7 fps = 68 sec. T = 1.1 min.

Channel flow:

Flow in 18" PVC discharge pipe from D-pond, flowing full
L = 230 ft., s = 0.5%, Q = 8.0 cfs, n = 0.012, V = 4.5 fps

T = L/V = 230 ft./4.5 fps = 51 sec. T = 0.9 min.

Total T_c = 30.5 min.

Discharge Pipe From Windsor Park Drive
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\fmw\windsor.fm2
Worksheet	Windsor Park Subdivision Drainage
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.012	
Channel Slope	0.005000	ft/ft
Depth	18.0	in
Diameter	18.00	in

Results		
Discharge	8.05	cfs
Flow Area	1.77	ft²
Wetted Perimeter	4.71	ft
Top Width	0.00	ft
Critical Depth	1.10	ft
Percent Full	100.00	
Critical Slope	0.006356	ft/ft
Velocity	4.55	ft/s
Velocity Head	0.32	ft
Specific Energy	FULL	ft
Froude Number	FULL	
Maximum Discharge	8.66	cfs
Full Flow Capacity	8.05	cfs
Full Flow Slope	0.005000	ft/ft

E. Trickle Channel to Detention Pond
Worksheet for Rectangular Channel

Project Description	
Project File	c:\haestad\fmw\windsor.fm2
Worksheet	Windsor Park Drainage
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.006600	ft/ft
Depth	0.70	ft
Bottom Width	3.50	ft

Results		
Discharge	14.33	cfs
Flow Area	2.45	ft^2
Wetted Perimeter	4.90	ft
Top Width	3.50	ft
Critical Depth	0.80	ft
Critical Slope	0.004385	ft/ft
Velocity	5.85	ft/s
Velocity Head	0.53	ft
Specific Energy	1.23	ft
Froude Number	1.23	
Flow is supercritical.		

Discharge Pipe, D-Pond Outlet Structure
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\fmw\windsor.fm2
Worksheet	Windsor Park Subdivision Drainage
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.012	
Channel Slope	0.005000	ft/ft
Depth	18.0	in
Diameter	18.00	in

Results		
Discharge	8.05	cfs
Flow Area	1.77	ft²
Wetted Perimeter	4.71	ft
Top Width	0.00	ft
Critical Depth	1.10	ft
Percent Full	100.00	
Critical Slope	0.006356	ft/ft
Velocity	4.55	ft/s
Velocity Head	0.32	ft
Specific Energy	FULL	ft
Froude Number	FULL	
Maximum Discharge	8.66	cfs
Full Flow Capacity	8.05	cfs
Full Flow Slope	0.005000	ft/ft

APPENDIX D

User Name: SES
Project: Windsor Park
Scenario: Detention-1

Date: 10-30-01
Time: 17:39:30
Page: 1

FLOOD HYDROGRAPH REPORT

Hydrograph Number: 1
Name: Existing 2-yr
Type: Modified Rational

[HYDROGRAPH INFORMATION]

Peak Flow (Qp)	=	2.22 (cfs)
Time to Peak (Tp)	=	19.00 (min)
Time of Base (Tb)	=	38.20 (min)
Volume	=	0.06 (ac-ft)
Time Step	=	2.00 (min)
Flow Multiplier	=	1.00

[Hydrograph Flow Values: Time vs. Flow]
[TIME CONCENTRATION -- 2.00]

Time Interval	Time (min)	Incremental Rainfall (in)	Cumulative Rainfall (in)	Incremental Outflow (cfs)	Design Outflow (cfs)
1	2.00	0.02	0.02	0.00	0.23
2	4.00	0.05	0.07	0.23	0.47
3	6.00	0.07	0.14	0.23	0.70
4	8.00	0.09	0.23	0.23	0.93
5	10.00	0.12	0.35	0.23	1.17
6	12.00	0.14	0.49	0.23	1.40
7	14.00	0.16	0.65	0.23	1.63
8	16.00	0.19	0.84	0.23	1.87
9	18.00	0.21	1.05	0.23	2.10
10	20.00	0.22	1.27	0.02	2.12
11	22.00	0.22	1.49	-0.23	1.89
12	24.00	0.22	1.72	-0.23	1.66
13	26.00	0.22	1.94	-0.23	1.42
14	28.00	0.22	2.16	-0.23	1.19
15	30.00	0.22	2.39	-0.23	0.96
16	32.00	0.22	2.61	-0.23	0.72
17	34.00	0.22	2.83	-0.23	0.49
18	36.00	0.22	3.06	-0.23	0.26
19	38.00	0.22	3.28	-0.23	0.02
20	38.20	0.22	3.50	-0.02	0.00

FLOOD HYDROGRAPH REPORT

Hydrograph Number: 2
Name: Existing 100-yr
Type: Modified Rational

[HYDROGRAPH INFORMATION]

Peak Flow (Qp)	=	11.07 (cfs)
Time to Peak (Tp)	=	19.00 (min)
Time of Base (Tb)	=	38.20 (min)
Volume	=	0.29 (ac-ft)
Time Step	=	2.00 (min)
Flow Multiplier	=	1.00

[Hydrograph Flow Values: Time vs. Flow]
[TIME CONCENTRATION -- 2.00]

Time Interval	Time (min)	Incremental Rainfall (in)	Cumulative Rainfall (in)	Incremental Outflow (cfs)	Design Outflow (cfs)
1	2.00	0.09	0.09	0.00	1.17
2	4.00	0.18	0.28	1.17	2.33
3	6.00	0.28	0.55	1.17	3.50
4	8.00	0.37	0.92	1.17	4.66
5	10.00	0.46	1.38	1.17	5.83
6	12.00	0.55	1.93	1.17	6.99
7	14.00	0.64	2.58	1.17	8.16
8	16.00	0.74	3.32	1.17	9.32
9	18.00	0.83	4.14	1.17	10.49
10	20.00	0.88	5.03	0.12	10.60
11	22.00	0.88	5.91	-1.17	9.44
12	24.00	0.88	6.80	-1.17	8.27
13	26.00	0.88	7.68	-1.17	7.11
14	28.00	0.88	8.56	-1.17	5.94
15	30.00	0.88	9.45	-1.17	4.78
16	32.00	0.88	10.33	-1.17	3.61
17	34.00	0.88	11.22	-1.17	2.45
18	36.00	0.88	12.10	-1.17	1.28
19	38.00	0.88	12.99	-1.17	0.12
20	38.20	0.88	13.87	-0.12	0.00

Modified Rational Storage Approximation

Area	= 14.40	(ac)
Runoff Coefficient	= 0.49	
Time of Concentration	= 31.00	(min)
Return Period	= 2 Year	
Storm Duration	= 0.52	(hr)
Total Rainfall	= 0.28	(in)
Flow Multiplier	= 1.00	
Receding Limb Factor	= 1.00	
Peak Discharge	= 3.78	(cfs)
Time to Peak (Tp)	= 31.00	(min)
Time of Base (Tb)	= 62.20	(min)
Volume	= 0.16	(ac-ft)
Time Step	= 1.00	(min)
Allowable Discharge	= 1.80	(cfs)
Computed Storage	= 0.09	(ac-ft)
	= 3715.51	(cu ft)

Modified Rational Storage Approximation

Area	= 14.40	(ac)
Runoff Coefficient	= 0.54	
Time of Concentration	= 31.00	(min)
Return Period	= 100 Year	
Storm Duration	= 0.52	(hr)
Total Rainfall	= 1.09	(in)
Flow Multiplier	= 1.00	
Receding Limb Factor	= 1.00	
Peak Discharge	= 16.46	(cfs)
Time to Peak (Tp)	= 31.00	(min)
Time of Base (Tb)	= 62.20	(min)
Volume	= 0.71	(ac-ft)
Time Step	= 1.00	(min)
Allowable Discharge	= 7.70	(cfs)
Computed Storage	= 0.38	(ac-ft)
	= 16413.48	(cu ft)

Slice Volume Results

Original Surface Model: Surface1
Final Surface Model: Surface3

Elev. Interval	Cut Area (sf)	Cut Vol.(cy)	Cumulative Cut (cy)
22.25 - 22.35	0.00	0.00	0.00
22.35 - 22.45	0.00	0.00	0.00
22.45 - 22.55	0.00	0.00	0.00
22.55 - 22.65	0.00	0.00	0.00
22.65 - 22.75	0.00	0.00	0.00
22.75 - 22.85	0.00	0.00	0.00
22.85 - 22.95	0.00	0.00	0.00
22.95 - 23.05	767.07	2.84	2.84
23.05 - 23.15	1561.05	5.78	8.62
23.15 - 23.25	1843.57	6.83	15.45
23.25 - 23.35	2464.57	9.13	24.58
23.35 - 23.45	3261.42	12.08	36.66
23.45 - 23.55	3919.34	14.52	51.17
23.55 - 23.65	4333.25	16.05	67.22
23.65 - 23.75	6600.74	24.45	91.67
23.75 - 23.85	7189.61	26.63	118.30
23.85 - 23.95	7524.49	27.87	146.17
23.95 - 24.05	7634.35	28.28	174.44
24.05 - 24.15	7937.65	29.40	203.84
24.15 - 24.25	8083.08	29.94	233.78
24.25 - 24.35	8605.29	31.87	265.65
24.35 - 24.45	11364.56	42.09	307.74
24.45 - 24.55	12037.80	44.58	352.33
24.55 - 24.65	13227.38	48.99	401.32
24.65 - 24.75	15522.22	57.49	458.81
24.75 - 24.85	16321.62	60.45	519.26
24.85 - 24.95	16880.75	62.52	581.78
24.95 - 25.05	8588.05	31.81	613.58

***Cumulative Cut (cf)= 16,570**

*Storage Available

OUTLET STRUCTURE RELEASE RATES FOR 38 DEGREE OPENING V-NOTCH WEIR

WINDSOR PARK SUBDIVISION

$Q = 0.861 \times H^{2.5}$ (38 DEGREE WEIR)

2-YEAR STORM EVENT RELEASE RATE

POND ELEVATION	HT. OF WATER IN WEIR (FT)	RELEASE RATE (CFS)
4522.25*	0.00	0.0
4523.60	1.35	1.8

*ELEVATION OF POND BOTTOM - WEIR INVERT

100-YEAR STORM EVENT RELEASE RATE

POND ELEVATION	HT. OF WATER IN WEIR (FT)	RELEASE RATE (CFS)
4522.25*	0.00	0.0
4524.65	2.40	7.7

*ELEVATION OF POND BOTTOM - WEIR INVERT

	2-YR	100-YR
REQ'D VOL*:	**3715**	**16,414**
AVAILABLE :	**3460**	**16,570**

*BASED ON APPROXIMATE VOLUMES
**ALL VOLUMES ARE IN CUBIC FEET