

June 30, 2015

Mary Romero
Project Manager
U.S. Army Corps of Engineers - Alaska District
Regulatory Division
Post Office Box 6898
JBER, Alaska 99506-0898



RE: Proposed Blue Sky Estates Subdivision Development Drainage Summary, Bethel, Alaska

Dear Ms. Romero:

The layout for the proposed Blue Sky Estates Subdivision, located in Bethel, Alaska, forms a horseshoe shape around the north, east, and west sides of the adjacent existing Tsikoyak Subdivision with BIA road forming the southern border of the Tsikoyak Subdivision. Tsikoyak Subdivision residents had commented to the City of Bethel and USACE during previous public comment periods (for Blue Sky Estates Subdivision) about existing drainage issues in the subdivision and concerns about the new proposed subdivision exacerbating the problem. On behalf of Lyman Hoffman, Restoration Science & Engineering, LLC (RSE) conducted a drainage analysis which analyzed drainage at the proposed Blue Sky Estates Subdivision.

RSE analyzed topographical information collected from the area of the proposed subdivision and the adjacent Tsikoyak Subdivision to determine drainage directions and divided the area into five drainage areas each which collect runoff and discharge through a common location. Typical ground cover for the existing and proposed subdivisions was modeled and runoff from the five drainage areas was analyzed used HydroCAD modeling software to determine peak flow rates that drainages and culverts could be expected to experience from a 100-year 24-hour storm event (3.5 inches of rain for Bethel). Based on the results of the drainage analysis, culverts were located and were sized to pass the 3.5-inch rain event which is almost $\frac{1}{4}$ of the annual precipitation that Bethel receives.

The Blue Sky Estates Subdivision was designed to ensure general continuation of existing drainage patterns conveying runoff away from the Tsikoyak Subdivision and minimize future drainage issues due to construction of the Blue Sky Estates Subdivision. Blue Sky Estates lots that border Tsikoyak Subdivision lots include 10 to 20 foot drainage easements along the subdivision boundary which when coupled with existing 10 foot drainage easements along the outside of Tsikoyak Subdivision lots provide 20 to 30 feet of designated space for drainage conveyance. The proposed Blue Sky Estates design includes all main drainage ways that convey runoff away from the Tsikoyak Subdivision and through the proposed Blue Sky Estates Subdivision maintained as open space preservation areas to ensure drainage is not restricted. Culverts will convey runoff away from the subdivision to the existing drainage channels leading away from the Blue Sky Estates Subdivision.

If you have any questions regarding this submittal, please feel free to contact me at 278-1023 ext. 1108, or nwaggoner@restorsci.com or David Nyman at ext. 1103 or dnyman@restorsci.com. Thank you for your time.

Sincerely,

A handwritten signature in blue ink, appearing to read 'NW', with a long horizontal flourish extending to the right.

Neil Waggoner, PE
RESTORATION SCIENCE & ENGINEERING, LLC

Attachments:

1. Proposed Bethel Hoffman Subdivision Drainage Analysis, December 10, 2014



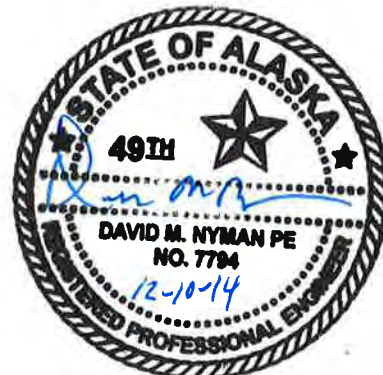
Proposed Bethel Hoffman Subdivision Drainage Analysis: December 10, 2014

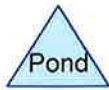
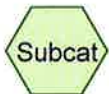
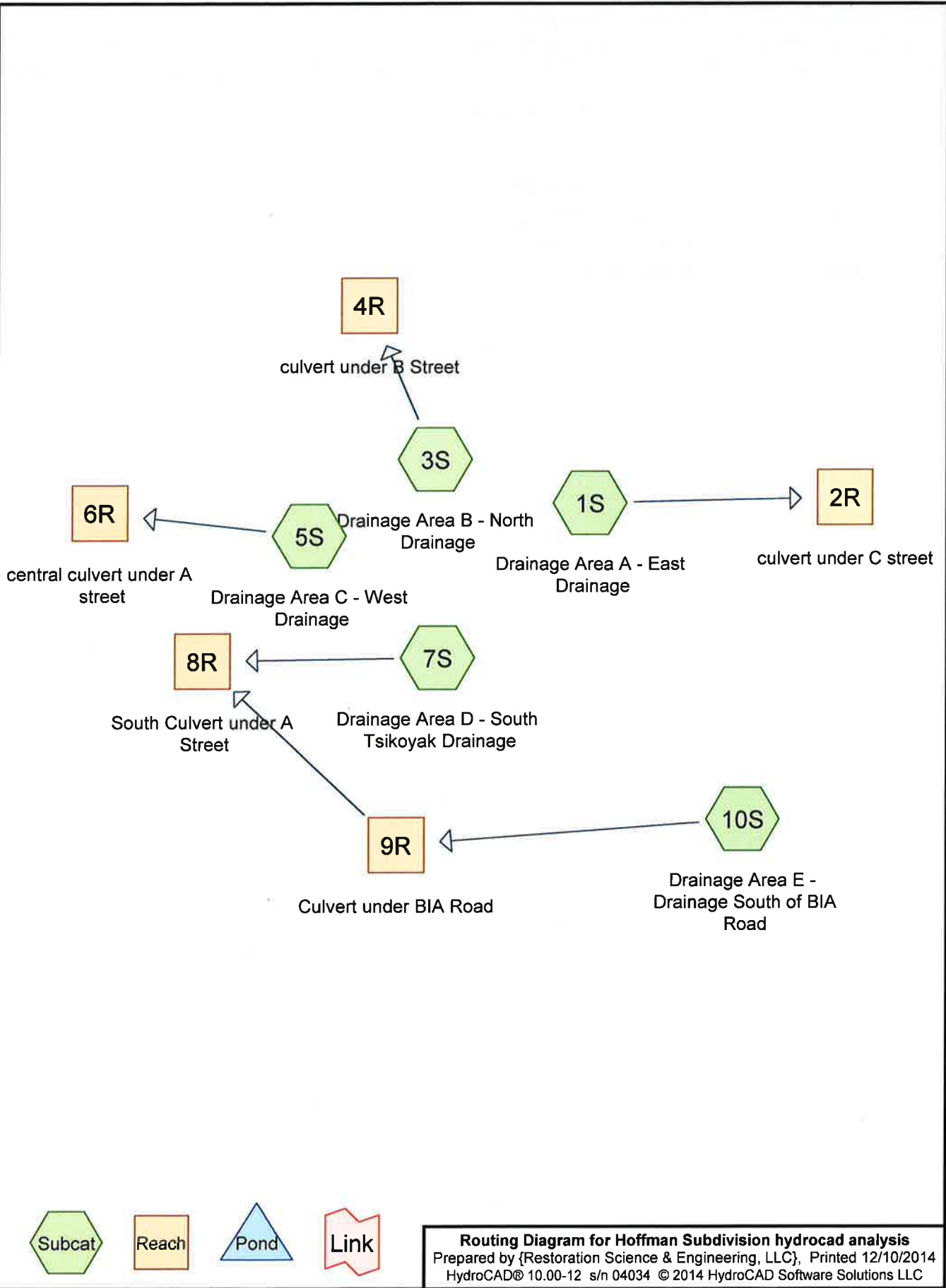
A drainage analysis was conducted for the proposed Hoffman Subdivision in Bethel, Alaska to ensure general continuation of existing drainage patterns and minimize future drainage issues due to construction of the subdivision.

Discrete drainage areas that will outfall through culverts beneath roads in the proposed Hoffman Subdivision were delineated using recent surveyed topographic mapping and site knowledge. Drainage area boundaries and total area of each drainage were calculated using AutoCAD software. Drainage areas, site slopes, and area ground cover were modeled in HydroCAD software and the 100-year 24-hour storm event for Bethel (3.5 inches of rain) was applied to the modeled drainage areas.

All culverts were modeled as corrugated metal pipes (CMP) and sized conservatively to convey the peak runoff from the 100-year 24-hour storm event. Culvert carrying capacity varies with culvert diameter, length, and slope from end to end.

Culvert ID	Diameter	Peak Runoff (100-yr 24-hr storm)	Peak Culvert Capacity
Culvert Under C Street	36"	22.71 cubic feet per second (cfs)	31.66 cfs
Culvert under B Street	24"	10.04 cfs	10.74 cfs
Central Culvert under A Street	36"	15.21 cfs	44.78 cfs
South Culvert Under A Street	36"	22.19 cfs	33.58 cfs
New Culvert under BIA Road	30"	15.61 cfs	23.85 cfs





Routing Diagram for Hoffman Subdivision hydrocad analysis
 Prepared by {Restoration Science & Engineering, LLC}, Printed 12/10/2014
 HydroCAD® 10.00-12 s/n 04034 © 2014 HydroCAD Software Solutions LLC

Hoffman Subdivision hydrocad analysis

Prepared by {Restoration Science & Engineering, LLC}

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Printed 12/10/2014

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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
37.815	75	1/4 acre lots, 38% imp, HSG B (1S, 3S, 5S, 7S)
15.480	69	50-75% Grass cover, Fair, HSG B (10S)
53.295	73	TOTAL AREA

Hoffman Subdivision hydrocad analysis

Prepared by {Restoration Science & Engineering, LLC}

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Printed 12/10/2014

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Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
53.295	HSG B	1S, 3S, 5S, 7S, 10S
0.000	HSG C	
0.000	HSG D	
0.000	Other	
53.295		TOTAL AREA

Hoffman Subdivision hydrocad analysis

Prepared by {Restoration Science & Engineering, LLC}

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Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	37.815	0.000	0.000	0.000	37.815	1/4 acre lots, 38% imp	1S, 3S, 5S, 7S
0.000	15.480	0.000	0.000	0.000	15.480	50-75% Grass cover, Fair	10S
0.000	53.295	0.000	0.000	0.000	53.295	TOTAL AREA	

Hoffman Subdivision hydrocad analysis

Prepared by {Restoration Science & Engineering, LLC}

Printed 12/10/2014

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Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	2R	80.75	80.25	60.0	0.0083	0.025	36.0	0.0	0.0
2	4R	85.00	84.50	60.0	0.0083	0.025	24.0	0.0	0.0
3	6R	78.50	77.50	60.0	0.0167	0.025	36.0	0.0	0.0
4	8R	78.50	77.75	80.0	0.0094	0.025	36.0	0.0	0.0
5	9R	83.00	82.00	80.0	0.0125	0.025	30.0	0.0	0.0

Time span=4.00-26.00 hrs, dt=0.05 hrs, 441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Drainage Area A - East Runoff Area=16.260 ac 38.00% Impervious Runoff Depth=1.30"
Flow Length=1,000' Slope=0.0339 '/ Tc=20.0 min CN=75 Runoff=22.71 cfs 1.764 af

Subcatchment 3S: Drainage Area B - North Runoff Area=6.275 ac 38.00% Impervious Runoff Depth=1.30"
Flow Length=800' Slope=0.0384 '/ Tc=15.7 min CN=75 Runoff=10.04 cfs 0.681 af

Subcatchment 5S: Drainage Area C - West Runoff Area=10.700 ac 38.00% Impervious Runoff Depth=1.30"
Flow Length=1,000' Slope=0.0360 '/ Tc=19.4 min CN=75 Runoff=15.21 cfs 1.161 af

Subcatchment 7S: Drainage Area D - South Runoff Area=4.580 ac 38.00% Impervious Runoff Depth=1.30"
Flow Length=1,200' Slope=0.1323 '/ Tc=11.7 min CN=75 Runoff=8.44 cfs 0.497 af

Subcatchment 10S: Drainage Area E - Runoff Area=15.480 ac 0.00% Impervious Runoff Depth=0.95"
Flow Length=925' Slope=0.0494 '/ Tc=18.4 min CN=69 Runoff=15.61 cfs 1.231 af

Reach 2R: culvert under C street Avg. Flow Depth=1.88' Max Vel=4.87 fps Inflow=22.71 cfs 1.764 af
36.0" Round Pipe n=0.025 L=60.0' S=0.0083 '/ Capacity=31.66 cfs Outflow=22.64 cfs 1.764 af

Reach 4R: culvert under B Street Avg. Flow Depth=1.53' Max Vel=3.88 fps Inflow=10.04 cfs 0.681 af
24.0" Round Pipe n=0.025 L=60.0' S=0.0083 '/ Capacity=10.74 cfs Outflow=9.98 cfs 0.681 af

Reach 6R: central culvert under A Avg. Flow Depth=1.21' Max Vel=5.72 fps Inflow=15.21 cfs 1.161 af
36.0" Round Pipe n=0.025 L=60.0' S=0.0167 '/ Capacity=44.78 cfs Outflow=15.16 cfs 1.161 af

Reach 8R: South Culvert under A Street Avg. Flow Depth=1.78' Max Vel=5.08 fps Inflow=22.19 cfs 1.727 af
36.0" Round Pipe n=0.025 L=80.0' S=0.0094 '/ Capacity=33.58 cfs Outflow=22.08 cfs 1.727 af

Reach 9R: Culvert under BIA Road Avg. Flow Depth=1.48' Max Vel=5.17 fps Inflow=15.61 cfs 1.231 af
30.0" Round Pipe n=0.025 L=80.0' S=0.0125 '/ Capacity=23.85 cfs Outflow=15.54 cfs 1.231 af

Total Runoff Area = 53.295 ac Runoff Volume = 5.333 af Average Runoff Depth = 1.20"
73.04% Pervious = 38.925 ac 26.96% Impervious = 14.370 ac

Summary for Subcatchment 1S: Drainage Area A - East Drainage

Runoff = 22.71 cfs @ 12.14 hrs, Volume= 1.764 af, Depth= 1.30"

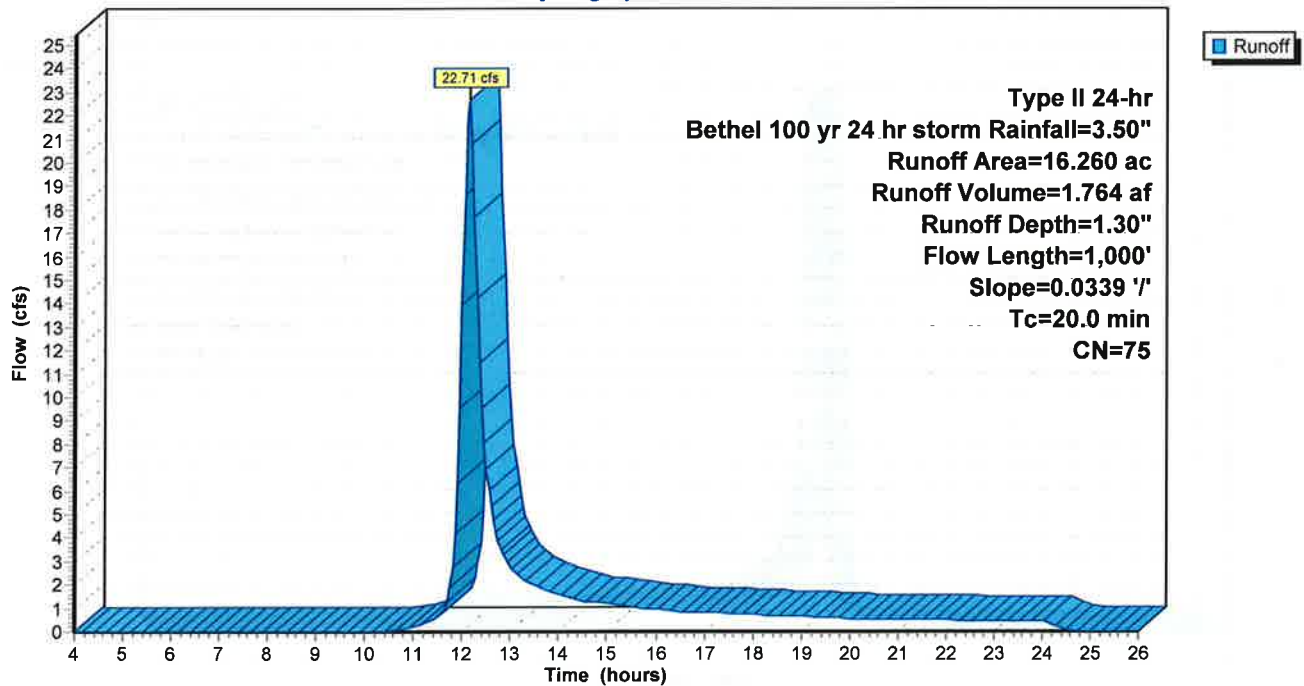
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Type II 24-hr Bethel 100 yr 24 hr storm Rainfall=3.50"

Area (ac)	CN	Description
16.260	75	1/4 acre lots, 38% imp, HSG B
10.081		62.00% Pervious Area
6.179		38.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,000	0.0339	0.83		Lag/CN Method, Contour Length= 1,000' Interval= 24'

Subcatchment 1S: Drainage Area A - East Drainage

Hydrograph



Summary for Subcatchment 3S: Drainage Area B - North Drainage

Runoff = 10.04 cfs @ 12.09 hrs, Volume= 0.681 af, Depth= 1.30"

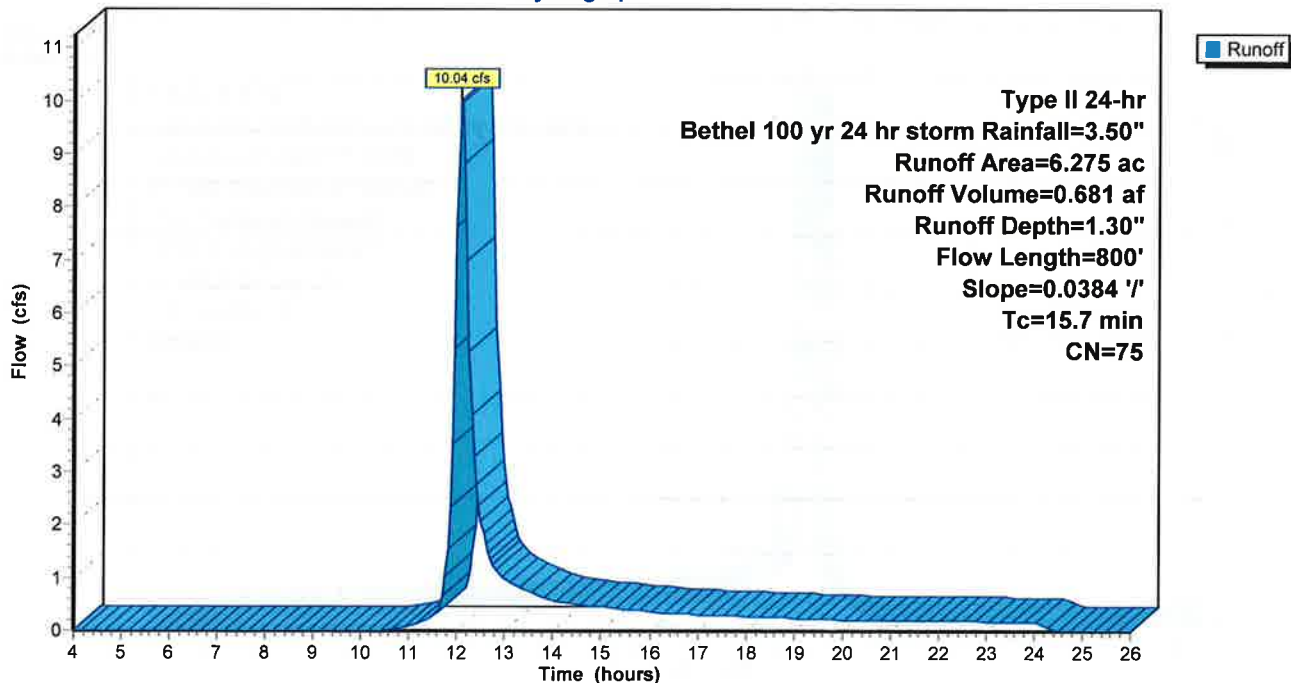
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Type II 24-hr Bethel 100 yr 24 hr storm Rainfall=3.50"

Area (ac)	CN	Description
6.275	75	1/4 acre lots, 38% imp, HSG B
3.890		62.00% Pervious Area
2.385		38.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.7	800	0.0384	0.85		Lag/CN Method, Contour Length= 700' Interval= 15'

Subcatchment 3S: Drainage Area B - North Drainage

Hydrograph



Summary for Subcatchment 5S: Drainage Area C - West Drainage

Runoff = 15.21 cfs @ 12.13 hrs, Volume= 1.161 af, Depth= 1.30"

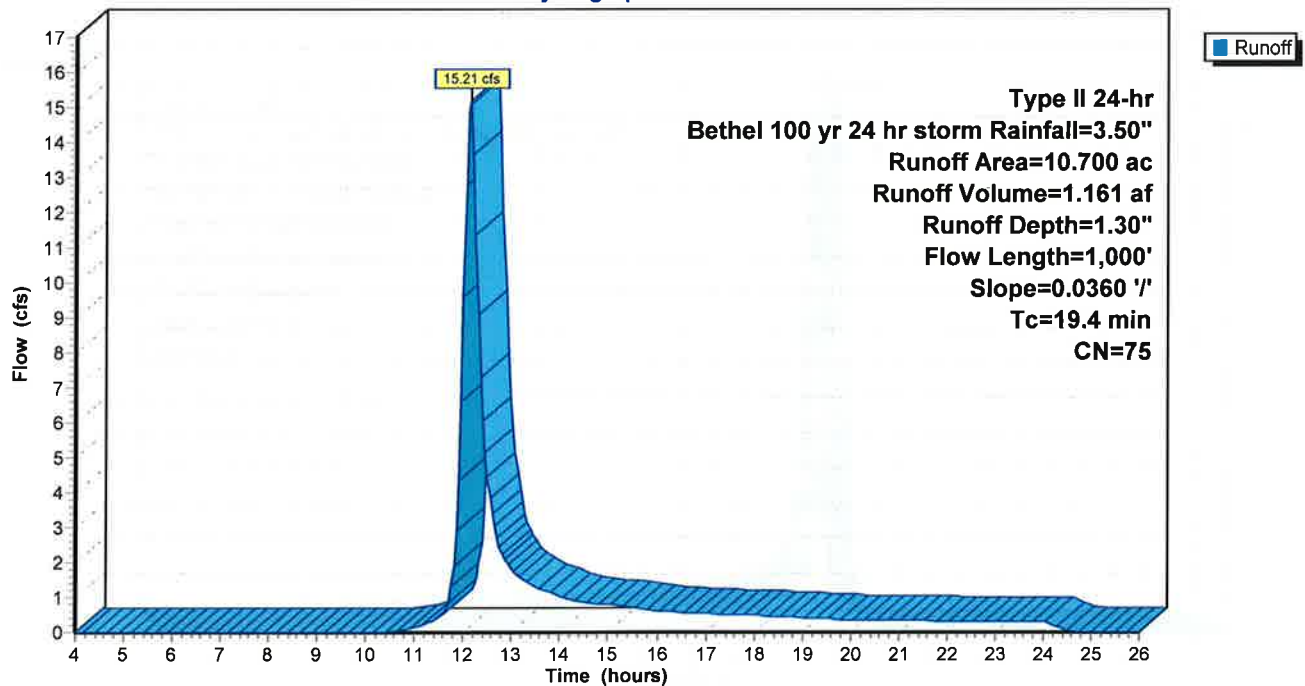
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Type II 24-hr Bethel 100 yr 24 hr storm Rainfall=3.50"

Area (ac)	CN	Description
10.700	75	1/4 acre lots, 38% imp, HSG B
6.634		62.00% Pervious Area
4.066		38.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.4	1,000	0.0360	0.86		Lag/CN Method, Contour Length= 800' Interval= 21'

Subcatchment 5S: Drainage Area C - West Drainage

Hydrograph



Summary for Subcatchment 7S: Drainage Area D - South Tsikoyak Drainage

Runoff = 8.44 cfs @ 12.04 hrs, Volume= 0.497 af, Depth= 1.30"

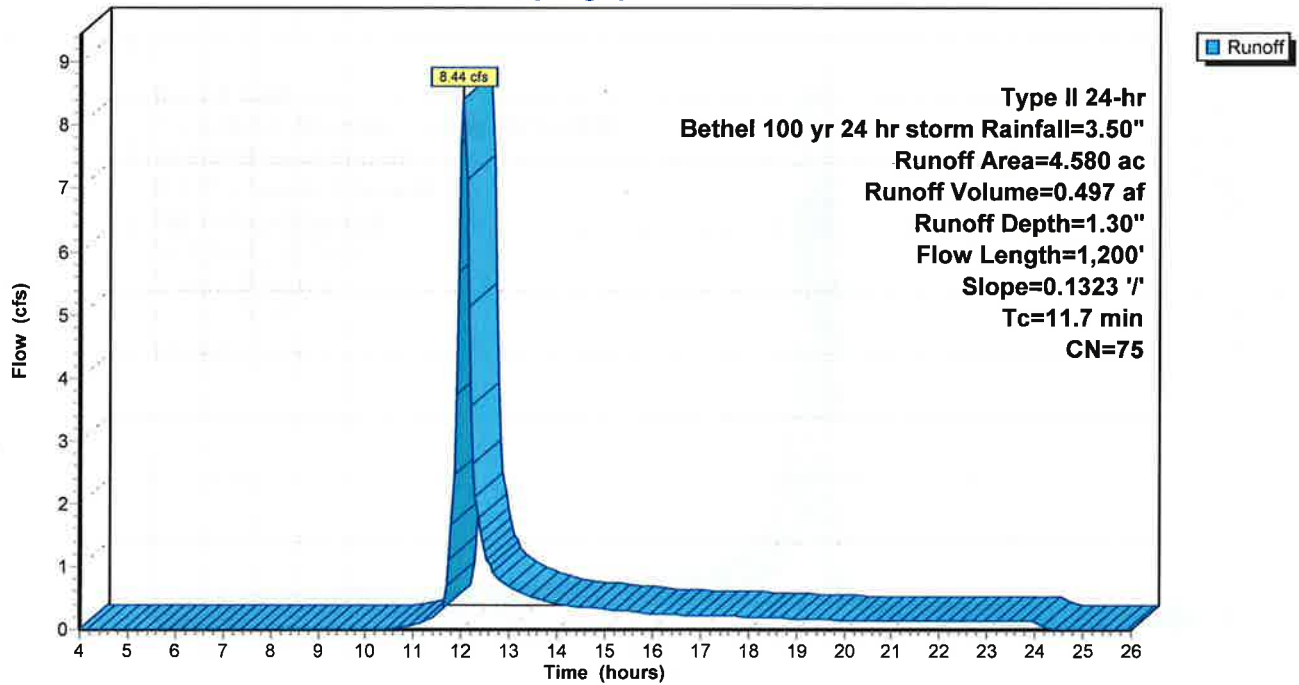
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Type II 24-hr Bethel 100 yr 24 hr storm Rainfall=3.50"

Area (ac)	CN	Description
4.580	75	1/4 acre lots, 38% imp, HSG B
2.840		62.00% Pervious Area
1.740		38.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.7	1,200	0.1323	1.70		Lag/CN Method, Contour Length= 1,200' Interval= 22'

Subcatchment 7S: Drainage Area D - South Tsikoyak Drainage

Hydrograph



Summary for Subcatchment 10S: Drainage Area E - Drainage South of BIA Road

Runoff = 15.61 cfs @ 12.13 hrs, Volume= 1.231 af, Depth= 0.95"

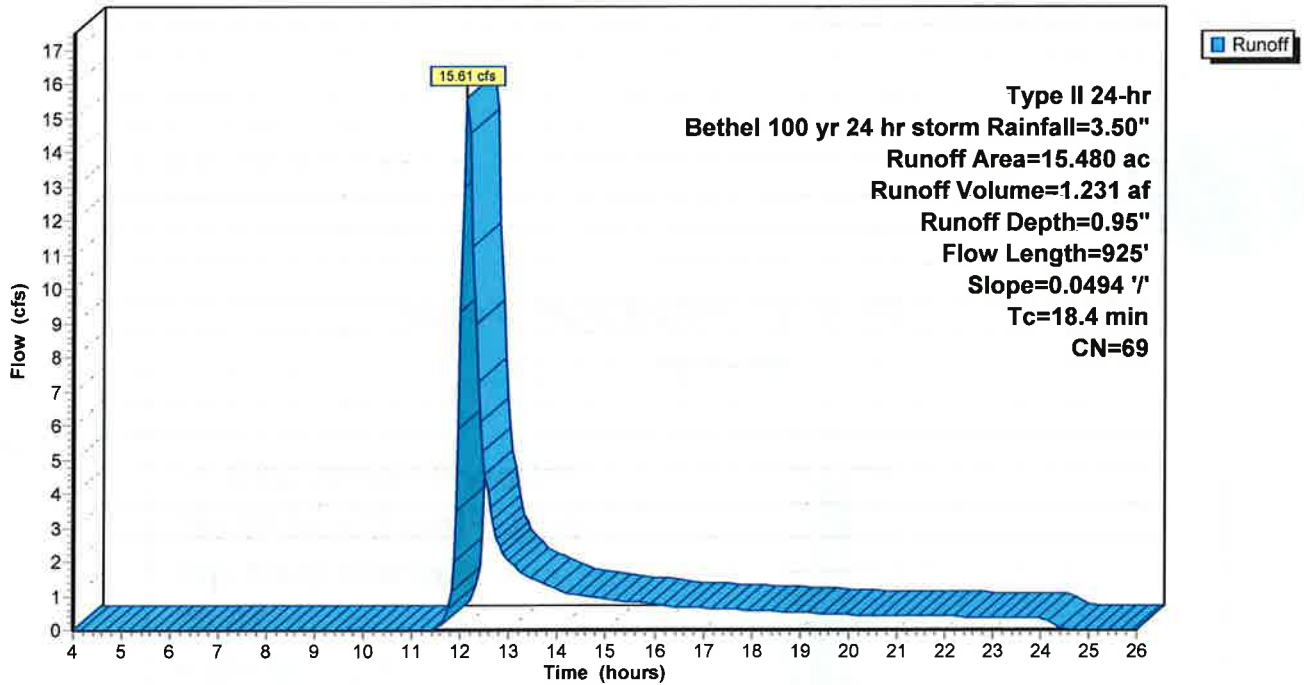
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Type II 24-hr Bethel 100 yr 24 hr storm Rainfall=3.50"

Area (ac)	CN	Description
15.480	69	50-75% Grass cover, Fair, HSG B
15.480		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.4	925	0.0494	0.84		Lag/CN Method, Contour Length= 925' Interval= 36'

Subcatchment 10S: Drainage Area E - Drainage South of BIA Road

Hydrograph



Summary for Reach 2R: culvert under C street

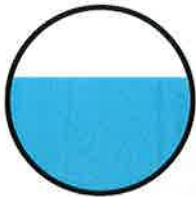
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 16.260 ac, 38.00% Impervious, Inflow Depth = 1.30" for Bethel 100 yr 24 hr storm event
 Inflow = 22.71 cfs @ 12.14 hrs, Volume= 1.764 af
 Outflow = 22.64 cfs @ 12.14 hrs, Volume= 1.764 af, Atten= 0%, Lag= 0.4 min

Routing by Stor-Ind+Trans method, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Max. Velocity= 4.87 fps, Min. Travel Time= 0.2 min
 Avg. Velocity = 1.89 fps, Avg. Travel Time= 0.5 min

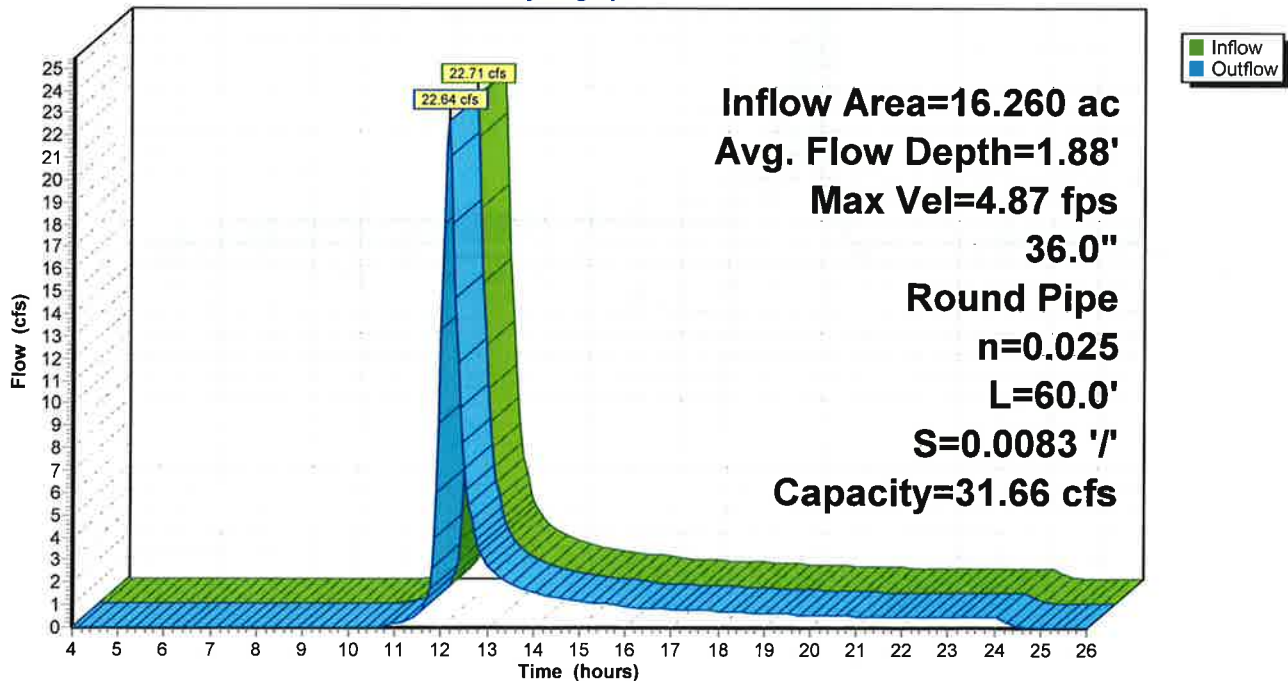
Peak Storage= 280 cf @ 12.14 hrs
 Average Depth at Peak Storage= 1.88'
 Bank-Full Depth= 3.00' Flow Area= 7.1 sf, Capacity= 31.66 cfs

36.0" Round Pipe
 n= 0.025 Corrugated metal
 Length= 60.0' Slope= 0.0083 '/'
 Inlet Invert= 80.75', Outlet Invert= 80.25'



Reach 2R: culvert under C street

Hydrograph



Summary for Reach 4R: culvert under B Street

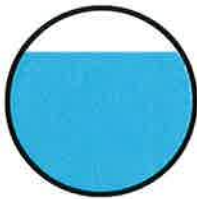
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 6.275 ac, 38.00% Impervious, Inflow Depth = 1.30" for Bethel 100 yr 24 hr storm event
 Inflow = 10.04 cfs @ 12.09 hrs, Volume= 0.681 af
 Outflow = 9.98 cfs @ 12.10 hrs, Volume= 0.681 af, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Max. Velocity= 3.88 fps, Min. Travel Time= 0.3 min
 Avg. Velocity = 1.51 fps, Avg. Travel Time= 0.7 min

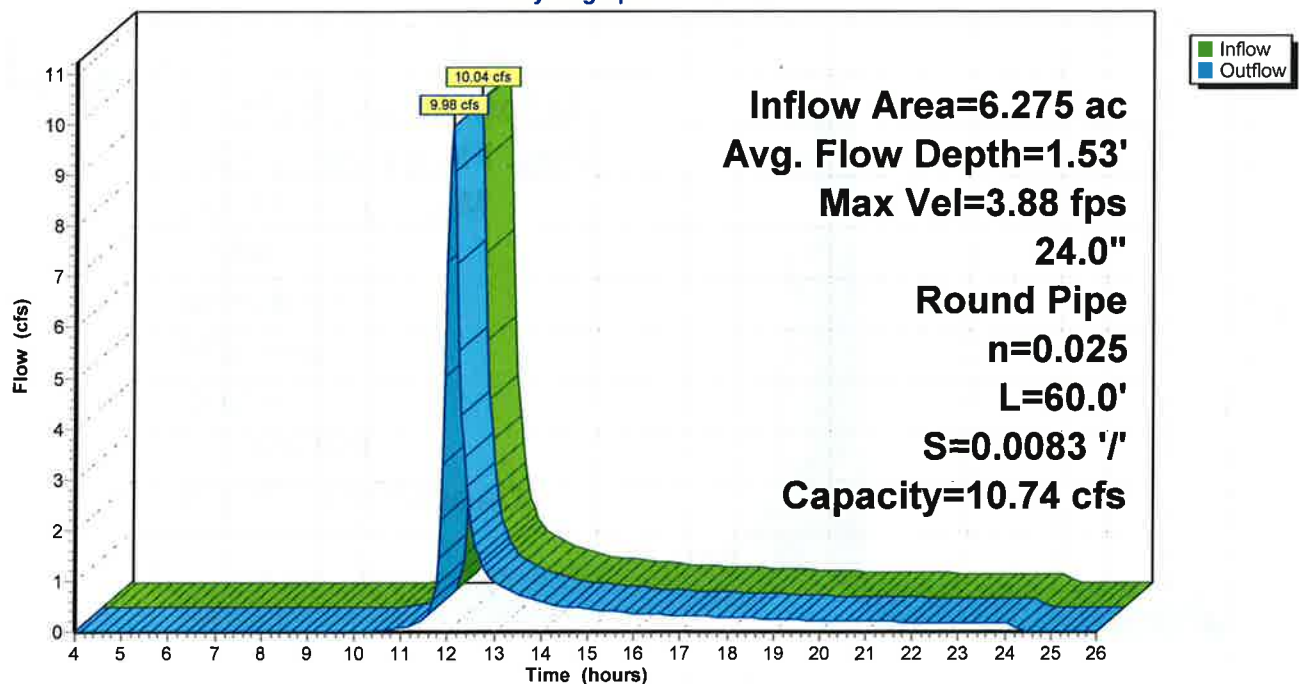
Peak Storage= 155 cf @ 12.09 hrs
 Average Depth at Peak Storage= 1.53'
 Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 10.74 cfs

24.0" Round Pipe
 n= 0.025 Corrugated metal
 Length= 60.0' Slope= 0.0083 '/'
 Inlet Invert= 85.00', Outlet Invert= 84.50'



Reach 4R: culvert under B Street

Hydrograph



Summary for Reach 6R: central culvert under A street

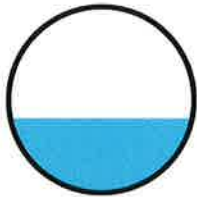
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 10.700 ac, 38.00% Impervious, Inflow Depth = 1.30" for Bethel 100 yr 24 hr storm event
 Inflow = 15.21 cfs @ 12.13 hrs, Volume= 1.161 af
 Outflow = 15.16 cfs @ 12.14 hrs, Volume= 1.161 af, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Max. Velocity= 5.72 fps, Min. Travel Time= 0.2 min
 Avg. Velocity = 2.14 fps, Avg. Travel Time= 0.5 min

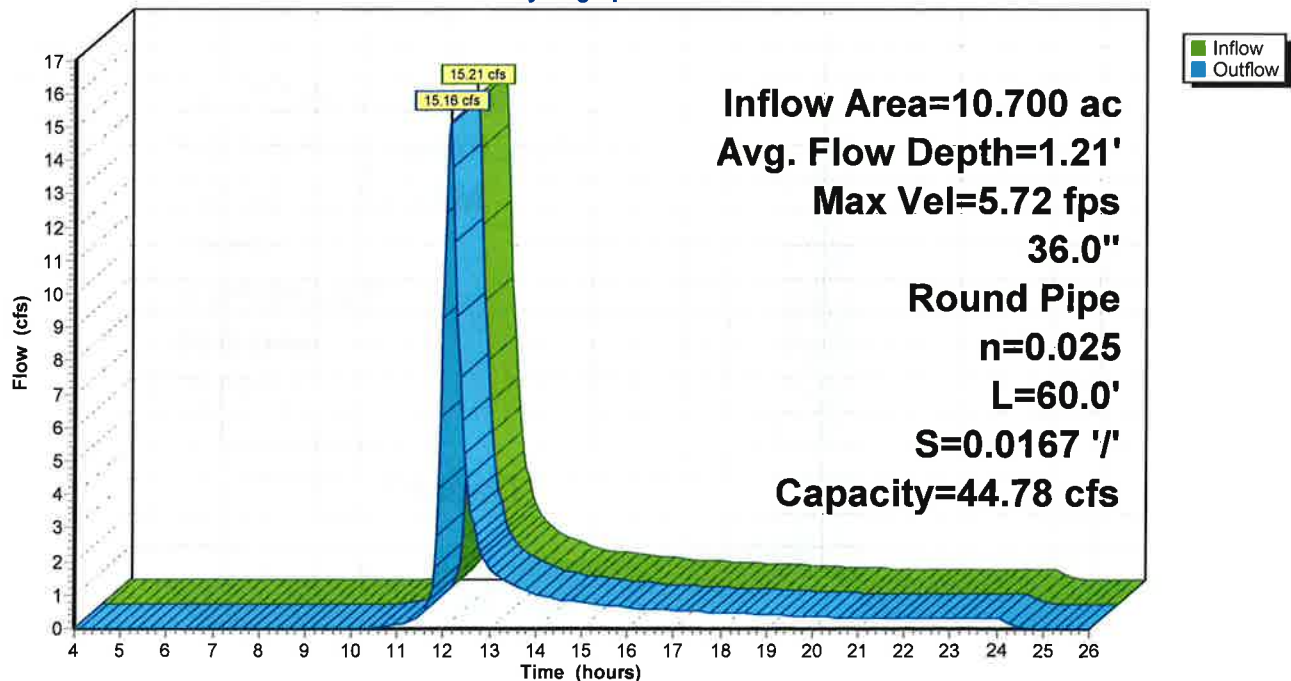
Peak Storage= 159 cf @ 12.13 hrs
 Average Depth at Peak Storage= 1.21'
 Bank-Full Depth= 3.00' Flow Area= 7.1 sf, Capacity= 44.78 cfs

36.0" Round Pipe
 n= 0.025 Corrugated metal
 Length= 60.0' Slope= 0.0167 '/'
 Inlet Invert= 78.50', Outlet Invert= 77.50'



Reach 6R: central culvert under A street

Hydrograph



Summary for Reach 8R: South Culvert under A Street

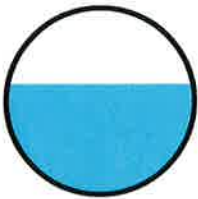
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 20.060 ac, 8.68% Impervious, Inflow Depth = 1.03" for Bethel 100 yr 24 hr storm event
 Inflow = 22.19 cfs @ 12.10 hrs, Volume= 1.727 af
 Outflow = 22.08 cfs @ 12.11 hrs, Volume= 1.727 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Max. Velocity= 5.08 fps, Min. Travel Time= 0.3 min
 Avg. Velocity = 1.96 fps, Avg. Travel Time= 0.7 min

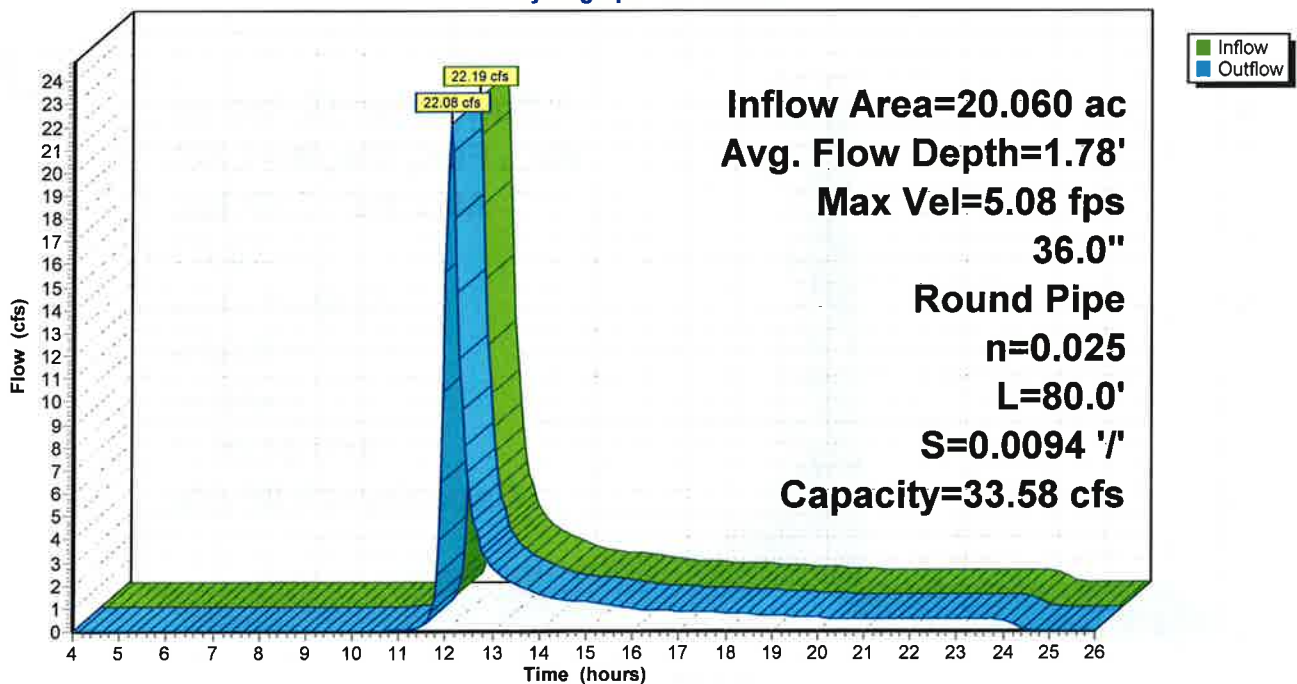
Peak Storage= 350 cf @ 12.10 hrs
 Average Depth at Peak Storage= 1.78'
 Bank-Full Depth= 3.00' Flow Area= 7.1 sf, Capacity= 33.58 cfs

36.0" Round Pipe
 n= 0.025 Corrugated metal
 Length= 80.0' Slope= 0.0094 '/'
 Inlet Invert= 78.50', Outlet Invert= 77.75'



Reach 8R: South Culvert under A Street

Hydrograph



Summary for Reach 9R: Culvert under BIA Road

[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 15.480 ac, 0.00% Impervious, Inflow Depth = 0.95" for Bethel 100 yr 24 hr storm event
 Inflow = 15.61 cfs @ 12.13 hrs, Volume= 1.231 af
 Outflow = 15.54 cfs @ 12.14 hrs, Volume= 1.231 af, Atten= 0%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 4.00-26.00 hrs, dt= 0.05 hrs
 Max. Velocity= 5.17 fps, Min. Travel Time= 0.3 min
 Avg. Velocity = 2.10 fps, Avg. Travel Time= 0.6 min

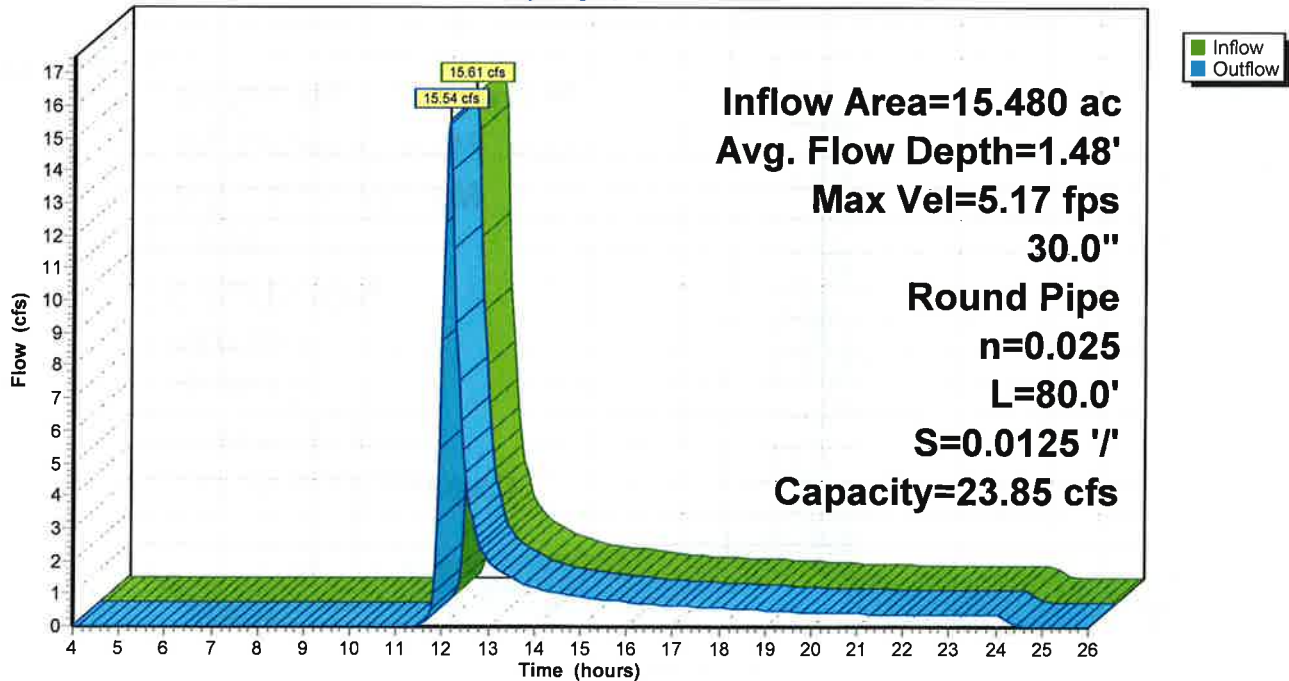
Peak Storage= 241 cf @ 12.13 hrs
 Average Depth at Peak Storage= 1.48'
 Bank-Full Depth= 2.50' Flow Area= 4.9 sf, Capacity= 23.85 cfs

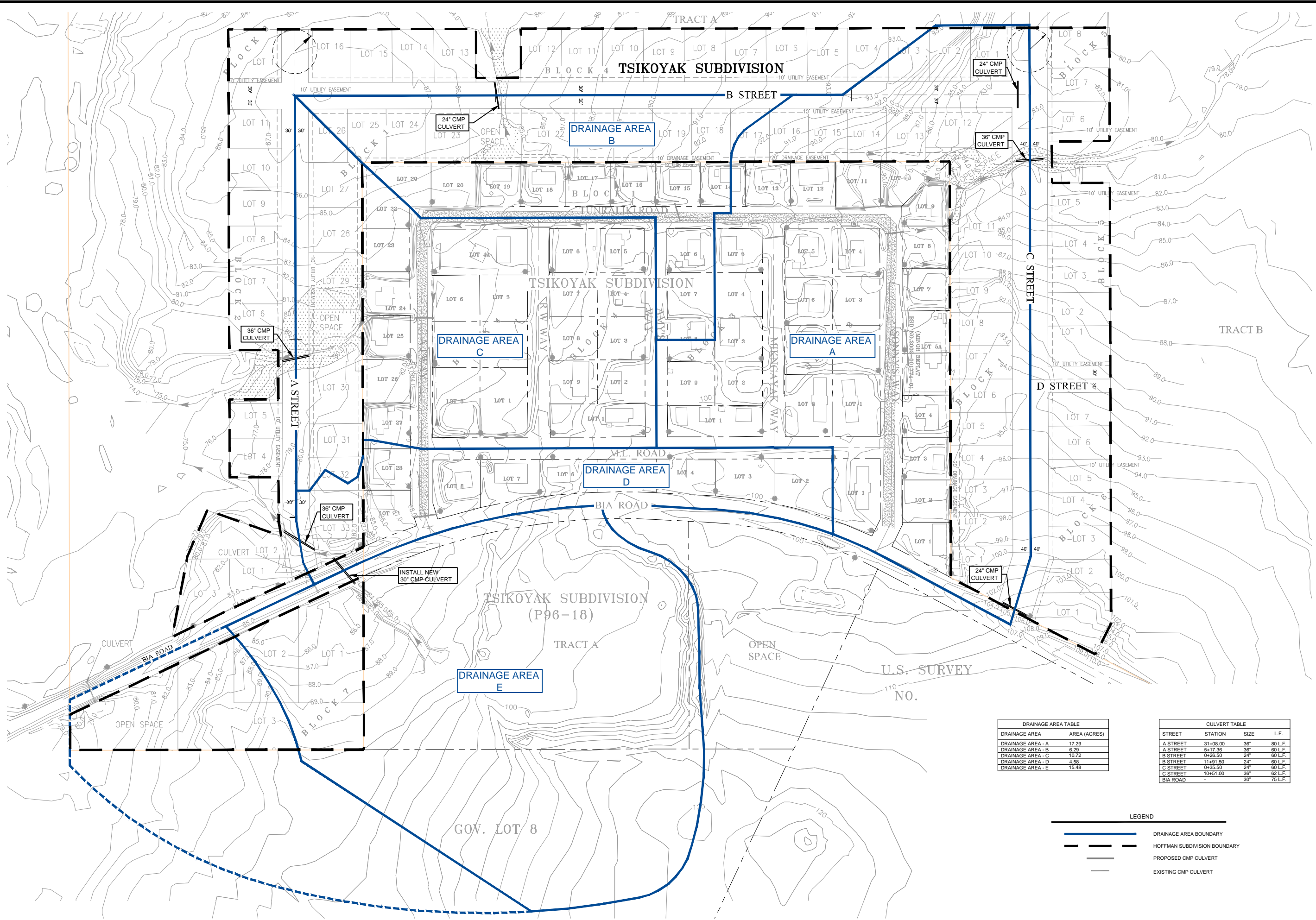
30.0" Round Pipe
 n= 0.025 Corrugated metal
 Length= 80.0' Slope= 0.0125 '/'
 Inlet Invert= 83.00', Outlet Invert= 82.00'



Reach 9R: Culvert under BIA Road

Hydrograph





DRAINAGE AREA TABLE	
DRAINAGE AREA	AREA (ACRES)
DRAINAGE AREA - A	17.29
DRAINAGE AREA - B	6.29
DRAINAGE AREA - C	10.72
DRAINAGE AREA - D	4.58
DRAINAGE AREA - E	15.48

CULVERT TABLE			
STREET	STATION	SIZE	L.F.
A STREET	31+08.00	36"	80 L.F.
A STREET	5+17.36	36"	60 L.F.
B STREET	0+26.50	24"	60 L.F.
B STREET	11+91.50	24"	60 L.F.
C STREET	0+35.50	24"	60 L.F.
C STREET	10+51.00	36"	62 L.F.
BIA ROAD	-	30"	75 L.F.

LEGEND

- DRAINAGE AREA BOUNDARY
- HOFFMAN SUBDIVISION BOUNDARY
- PROPOSED CMP CULVERT
- EXISTING CMP CULVERT

DATE: _____

REVISION:

HOFFMAN SUBDIVISION DRAINAGE AREAS	
JOB NUMBER: 14-1291	DRAWN BY: MSB
SCALE: 1"=100'	CHECKED BY: DN/NW
	DATE: 12-03-2015
	FIELD BOOK: N/A

RESTORATION
Science & Engineering, LLC

911 West 8th Avenue, Suite 100
Anchorage, Alaska 99501
PH (907) 278-1023 FAX (907) 277-5718