CITY OF ALBUQUERQUE

Timothy M. Keller, Mayor

January 3, 2018

John Nourzad, P.E.
GreenbergFarrow
1430 West Peachtree Street, NW, Suite 200
Atlanta, GA 30309

RE: Murphy Express – 1358 Wyoming Blvd
Grading Plan
Stamp Date: 11/15/17
Drainage Report
Stamp Date: 11/27/17
Hydrology File: J20D037

PO Box 1293

Albuquerque

NM 87103

www.cabq.gov

Dear Mr. Nourzad:

Based upon the information provided in your submittal received 12/27/17, the Grading Plan and Drainage Report **is not** approved for Building Permit. The following comments need to be addressed for approval of the above referenced project:

Grading Plan:

1. Please provide the benchmark information for the survey contour information provided.

Drainage Repot:

1. The City of Albuquerque Hydrology Section recognizes that the NRCS SCS method needs to be further studied and this method needs to be added to the City's DPM. We also recognize that a majority of the FEMA accepted models use the SCS method. Therefore, we would like you to use the following parameters in the HydroCAD model until the City revises the DPM. If HydroCAD does not allow you to adjust the parameters, then use the free HEC-HMS model from the Corps of Engineers.

    a. The use of just four CN values, one for each of the land treatments already described in the DPM: A=76, B=80, C=85 and D=98. This way the

Orig: Drainage File

hydrologic soil groups don't need to be determined to select the CN and the soil maps do not need to be consulted.

b. These CNs are for a 24 hour precipitation distribution using NOAA Atlas 14 with the peak at 12 hours.
c. Lag=0.6Tc where Tc is calculated using the procedure already in the DPM

2. Appendix "A" – Bio Retention Area. Please look into your use of Filtrexx® within the water quality pond. Here in Albuquerque, unless this area is going to be irrigated, all water quality ponds are usually graveled. If you want to use landscaping please make sure it fits with xeriscape theme.

If you have any questions, please contact me at 924-3995 or rbrissette@cabq.gov.

Sincerely,

Renée C Brissette

Renée C. Brissette, P.E. CFM
Senior Engineer, Hydrology
Planning Department

PO Box 1293

Albuquerque

NM 87103

www.cabq.gov

Orig: Drainage File

City of Albuquerque

Planning Department

Development & Building Services Division

DRAINAGE AND TRANSPORTATION INFORMATION SHEET (REV 11/2016)

Project Title: Murphy Express - Albuquerque, NM Building Permit #: 2017-43000 Hydrology File #: ____

DRB#: ____ EPC#: ____ Work Order#: ____

Legal Description: Tract A and portions of Tract B, Block 8, Mesa Village section 8, township 10 North, Range 3 East

City Address: 1358 Wyoming Blvd, Albuquerque NM

Applicant: Murphy Oil USA, Inc. Contact: Dominic Serra

Address: 1430 W. Peachtree St. NW, Atlanta GA, 30309

Phone#: 404-205-8428 Fax#: ____ E-mail: dserra@greenbergfarrow.com

Other Contact: Dominic Serra (Greenbergfarrow) Contact: Dominic Serra

Address: 1430 W. Peachtree St. NW, Atlanta GA, 30309

Phone#: ____ Fax#: ____ E-mail: dserra@greenbergfarrow.com

Check all that Apply:

DEPARTMENT:

x HYDROLOGY/ DRAINAGE
____ TRAFFIC/ TRANSPORTATION

TYPE OF SUBMITTAL:

X ENGINEER/ARCHITECT CERTIFICATION

____ CONCEPTUAL G & D PLAN
X GRADING PLAN
____ DRAINAGE MASTER PLAN
X DRAINAGE REPORT
____ CLOMR/LOMR

____ TRAFFIC CIRCULATION LAYOUT (TCL)
____ TRAFFIC IMPACT STUDY (TIS)

____ OTHER (SPECIFY) ____
____ PRE-DESIGN MEETING?

IS THIS A RESUBMITTAL?: ____ Yes ____ No

TYPE OF APPROVAL/ACCEPTANCE SOUGHT:

X BUILDING PERMIT APPROVAL
____ CERTIFICATE OF OCCUPANCY

____ PRELIMINARY PLAT APPROVAL
____ SITE PLAN FOR SUB'D APPROVAL
____ SITE PLAN FOR BLDG. PERMIT APPROVAL
____ FINAL PLAT APPROVAL

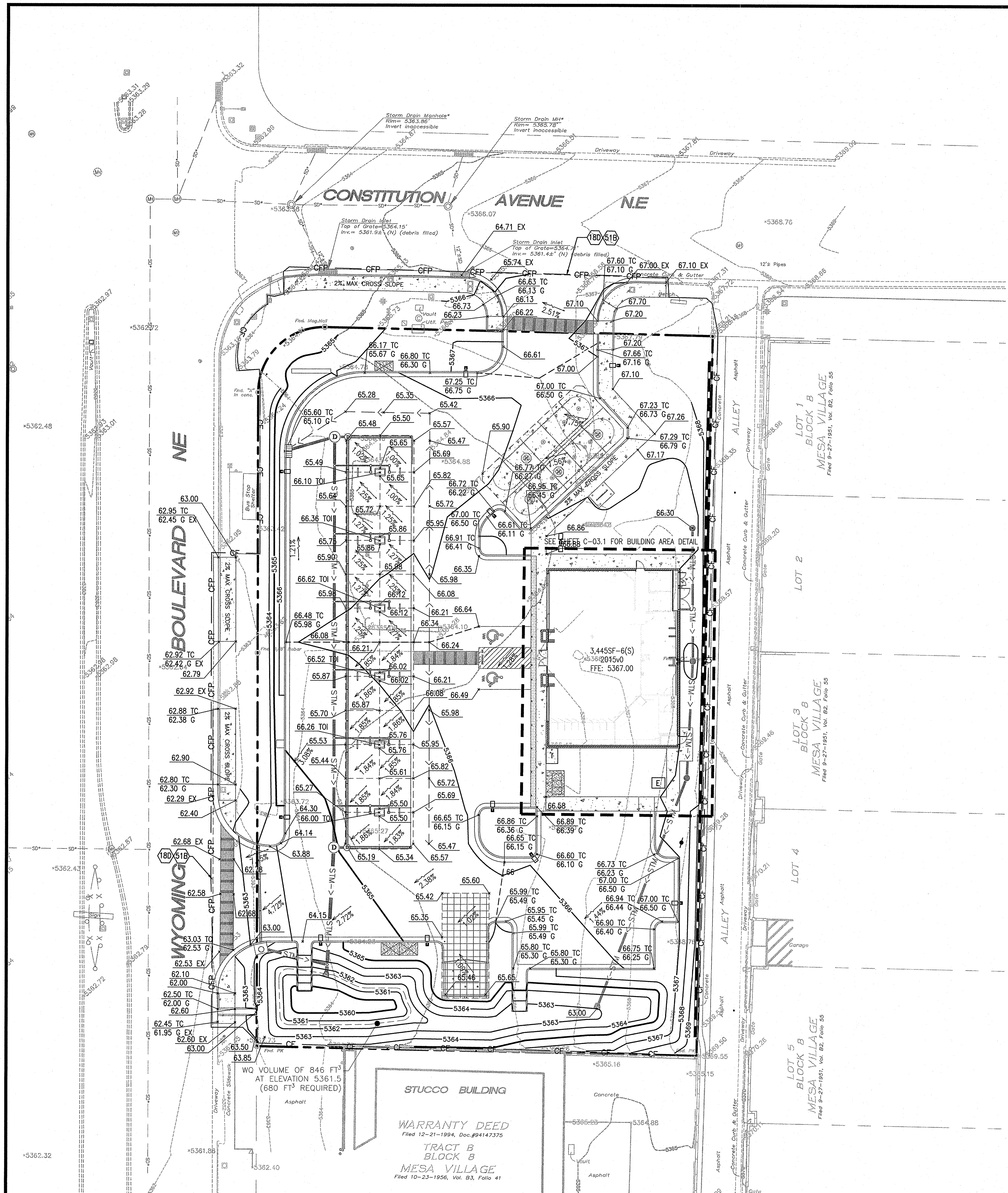
____ SIA/ RELEASE OF FINANCIAL GUARANTEE
____ FOUNDATION PERMIT APPROVAL
____ GRADING PERMIT APPROVAL
____ SO-19 APPROVAL
____ PAVING PERMIT APPROVAL
____ GRADING/ PAD CERTIFICATION
____ WORK ORDER APPROVAL
____ CLOMR/LOMR

____ OTHER (SPECIFY) ____

DATE SUBMITTED: 12/21/2017 By: Dominic Serra (Greenbergfarrow)

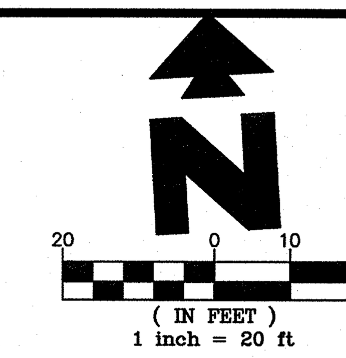
COA STAFF: ELECTRONIC SUBMITTAL RECEIVED: ____

FEE PAID: ____



CITY WATER QUALITY REQUIREMENT

$0.26 \times \text{IMPERVIOUS AREA} \times 43560 \times (\frac{1}{12})$:
$0.26 \text{ IN} \times 0.72 \text{ AC} \times 43560 \times (1\text{FT}/12\text{IN}) = 680 \text{ FT}^3$



CROSSWALKS AND AREAS WITHIN 5' OF BUILDING SHALL HAVE A MAXIMUM CROSS SLOPE OF 2%

EXISTING

- Sanitary Sewer Manhole
- Sanitary Sewer Manhole as shown on provided plans – Not Found
- Manhole Unknown Utility
- Manhole as shown on provided plans – Not Found
- Storm Drain Inlet
- Power Pole
- Power Pole w/underground feed
- Power Pole/Light Pole
- Guy Wire
- Sanitary Sewer Clean-out
- Water Meter
- Water Valve
- Hydrant
- Electric Pedstal
- EM Electric Meter
- Traffic Box
- SAS* SANITARY SEWER LINE
- SD* STORM DRAIN LINE
- G* GAS LINE
- OHW OVERHEAD POWER LINE
- Telephone Pedestal
- Traffic Light Pole
- Overhead Traffic Light Pole
- Pedestrian Pushbutton Post
- Utility Box
- Light Pole
- Bollard
- Concrete Symbol
- Gas Meter
- Gas Valve
- Metal Post Fence
- Chain Link Fence
- Guard Rail
- Qwest Manhole
- Communications Manhole
- Sign
- Tree

PROPOSED

- PROPERTY LINE
- CONCRETE CURB & GUTTER
- XXXX PROPOSED CONTOUR
- CF CONSTRUCTION FENCE
- CFP CONSTRUCTION FENCE ON PAVEMENT (SEE DETAIL SHEETS)
- X% DRAINAGE SLOPE AND DIRECTION
- SPOT ELEVATIONS:
  - XXXX TC TOP OF CURB
  - XXXX G GUTTER
  - XXXX TOI TOP OF ISLAND
  - XXXX EX. EXISTING ELEVATION
  - XXXX TS TOP OF SIDEWALK
- RIDGELINE
- STM-> STM-> PROPOSED STORM SEWER PIPE
- HC ACCESSIBLE PATH. CROSS SLOPE SHALL BE 2% OR LESS
- <— <— DRAINAGE PATH

NOTE: SPOT ELEVATIONS SHORTENED FOR CLARITY. ADD 5300 TO ELEVATION STATED.

GENERAL GRADING NOTES

A. PRIOR TO INSTALLATION OF STORM OR SANITARY SEWER, WATER MAIN OR ANY OTHER UTILITIES, THE CONTRACTOR SHALL EXCAVATE, VERIFY, AND CALCULATE ALL POINTS OF CONNECTION AND ALL UTILITY CROSSINGS AND INFORM THE OWNER AND THE ENGINEER OF ANY CONFLICTS OR REQUIRED DEVIATIONS FROM THE PLAN PRIOR TO CONSTRUCTION. NOTIFICATION SHALL BE MADE A MINIMUM OF 72 HOURS PRIOR TO CONSTRUCTION, THE ENGINEER AND ITS CLIENTS SHALL BE HELD HARMLESS IN THE EVENT THAT THE CONTRACTOR FAILS TO MAKE SUCH NOTIFICATION.

B. ALL SLOPES AND AREAS DISTURBED BY CONSTRUCTION SHALL BE GRADED SMOOTH AND FOUR INCHES OF TOPSOIL APPLIED. IF ADEQUATE TOPSOIL IS NOT AVAILABLE ON SITE, THE CONTRACTOR SHALL PROVIDE TOPSOIL, APPROVED BY THE OWNER, AS NEEDED. THE AREA SHALL THEN BE SEEDED/SODDED, FERTILIZED, MULCHED, WATERED AND MAINTAINED UNTIL HARDY GRASS GROWTH IS ESTABLISHED IN ALL AREAS. ANY RELOCATED TREES SHALL BE MAINTAINED UNTIL SUCH POINT AS TREE IS RE-ESTABLISHED. ANY AREAS DISTURBED FOR ANY REASON PRIOR TO FINAL ACCEPTANCE OF THE PROJECT SHALL BE CORRECTED BY THE CONTRACTOR AT NO ADDITIONAL COST TO THE OWNER.

C. THE CONTRACTOR IS SPECIFICALLY CAUTIONED THAT THE LOCATION AND/OR ELEVATION OF EXISTING UTILITIES AS SHOWN ON THESE PLANS IS BASED ON RECORDS OF THE VARIOUS UTILITY COMPANIES, AND WHERE POSSIBLE, MEASUREMENTS TAKEN IN THE FIELD. THE INFORMATION IS NOT TO BE RELIED ON AS BEING EXACT OR COMPLETE. THE CONTRACTOR MUST CALL THE APPROPRIATE UTILITY COMPANY AT LEAST 72 HOURS BEFORE ANY EXCAVATION TO REQUEST EXACT FIELD LOCATION OF UTILITIES.

D. CONTRACTOR IS SPECIFICALLY CAUTIONED THAT THE PROPOSED GRADES SHOWN ON THESE PLANS ARE NOT FROM AN AS-BUILT SURVEY. THE INFORMATION IS NOT TO BE RELIED ON AS BEING EXACT OR COMPLETE. THE CONTRACTOR WILL BE RESPONSIBLE FOR VERIFYING EXISTING ELEVATIONS BEFORE COMMENCING CONSTRUCTION. EXISTING AND PROPOSED CONTOURS ARE FOR REFERENCE ONLY.

E. THE CONTRACTOR IS SPECIFICALLY CAUTIONED THAT THE LOCATION OF THE CONSTRUCTION TRAILER AND FENCING SHALL NOT AFFECT THE WAL-MART TRAFFIC FLOW.

F. CONTRACTOR TO FIELD VERIFY ELEVATIONS OF PROPOSED DRAINAGE STRUCTURES AND ADJACENT PAVEMENT CONSTRUCTED BY WAL-MART PRIOR TO STARTING CONSTRUCTION.

G. REFER TO GEOTECHNICAL REPORT FOR SPECIFIC SITE SOIL CONDITIONS AND CONSIDERATIONS.

H. CONTRACTOR SHALL COMPLY COMPLETELY WITH THE LATEST STANDARDS OF OSHA DIRECTIVES OR ANY OTHER AGENCY HAVING JURISDICTION FOR EXCAVATION AND TRENCHING PROCEDURES. THE CONTRACTOR SHALL USE SUPPORT SYSTEMS, SLOPING, BENCHING AND OTHER MEANS OF PROTECTION. THIS IS TO INCLUDE, BUT NOT LIMITED FOR ACCESS AND EGRESS FROM ALL EXCAVATION AND TRENCHING. CONTRACTOR IS RESPONSIBLE FOR COMPLYING WITH PERFORMANCE CRITERIA AS REQUIRED BY OSHA.

I. CONTRACTOR SHALL TAKE ALL APPROPRIATE MEASURES TO KEEP SEDIMENT FROM ENTERING THE WAL-MART PARKING AREA AND ENSURE THAT THE PARKING AREA IS KEPT CLEAN.

J. ALL HDPE PIPE SHALL BE N-12 WT IB (OR EQUIVALENT) WITH SMOOTH INTERIOR AND ANNULAR EXTERIOR CORRUGATIONS. 4"-48" PIPE SHALL MEET ASTM F2648 (OR AASHTO M252 TYPE S) REQUIREMENTS, AND SHALL HAVE A MINIMUM MANNINGS "n" DESIGN VALUE OF 0.012. JOINTS SHALL BE WATERTIGHT ACCORDING TO ASTM D3212 (OR AASHTO M252. M294) REQUIREMENTS. GASKETS SHALL MEET THE REQUIREMENTS OF ASTM F477. JOINT PERFORMANCE, FITTINGS, MATERIAL PROPERTIES, AND INSTALLATION SHALL BE DONE PER THE COMPLETE ADS SPECIFICATION FOR ADS N-12 WT IB PIPE FOUND IN THE ADS, INC. DRAINAGE HANDBOOK, LATEST EDITION.

K. IF USING HDPE PERFORATED PIPE FOR SUBSURFACE DRAINAGE AND DETENTION/RETENTION SYSTEMS, THE PERFORATIONS SHALL MEET THE AASHTO CLASS II STANDARD PERFORATION PATTERN REQUIREMENTS.

GRADING NOTES

18D MATCH EXISTING PAVEMENT ELEVATIONS
51B LIMITS OF SAWCUT AND PAVEMENT REMOVAL.

CALL BEFORE YOU DIG 1-800-321-ALERT NEW MEXICO ONE CALL SYSTEM

SHEET NO. C-3

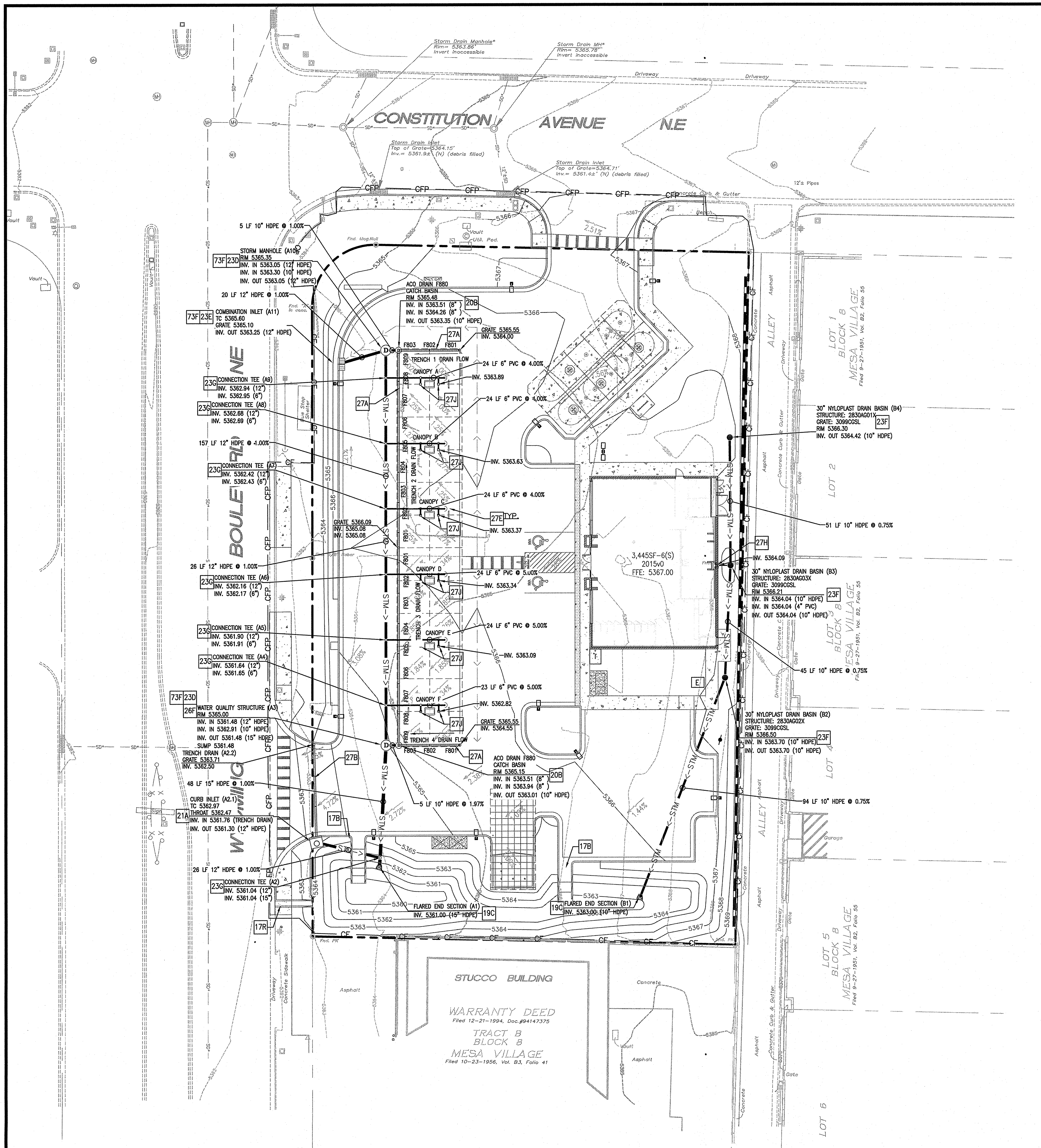
JOHN H. NOURZAD NEW MEXICO 19862 PROFESSIONAL ENGINEER 11/15/17

REV-1	11-15-17	YO	TR	DS	DS
	DATE	PRN	PM	DES	DRW

GRADING PLAN
MURPHY EXPRESS
1358 WYOMING BLVD
ALBUQUERQUE NEW MEXICO

GreenbergFarrow
1430 W. PEACHTREE ST. NW
ATLANTA, GA 30309
PHONE: (404) 601-4000
DWG NAME: ALBUQUERQUE, NM
JOB NO.: 20161221.0
20161221.0

MURPHY OIL USA, INC.
200 PEACH ST.
EL DORADO, AR 71730
MURPHY USA



CITY WATER QUALITY REQUIREMENT

0.26 X IMPERVIOUS AREA X 43560 X ($\frac{1}{12}$):
0.26 IN X 0.72 AC X 43560 X (1FT/12IN) = 680 FT^3

THIS PROPERTY IS NOT LOCATED WITHIN ANY PRESENTLY ESTABLISHED 100–YEAR FLOOD PLAIN, AS SHOWN BY THE FEDERAL EMERGENCY MANAGEMENT AGENCY, FLOOD INSURANCE RATE MAP # 35001C0356H, COMMUNITY PANEL NUMBER 356 OF 825 DATED AUGUST 16, 2012.

POST–DEV LAND USE

IMPERVIOUS AREA	0.72 AC
PERVIOUS AREA	0.36 AC
TOTAL AREA	1.08 AC

(IN FEET)
1 inch = 20 ft

EXISTING

Sanitary Sewer Manhole
Sanitary Sewer Manhole as shown on provided plans – Not Found
Manhole Unknown Utility
Manhole as shown on provided plans – Not Found
Storm Drain Inlet
Power Pole
Power Pole w/underground feed
Power Pole/Light Pole
Guy Wire
Sanitary Sewer Clean–out
Water Meter
Water Valve
Hydrant
Electric Pedstal
Electric Meter
Traffic Box
SAS* SANITARY SEWER LINE
SD* STORM DRAIN LINE
G* GAS LINE
OHW OVERHEAD POWER LINE
Telephone Pedestal
Traffic Light Pole
Overhead Traffic Light Pole
Pedestrian Pushbutton Post
Utility Box
Light Pole
Bollard
Concrete Symbol
Gas Meter
Gas Valve
Metal Post Fence
Chain Link Fence
Guard Rail
Qwest Manhole
Communications Manhole
Sign
Tree

PROPOSED

PROPERTY LINE
PROPOSED CURB AND GUTTER
XXXX PROPOSED CONTOUR
CF CONSTRUCTION FENCE
CFP CONSTRUCTION FENCE ON PAVEMENT (SEE DETAIL SHEETS)
X% DRAINAGE SLOPE AND DIRECTION
STM–> STM–> PROPOSED STORM SEWER PIPE

GENERAL GRADING NOTES

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F. ALL HDPE SHALL BE N–12 WT IB (OR EQUIVALENT) WITH SMOOTH INTERIOR AND ANNULAR EXTERIOR CORRUGATIONS. 4"–60" PIPE SHALL MEET ASTM F2648 (OR AASHTO M252 TYPE S) REQUIREMENTS, AND SHALL HAVE A MINIMUM MANNINGS "n" DESIGN VALUE OF 0.012. JOINTS SHALL BE WATERTIGHT ACCORDING TO ASTM D3212 (OR AASHTO M252. M294) REQUIREMENTS. GASKETS SHALL MEET THE REQUIREMENTS OF ASTM F477. JOINT PERFORMANCE, FITTINGS, MATERIAL PROPERTIES, AND INSTALLATION SHALL BE DONE PER THE COMPLETE ADS SPECIFICATION FOR ADS N–12 WT IB PIPE FOUND IN THE ADS, INC. DRAINAGE HANDBOOK, LATEST EDITION.

G. IF USING HDPE PERFORATED PIPE FOR SUBSURFACE DRAINAGE AND DETENTION/RETENTION SYSTEMS, THE PERFORATIONS SHALL MEET THE AASHTO CLASS II STANDARD PERFORATION PATTERN REQUIREMENTS.

H. UNLESS OTHERWISE INDICATED, ALL STORM SEWER LINES 18"–54" DIAMETER ARE TO BE REINFORCED CONCRETE PIPE ACCORDING TO ASTM C–76 TYPE III.

STORM DETAILS – SEE DETAIL SHEETS

17B CONCRETE FLUME
17R DRAINAGE SIDEWALK CULVERT W/ STEEL PLATE TOP
19C FLARED END SECTION
20A JUNCTION BOX
20B ACO DRAIN F880 CATCH BASIN
21A CURB INLET
23E COMBINATION INLET
23F NYLOPLAST ENGINEERED STRUCTURE MANUFACTURED BY ADS PIPE (OR APPROVED EQUAL). SEE STRUCTURE AND GRATE/LID MODEL NUMBER INDICATED AT SYMBOL. STRUCTURES IN DRIVES MUST BE DESIGNED TO WITHSTAND H–20 LOADING. STRUCTURES IN LANDSCAPED AREAS USE NON–TRAFFIC INSTALLATION DETAIL.
23G TEE CONNECTION (INSERTA TEE OR EQUIVALENT WATER TIGHT CONNECTION)
26F HYDRO INTERNATIONAL "FIRST DEFENSE" WQ UNIT
27A ACO DRAIN FLOWDRAIN – FG200 WITH LONGITUDINAL DUCTILE IRON GRATE (ADA COMPLIANT).
27B TRENCH DRAIN
27E STORM DRAIN CLEAN–OUT
27H ROOF DRAIN DOWNSPOUT CONNECTION
27J CANOPY DRAIN DOWNSPOUT CONNECTION
73F WATERSTOP STRUCTURE CONNECTION FOR HDPE PIPE

CALL BEFORE YOU DIG 1-800-321-ALERT NEW MEXICO ONE CALL SYSTEM

SHEET NO.
C-3.2

JOHN H. NOURZAD
NEW MEXICO
9062
PROFESSIONAL ENGINEER
11/15/17

REV–1	11–15–17	YO	TR	DS	DS
	DATE	PRN	PM	DES	DRW

STORM DRAINAGE PLAN
MURPHY EXPRESS
1358 WYOMING BLVD
ALBUQUERQUE NEW MEXICO

GreenbergFarrow
1430 W. PEACHTREE ST. NW
ATLANTA, GA 30309
PHONE: (404) 601-4000
DWG NAME: ALBUQUERQUE, NM
JOB NO.: 20161221.0
20161221.0

MURPHY OIL USA, INC.
MURPHY USA
200 PEACH ST.
EL DORADO, AR 71730

STORMWATER REPORT

PREPARED FOR

MURPHY EXPRESS

1358 Wyoming Blvd
Albuquerque, New Mexico

Prepared by:

GreenbergFarrow
1430 W. Peachtree Street NW, Suite 200
Atlanta, GA 30309
T: (404) 601-4000
F: (404) 601-3990

GFA PROJECT No. 20161221.0

November 27, 2017

JOHN H. NOURZAD
NEW MEXICO
PROFESSIONAL ENGINEER

11/27/17

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Appendix "A" – Bio Retention Area Specifications

Appendix "B" – Pre-Development Analysis

Appendix "C" – Post Development Analysis

Appendix " D" – Miscellaneous Information

Project Description:
The project site is located at the corner of Wyoming Boulevard and Constitution Avenue in Albuquerque, New Mexico. The Property Size is 1.08 acres. The disturbed acreage is 1.23 acres. The total area of study in this report is approximately 1.08 acres.

The project will consist of demolition, grading, utility installation, hardscape installation, erosion control and building construction. There will be no offsite drainage through this site. Storm water requirements from this site shall be handled via a bio retention area, trench drain system and storm drainage pipes design per the City of Albuquerque Drainage, Flood Control and Erosion Control Ordinance. Water quality requirements shall be handled through the bio retention area. The bio retention area will be irrigated. A hydro dynamic device (oil/water separator) shall function as a method of pre-treatment for the storm water before it flows into the proposed Bio Retention Area. This site located in a zone 3 precipitation zones between San Mateo and Eubank, North of Interstate 40, and between San Mateo and the East Boundary of Range 4 East, South of Interstate 40.

Methodology:
This report was prepared in accordance with the City of Albuquerque Drainage, Flood Control and Erosion Control Ordinance. The principal design storm is the 100 year 6 hour event defined by NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Vol. IV-New Mexico. Assume an AMC II condition (a normally dry watershed). For design of retention or detention ponds, storms of 24 hour or longer duration may be required. The 24-hour event is defined by the NOAA Atlas 2. The 4-day and 10-day events can be obtained using the procedures in S.C.S. TSC Technical Note-Hydrology, PO-6 (Rev.2). The peak discharge storm water runoff values shall be estimated for pre-developed to post developed conditions. The increased runoff must be controlled on site. In no instance shall storm water runoff be released from a site which may adversely impact the downstream capacity of any drainage structure either peak rate of flow or volume.

The analysis uses the SCS unit hydrograph method using a type II-24 hour storm distribution. A minimum time of concentration of 5 minutes was used where ever applicable. Rainfall totals and soil types where obtained from the above referenced documents and are included in Appendix D. Pond routing calculations were performed using, the computer program HydroCad (version 10.0) by Hydrocad software solutions LLC.

Storm pipe calculations were performed using Hydraflow Storm Sewer Extension for Civil 3D 2016 by Autodesk, Inc. The hydraulic grade line was analyzed using this software to ensure the proposed pipes have sufficient capacity to handle the expected post-developed flows for the 100 year storm event.

Soils Description:
The site consists of EtC, Embudo-Tijeras, soil. The EmbudoTijeras complex (EtC), 0 to 9% slopes. These soils consist of well drained gravelly fine sandy loam with a water table greater than 80 inches. This soil type has a hydraulic permeability of about 2.00 to 6.00 inches per hour, a high risk of corrosion of steel and exhibit a low shrink-swell potential. The infiltration rate has been determined to be 1.41 in/hr. The soil group has been determined to be “B”.

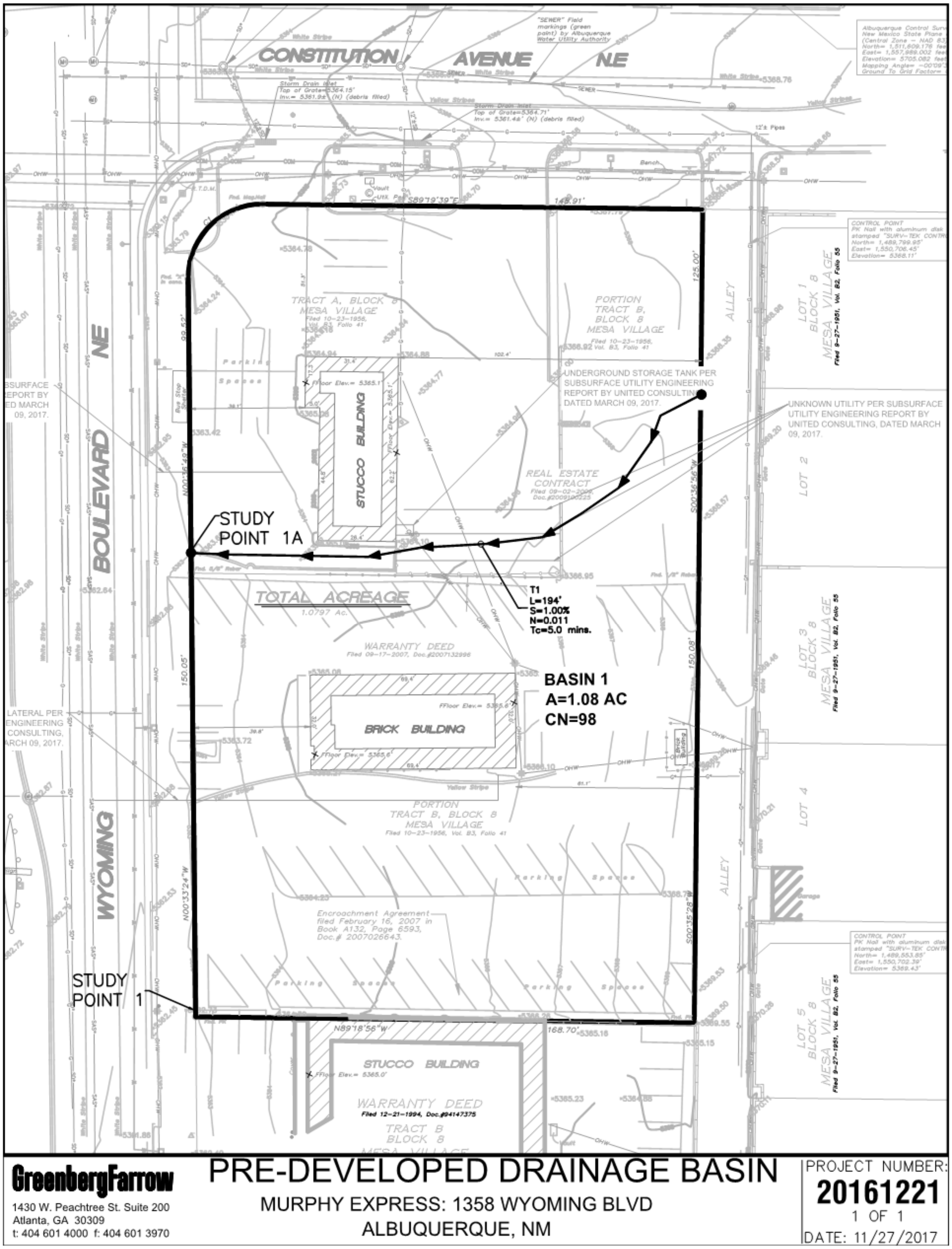
Pre-Developed Conditions:

The project site lies at the corner of Wyoming Blvd and Constitution Avenue NE in Albuquerque, New Mexico. The terrain consists of two existing building with all of their associated hardscape items and utilities. The storm water currently sheet flows and exits the site along the west side into Wyoming Blvd at Study Point 1A. Study Point 1A is equal to Study Point 1. Note that study point 1 has been defined as the furthermost point on our site at which the Basin 1 storm water flows impacts the existing storm drainage system located along Wyoming Boulevard. Constitution Avenue NE has no storm water impacts from this site.

		Pre-Developed Drainage Basin Information				
Basin No.	**Drain. Area, Ac**	**Imperv. Area, Ac**	**Perv. Area, Ac**	**Cnw**	**Tc, mins.**	**Study Pnt No.**
1	1.23	1.23	0	98	5.0	1A
Total	1.23	1.23	1.23			

Pre-Developed Storm Water Basin Flows			
Basin No.	**Q100, cfs**	**Vol. 100, cf**	**Study Pnt. No.**
1	4.71	10,760	1A
Total	4.71	10,760	

Pre-Developed Conditions Drainage Area Map



Post Developed Conditions:

The project will consist of the construction of a fuel station including a 3445 sf C-store with all of its associated utility and hardscape items. Storm water will flow from the northeast side of the site to the south side of the site into a proposed Bio Retention Area. The storm water will then flow into the groundwater system via exfiltration and an emergency overflow weir. All storm water flow for events equal to and greater than the 100-year storm event shall be routed through the emergency spillway. The storm water will then flow onto Wyoming Blvd. Study point 1A has been defined as storm water flows from Basin 1A that exits our site as sheet flow onto Wyoming Boulevard. Study point 1B has been defined as storm water flows from Basin 1B that flows into the proposed Bio Retention Area and eventually onto Wyoming Blvd. Study point 1 is now the sum of study point 1A and study point 1B. Study point 1 is total cumulative storm water flow that will directly affect Wyoming Blvd.

		Post-Developed Drainage Basin Information				
Basin No.	**Drain. Area, Ac**	**Imperv. Area, Ac**	**Perv. Area, Ac**	**Cnw**	**Tc, mins.**	**Study Pnt No.**
1A	0.24	0.110	0.130	97	5.0	1A
1B (ROUTED)	0.99	0.730	0.260	97	5.0	1B
Total	1.23	0.840	0.390			

Post-Developed Storm Water Basin Flows			
Basin No.	**Q100, cfs**	**Vol. 100, cf**	**Study Pnt. No.**
1A	0.90	2,005	1A
1B (ROUTED)	3.73	8,273	1B
Total	4.63	10,278	

Bio Retention Area Information			
Storm	**Release Rate, cfs**	**Peak Elev., Ft**	**Volume, cf**
Q100	2.09	5363.50	2323

Water Quality Volume Calculations(Per City Requirements):

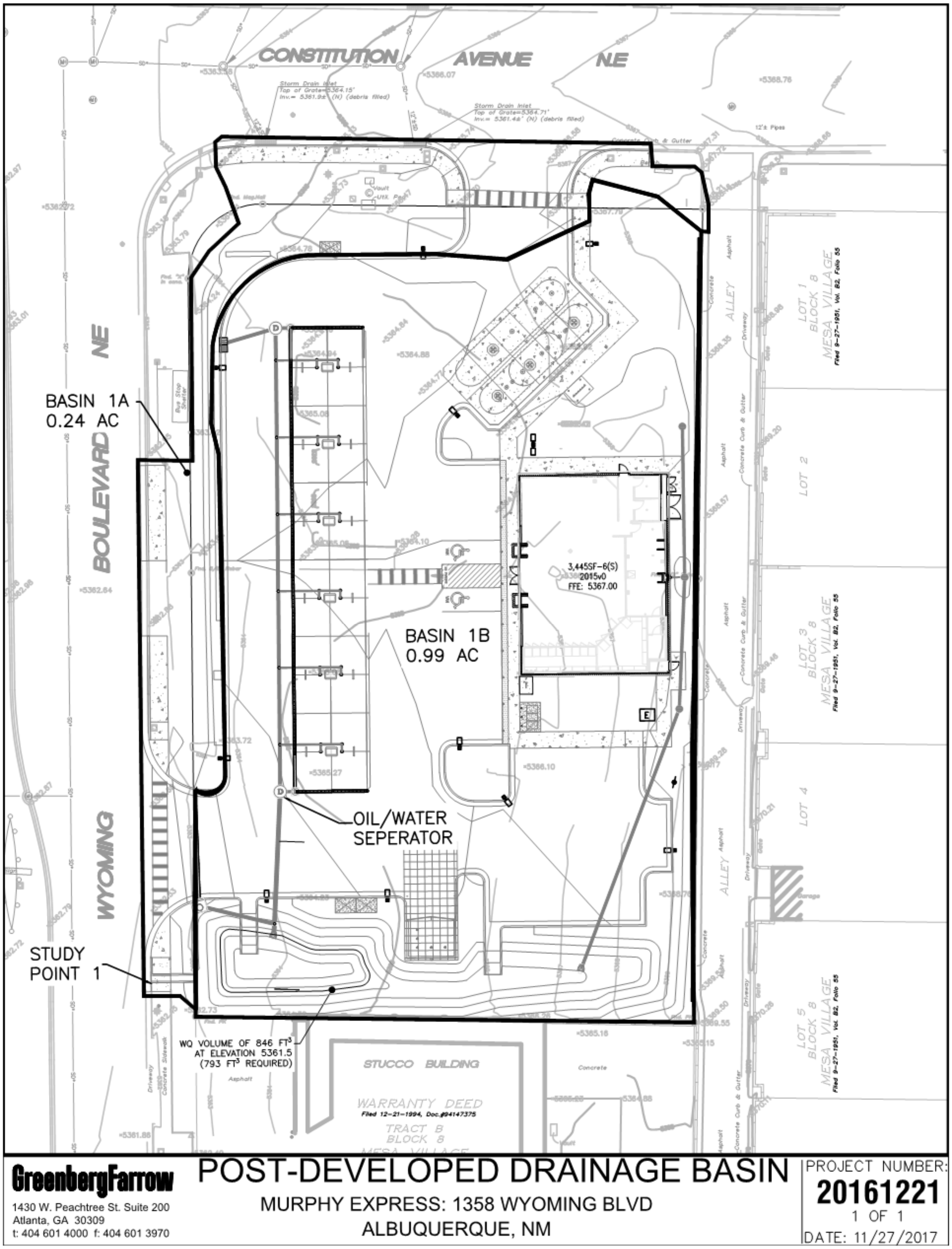
$WQv_{required} = 0.26*I*43560*(1/12)$

$WQv_{required}$=Water Quality Volume (ft^3)
I = Impervious Area in (Ac)

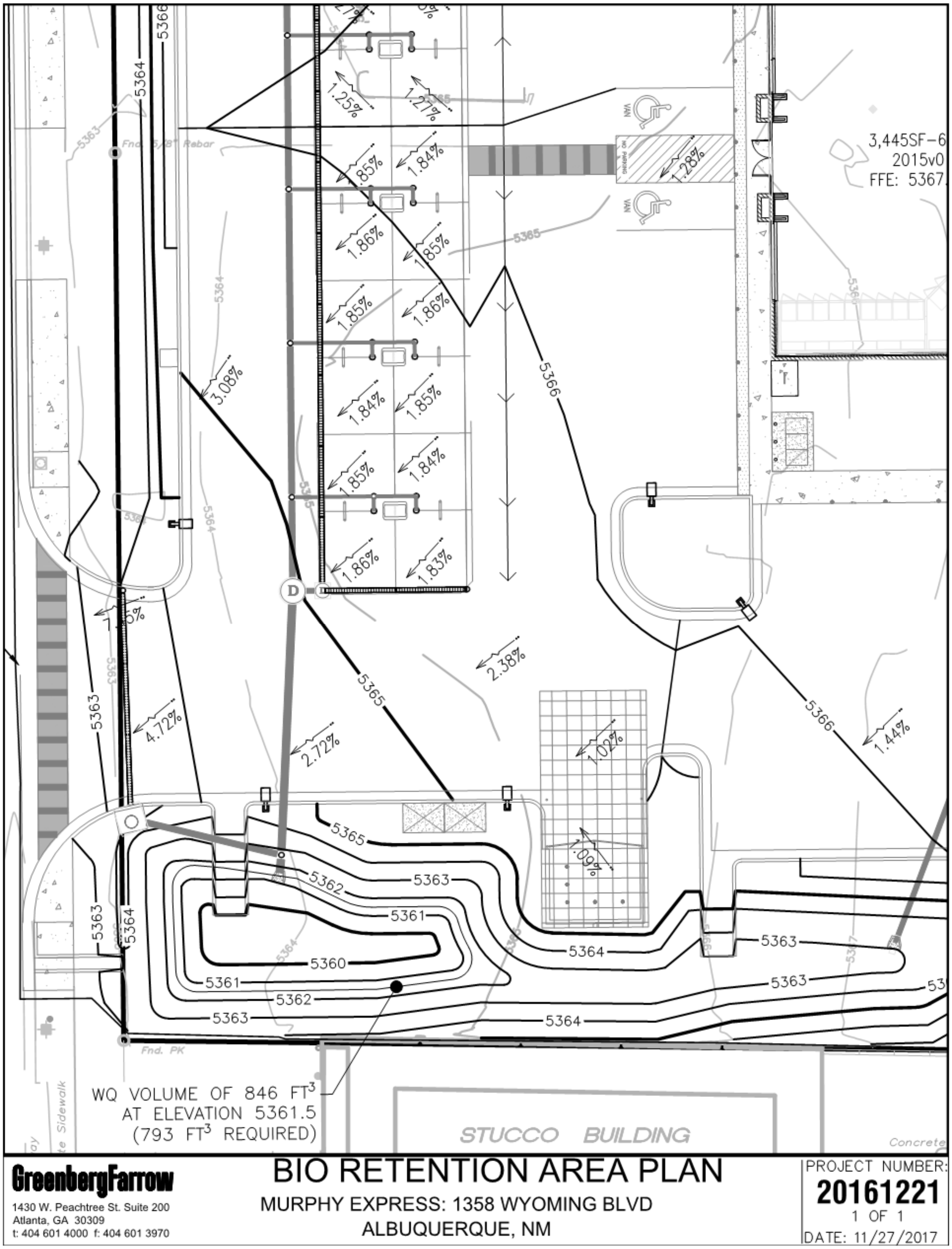
I = 0.84 Ac
$WQv_{required} = 0.26*0.84*43560*(1/12) = 793\ ft^3$

Water Quality Volume Elevation is 5361.50, with a provided water quality volume of 846 ft^3.

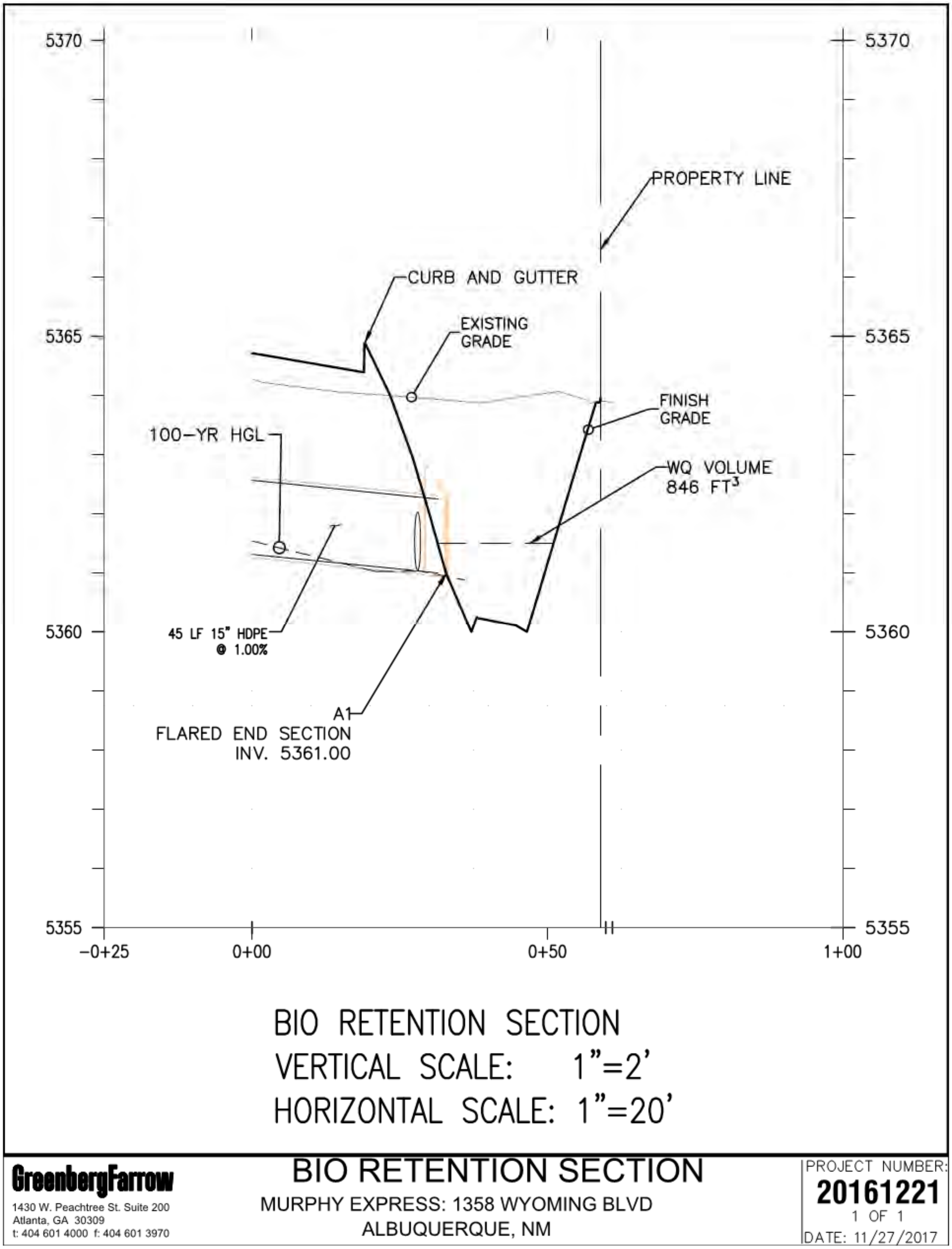
Post Development Drainage Area Map



Bio Retention Area Plan



Bio Retention Typical Section



Summary Tables:

Basin 100 Year Storm Water Flow Information		
Study Point	Pre-Develp. Conditions, cfs	Post Develp. Conditions,cfs
1	4.71	2.99

Basin 100 Year Storm Water Volume Information		
Study Point	Pre-Develp. Conditions, cf	Post Develp. Conditions,cf
1	10,760	4,328

The Post-developed runoff for the 100-Yr condition is less that the Pre-developed condition (2.99 cfs< 4.71 cfs)

It has been demonstrated in this report and shown in the above tables that the net developed storm runoff from the site for 100 year storm event will be less than the existing storm runoff for the 100 year storm event.

Appendix “A”- Bio Retention Area Specifications

2.7

SECTION 2: POST-CONSTRUCTION

Filtrexx® Rain Garden Bioretention System (GrowingMedia™/GroSoxx®)

PURPOSE & DESCRIPTION

The Filtrexx® **Rain Garden Bioretention System** is a storm water best management practice (BMP) that **utilizes soil, plants, and microbes to filter, retain, and infiltrate storm water runoff from developed sites**. Rain gardens are an important component of Low Impact Development (LID) strategies because it is relatively simple, inexpensive, effective and aesthetically attractive. Filtrexx® GrowingMedia™ is an important component of a successful rain garden installation.

APPLICATION

Rain gardens can be used on virtually any site utilizing a variety of design techniques. The most straightforward designs are on sites that (Winogradoff, 2001):

- Allow the rain garden facility to be located in close proximity to the source of run-off.
- Allow rain garden facilities to be dispersed uni formly throughout the site.
- Allow each rain garden facility to collect runoff from a sub-drainage area of one acre or less (maxi mum of two acres).
- Are large enough to accommodate the rain garden facilities within required setbacks.
- Contain high infiltration, stabile, and well structured in-situ soils.

Rain gardens can be installed on sites that do not meet all of these criteria, but it can be more difficult and often less successful. The key components of a rain garden are (Winogradoff, 2001):

- Pretreatment – it is important to filter excess debris and sediment from runoff before it reaches the rain garden in order to minimize maintenance.
- Flow Entrance – It is best to allow water to sheet flow directly into the facility, where concentrated flows enter through a curb cut or pipe it is important to dissipate the velocity of the runoff with stone, rip rap, or similar method.
- Ponding Area – The surface storage of runoff is accommodated in the ponding area. Acceptable depths range from 3 in -12 in (75-300mm), with 6 in (150mm) recommended.

Media Installation Method

- Plant Materials – Plants in a rain garden facility help to bind and uptake pollutants, remove water through evapotranspiration, encourage infiltration, and create an aesthetically pleasing landscape feature.
- Mulch – The mulch layer is an important medium for the adsorption and filtering of pollutants, as well as protecting the soil from eroding and drying out. A 3 in (75mm) blanket of Filtrexx® FilterMedia™ is recommended for this application.
- Planting Soil – The soil in a rain garden facility is specifically designed to filter pollutants, infiltrate water, and support plant growth. The soil must have a minimum infiltration rate of 2 in (50mm)/hr. A mixture of 75% coarse construction sand (grain size 0.02 in – 0.04 in [0.5-1.0mm]) and 25% GrowingMedia is recommended for this application.
- Underdrain with Pea Gravel Diaphragm – An underdrain is necessary when in-situ soils have an infiltration rate of less than 1 in/hr in order to ensure that the facility drains properly. A perforated pipe surrounded with a 6-9 in (150-225mm) layerof pea gravel that leads to a discharge point will serve this purpose.
- Overflow Outlet – All rain garden facilities must provide a means for excess water to overflow and be conveyed downstream.

ADVANTAGES AND DISADVANTAGES

Advantages

(Winogradoff, 2001; Hunt and Lord, 2006)

- Rain gardens reduce the volume of stormwater runoff leaving a developed site through interception of rainfall on vegetated surfaces.
- Rain gardens reduce the volume of stormwater runoff leaving a developed site through infiltration of runoff into the soil and groundwater.
- Rain gardens reduce the volume of stormwater runoff leaving a developed site through evapotranspiration.
- Rain gardens filter pollutants commonly found in storm water runoff by facilitating the settling of large particles.
- Rain gardens filter pollutants commonly found in storm water runoff by filtration through vegetation, GrowingMedia, and soil.
- Rain gardens filter pollutants commonly found in storm water runoff by uptake and assimilation by vegetation.
- Rain gardens filter pollutants commonly found in storm water runoff by adsorption to surfaces of solids in the soil mix and humus in GrowingMedia.
- Rain gardens filter pollutants commonly found in storm water runoff by decomposition of organic compounds by soil bacteria, fungi, and macro fauna.
- Rain gardens can reduce the temperature of storm water runoff before it enters surface water bodies.
- Rain gardens provide attractive landscape opportunities, which have been shown to increase property values up to 20%.
- Rain gardens create wildlife habitat and a sense of place when plants native to the region are specified.
- Rain gardens can increase awareness and stewardship of the environment.
- Rain gardens are a permanent BMP that will provide years of benefit.
- Rain gardens are adaptable, and designs can be customized to accommodate virtually any site.
- Proper rain garden design can help developed sites mimic pre-development hydrology.
- Rain gardens are an important component of a LID approach to storm water management.
- Rain gardens can often be retrofitted into existing sites.
- If planned appropriately, the comprehensive use of rain gardens, rather than conventional pipe and pond methods, can save 15-50% of site development costs.
- Rain gardens may assist in qualification for LEED® Green Building Rating and Certification credits under LEED Building Design & Construction (BD+C), New Construction v4. Awarded credits may be possible from the categories of Sustainable Sites, Water Efficiency, Materials & Resources, and Innovation. *Note: LEED is an independent program offered through the U.S. Green Building Council. LEED credits are determined on a per project basis by an independent auditing committee. Filtrexx neither guarantees nor assures LEED credits from the use of its products. LEED is a trademark of the U.S. Green Building Council.*

ADVANTAGES	LOW	MED	HIGH
Installation Difficulty	✓		
Sediment Control		✓	
Solluable Pollutant Control			✓
Infiltration Reduction		✓	
Runoff Velocity Reduction		✓	
Vegetation Establishment			✓

Disadvantages

- If not installed correctly, maintained or used for a purpose or intention that does not meet specifications, performance may be diminished.
- If rain garden soil is not the specified mix of sand and GrowingMedia, performance may be diminished.
- If rain garden soils are compacted, performance may be severely diminished.
- Rain gardens should not be used in areas with a high water table (must be 2 in (50mm) below the invert elevation of the facility).
- Each rain garden facility should not receive runoff from a drainage area of greater than 1 acre (0.4 ha) with max 2 acres (0.8 ha).
- Rain garden facilities should not receive concentrated, high-velocity flows.
- Rain garden facilities should be located 100 ft (30m) or more away from wells or

source-water locations.
- Rain garden facilities should be placed 50 ft (15m) or more away from the edge of septic drain fields.
- Rain garden facilities should be placed 5 ft (1.5m) or more away from buildings and foundations, and at least 25 ft (8m) away from basements. If bedrock or subsurface geologic formations direct subsurface flow toward building foundation, distances should be increased.

MATERIAL SPECIFICATIONS

Rain gardens use only Soxx™ photodegradable or biodegradable netting materials available from Filtrexx International, and are the only mesh materials accepted in creating filtration systems for any application. For Soxx Material Specifications see Table 1.1.

GROWINGMEDIA CHARACTERISTICS

Rain garden designs use only Filtrexx GrowingMedia which is a composted material that is specifically designed for management of storm water runoff, and establishment and sustainability of plant vegetation. GrowingMedia may be third party tested to meet minimum performance criteria defined by Filtrexx International. Performance parameters include: hydraulic flow-though rate, percent cover of vegetation, water holding capacity, pH, organic matter, soluble salts, moisture content, biological stability, percent inert material, bulk density and particle size distribution. For information on the physical, chemical, and biological properties of GrowingMedia refer to refer to Specification 6.2 Filtrexx® GrowingMedia™

PERFORMANCE

Testing conducted at the Soil Control Lab, Inc. under simulated runoff conditions of sediment-laden water found that hydraulic flow-through rates for GrowingMedia used in Runoff diversion is less than 1 gpm/linear ft (<1 L/min/m). Field testing conducted by Filtrexx International has shown that vegetation establishment can be near 100%. Although research has not been conducted on Filtrexx rain gardens, conservative assumptions can be made from performance testing and research on Filtrexx® Compost Erosion Control Blanket™ and Filtrexx® SiltSoxx™. Summaries of performance testing and research results from these systems can be found in the Appendices. Hunt and Lord (2006) reported that rain gardens can:

Fully Established, Functioning Rain garden

- Reduce Nitrogen loads up to 40%,
- Reduce TSS up to 98%,
- Reduce metals up to 95%,
- Reduce COD up to 97%,
- Reduce Temperatures 5-10 degrees, and
- Reduce oil and grease 67%.

Dietz and Clausen (2006) reported that a 2 in (50 mm) layer of organic hardwood mulch on the surface of a rain garden retained 33% of total total nitrogen (TN) and 100% of total total phosphorus (TP) inputs from storm runoff over a 2 yr period. Further, the organic layer retained 98%, 36%, and 16% of copper (Cu), lead (Pb), and zinc (Zn) inputs, respectively. The study concluded that the organic layer was a sink for nutrient and metal pollutants, retaining a much greater percentage of these pollutants than the vegetation in the rain garden.
Note: The Engineer may work outside the minimum construction requirements as needed to create a functioning stormwater management system.

DESIGN CRITERIA

Sizing:
There are many methods available to size rain garden areas. Check with your local development office or jurisdictional storm water management design manual to determine if there are specific guidelines or requirements for your area. A simple method is provided here.

Step 1: Delineate the development site drainage in the pre and post development condition. Delineate sub drainage divides for the post development condition, identifying strategic locations for possible rain garden facilities. rain gardens are most effective with many small facilities distributed throughout the site. The drainage area for each facility should be one acre or less, with a maximum of two acres.

Step 2: Determine the 'first flush' rainfall amount in your area. This should be somewhere between a 0.5 in (15mm) and 1.5 in (40mm) rainfall event. If no information exists for your area, use 1 in as the first flush event.

Step 3: Determine the amount of runoff contributed by each sub drainage area during the first flush rain event. This can be done in two steps, starting by using an equation from the National Resource Conservation Service (NRCS), TR-55 Method, to determine the amount of runoff from a given surface:

Runoff depth (in,mm) = $(P - 0.2 S)^2 \div (P + 0.8 S)$

Where,
P = Precipitation (typically use 1 in [25mm])
S = 1,000 ÷ CN – 10
CN = Curve Number
CN is a measure of the amount of water that will infiltrate a particular surface type during a storm. Curve Numbers for various surface types are provided by the NRCS, and some are summarized in Table 7.1.

Step 4: Determine a volume of water to be collected in the rain garden facility. Multiply the **Runoff Depth** from above (upslope) by the area of the sub drainage area. Be sure to convert the runoff depth from inches to feet before continuing.

Runoff Volume (cubic ft., cubic m) =
Drainage Area x Runoff Depth

This is the total volume that the rain garden must hold for this sub drainage area.

Step 5: Determine the surface area required for the rain garden facility. Simply divide the volume by the design depth (typically 0.5 ft [150mm])

Rain garden Surface Area =
Rain garden Volume ÷ Rain garden Depth

Gradient:
The bottom of the rain garden facility should be level and flat in order to disperse the inflow across the entire surface area and prevent concentration in low areas.

Rain gardens should not be placed in areas that have slopes greater than 20%.

Overflow:
Since rain gardens are designed to collect runoff from relatively small and frequent storm events, an alternate path must be provided for runoff during large (anything larger than the first flush rainfall amount) storm events. The overflow can be accommodated over the top of the rain garden area if the top and the conveyance channel downstream are appropriately stabilized. More typically, an overflow pipe is provided in the rain garden facility with the top of the pipe set at the design depth of the rain garden facility. The downstream discharge point must be appropriately stabilized.

Soil Depth:
For the best pollutant removal performance, the rain garden soil depth should be at least 30 in (750mm). The rain garden should be installed on non-compacted soil with a minimum of 2 ft (600mm) between the bottom of the structure and bedrock. Areas underlain by carbonate geology may require an impermeable lining based on municipal ordinances or at the recommendation of a geologic site investigation.

Existing Vegetation:
Existing trees or other native vegetation should not be cleared to make room for rain garden. Plan ahead to save areas of existing vegetation and locate rain garden in disturbed areas.

INSTALLATION

1. GrowingMedia used for rain garden facilities shall meet all Filtrexx specifications.
2. Contractor is required to be a Filtrexx® Certified℠ Installer as determined by Filtrexx International, (440-926-2607). Certification shall be considered current if appropriate identification is shown during time of bid or at time of application. Look for the Filtrexx Certified Installer Seal.

Completed Rain garden

3. Schedule a pre-construction meeting with Engineer, Filtrexx Certified Installer , and any other consultants that will be involved in the rain garden installation.
4. Rain garden facilities will be placed at locations indicated on plans as directed by the Engineer
5. Rain garden areas should be protected from compaction during the site construction phase
6. Construction site shall be graded and stabilized prior to the installation of rain garden facilities.
7. If in-situ soils were compacted during site construction, they shall be roto-tilled to a depth of 18 in (450mm) to restore porosity and infiltration capacity in areas designated for rain gardens.
8. Excavation and grading of rain garden areas shall be done by equipment located outside of the limits of the rain garden facility, or by equipment with marsh tracks or light equipment with turf-type tires.
9. Rain garden areas must be protected from erosion and sedimentation after final grades have been established for the facility.
10. Install underdrain system and observation wells, if specified.
11. Rain garden soil mix shall consist of 25% GrowingMedia and 75% coarse (grain size 0.02 in – 0.04 in [0.5-1.0mm]) construction sand that is clean and free of deleterious materials. The soil shall be mixed thoroughly to ensure a homogonous and consistent texture.
12. Rain garden soils shall be installed in lifts of 12 – 18 in (300-450mm) pneumatically or with non compacting methods. Each lift shall be lightly watered to encourage natural compaction. No mechanical compaction is permitted.
13. Rain garden's base should be at least 2 ft (600mm) above bedrock or geologic structures.
14. Rain garden soil mix shall have a minimum infiltration rate of 2 in (50mm) per hour.
15. Ensure that final grades are achieved as specified, taking into account the mulch layer that will be added after planting. Fine grading is extremely important for rain garden facilities. They are typically only 6 in (150mm) deep so an error of 2 in (50mm) may cause a 33% change in storage volume.
16. Install vegetation specified in the planting plan.
17. Install a 3 in (75mm) FilterMedia blanket as mulch over the entire rain garden area, or as specified by the Engineer. Install erosion control at entrance points in the form of surge stone or river rock, or as specified.
18. New planting may require irrigation during establishment. See design drawing details for correct rain garden installation (Figure 7.1 through 7.3).

INSPECTION

Regular inspection should occur throughout the installation process at the following times:

1. Pre-construction meeting.
2. Stabilization of construction site and beginning of excavation.
3. Installation of underdrain.
4. Delivery and installation of soil materials, including GrowingMedia.
5. Establishment of final grades of rain garden facility.
6. Delivery and installation of plant material.
7. Delivery and installation of FilterMedia blanket or mulch.
8. Establishment phase of plant material.

MAINTENANCE

1. The Contractor shall ensure that the site upstream from the rain garden area remains stabilized and does not contribute excessive sediment that may impair the performance of the rain garden area.
2. Plant materials may need to be irrigated during establishment.
3. Plant materials that do not establish, may need to be replaced.
4. The rain garden facility should be monitored for invasive non-native plant species. Any that are found should be eradicated.
5. FilterMedia should be replaced as necessary to ensure complete coverage of the surface of the rain garden area.

METHOD OF MEASUREMENT

Bid items shall show measurement as 'Filtrexx® Rain Garden' per square ft, square yd, square m, hectare, or acre installed, per depth (in. or mm) of system.

Engineer shall notify Filtrexx of location, description, and details of project prior to the bidding process so that Filtrexx can provide design aid and technical support.

ADDITIONAL INFORMATION

For other references on this topic, including additional research reports and trade magazine and press coverage, visit the Filtrexx website at www.filtrexx.com

Filtrexx International, Technical Support
61 N Clev-Mass Rd, Ste E, Akron, OH 44333
877-542-7699 | 234-466-0810 (fax)
www.filtrexx.com | info@filtrexx.com
Call for complete list of international installers.

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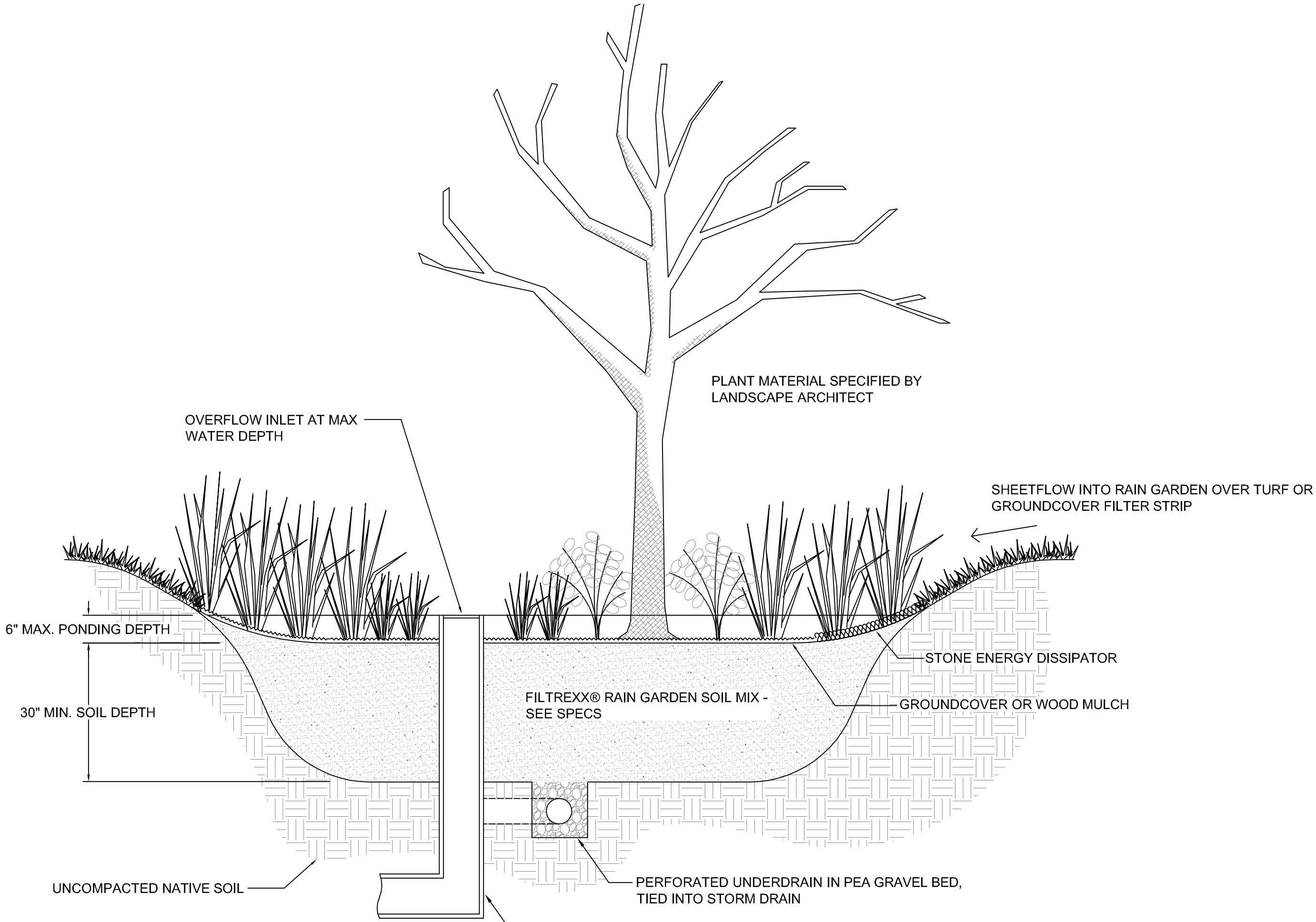
TABLES & FIGURES:

Table 7.1. USDA Soil Conservation Service Runoff Curve Numbers.

Description of Land Use	Hydrologic Soil Group			
	A	B	C	D
Paved parking lots, roofs, driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land*:				
Without conservation treatment (no terraces)	72	81	88	91
With conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre (0.05 ha) lots, about 65% impervious	77	85	90	92
1/4 Acre (0.1 ha) lots, about 38% impervious	61	75	83	87
1/2 Acre (0.2 ha) lots, about 25% impervious	54	70	80	85
1 Acre (0.4 ha) lots, about 20% impervious	51	68	79	84

Source: USDA-SCS, 1986; *From Chow et al. (1988).

Table 7.1. Typical Rain Garden Cross-section.



NOTES:

1. ALL MATERIAL TO MEET FILTREXX® SPECIFICATIONS.
2. RAIN GARDEN AREA MUST BE SIZED APPROPRIATELY FOR SITE CONDITIONS .
3. ALL PLANT MATERIAL TO BE SPECIFIED BY LANDSCAPE ARCHITECT.
4. SITE MUST BE FULLY STABILIZED PRIOR TO RAIN GARDEN CONSTRUCTION.
5. NATIVE SOIL BELOW AND SURROUNDING THE RAIN GARDEN AREA MUST NOT BE COMPACTED.
6. NO CONSTRUCTION SEDIMENT MAY BE PERMITTED TO ENTER THE RAIN GARDEN.

FILTREXX® RAIN GARDEN

NTS

Table 7.2. Rain Garden Placement on a Residential Site.

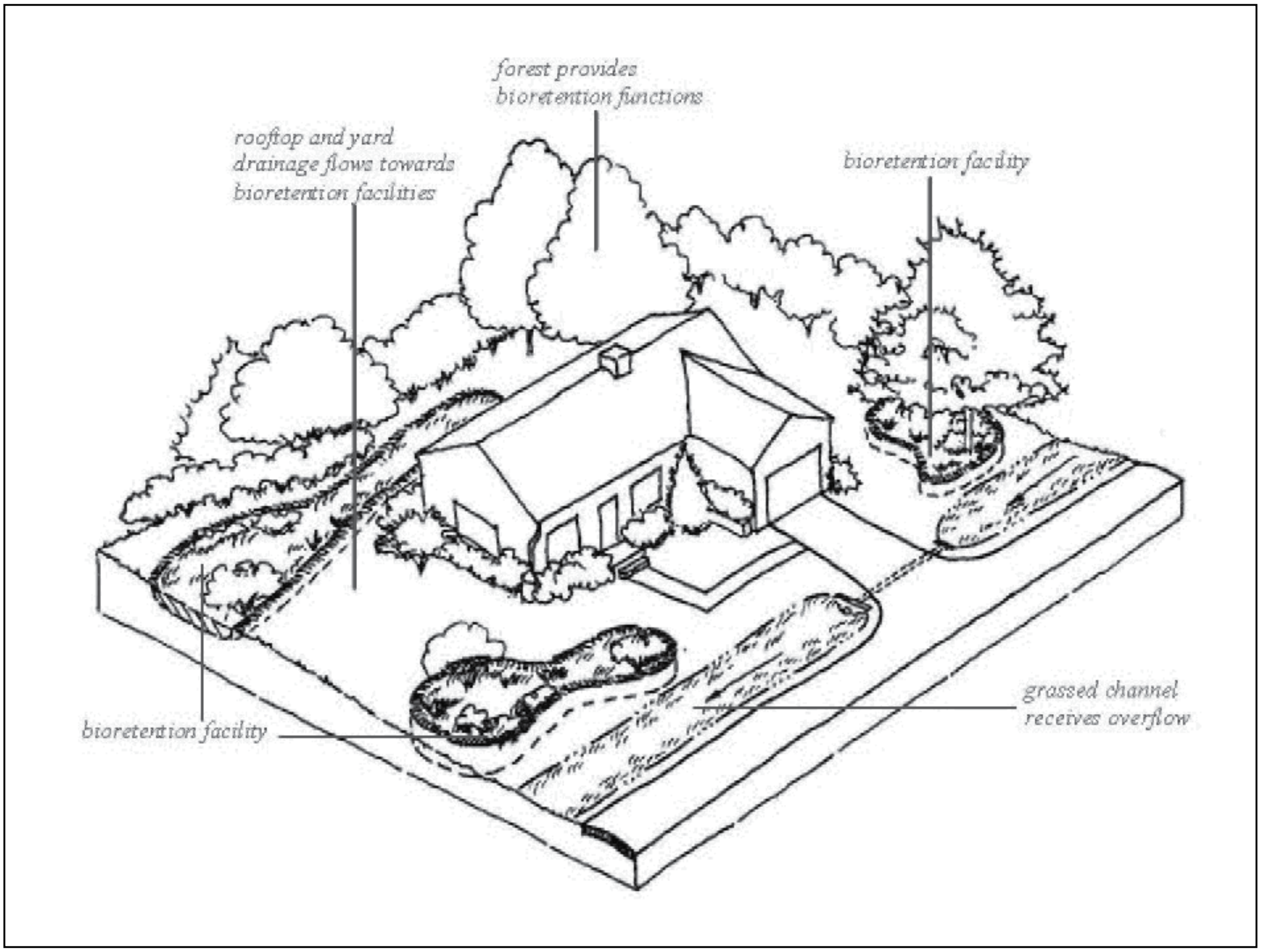
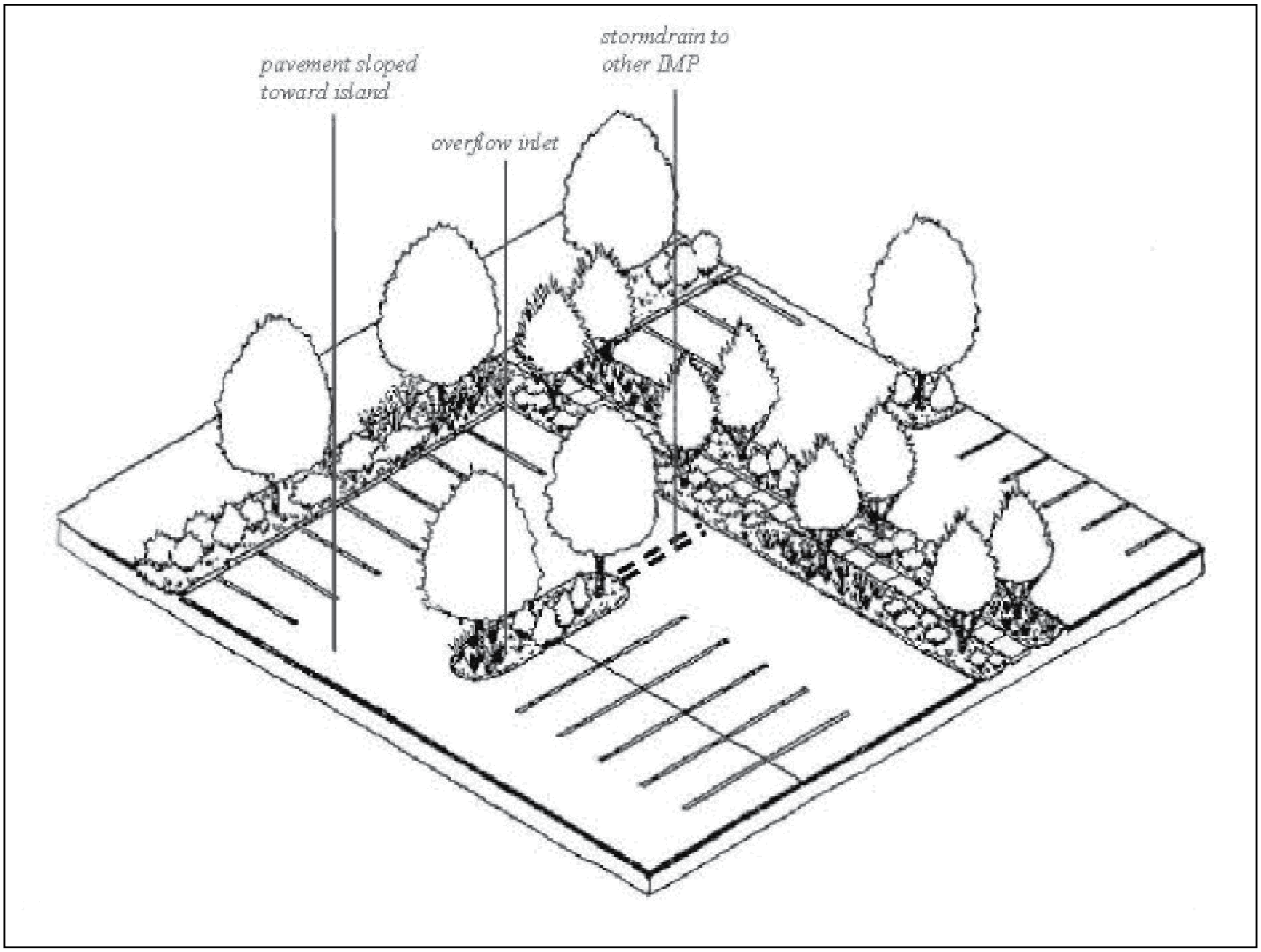


Table 7.3. Rain Garden Placement in a Parking Lot.



SECTION 2: POST-CONSTRUCTION

Filtrexx® Engineered Soil (GrowingMedia™)

PURPOSE & DESCRIPTION

Filtrexx® Engineered Soil is a **permanent storm water infiltration** practice used to reduce storm runoff volume and loading of sediment and soluble pollutants, such as nutrients, heavy metals, and petroleum hydrocarbons, from a contributing watershed or drainage area. Engineered soil is manufactured on site using using Filtrexx® GrowingMedia™ and native soil. Engineered soils manage storm water by:

- Reducing runoff volume through increased soil water holding capacity, and infiltration,
- Increasing infiltration by reducing runoff velocity,
- Reducing pollutant loads by reducing runoff volume,
- Chemical adsorption of nutrients and metals to humus colloids,
- Recycling nutrients and metals by plant uptake and microbial decomposition and uptake.

Engineered soil is manufactured on site by incorporating 2-4 in (50-100mm) of GrowingMedia with the native soil to a depth of 6-12 in (150-300mm) to create a functional soil designed for high infiltration, filtration, and plant sustainability. Engineered soils improve infiltration by increasing water absorption (water holding capacity), soil porosity, and soil structure through the incorporation of organic matter and humus. Storm water runoff volume reduction is closely correlated to reduction of sediment and soluble pollutant loading to receiving waters. Organic matter and humus in GrowingMedia is known to bind or adsorb soluble water pollutants such as phosphorus, ammonium-nitrogen, heavy metals, and petroleum hydrocarbons. Microorganisms in GrowingMedia™ can decompose these pollutants to less toxic and even beneficial forms, while plant uptake can further reduce pollutant concentrations in soil solution. Soil amendments used to construct engineered soils can be easily applied with a pneumatic blower truck, spreader truck or equivalent equipment.

Industrial Site Remediation

APPLICATION

Engineered soils are used in post-construction applications with permanent vegetation to increase infiltration and reduce sediment and soluble pollutant loading to receiving waters. Typically engineered soils are constructed for vegetated storm water collection systems; however, engineered soils can be used in any landscape where overland sheet flow and subsurface flow (interflow) exists. Applications where engineered soils may be required include:

- Bioretention ponds and rain gardens,
- Storm water and sediment retention ponds,
- Parking lot infiltration islands,
- Vegetated (green) roof systems,
- Upslope from storm water receiving or conveyance systems, including channels, ditches, streams, rivers, lakes, and wetlands,
- Runoff receiving areas from impervious surfaces, hardscapes, and source pollutant landscapes, including roads, highways, parking lots, and land disturbing activities.

Engineered soil can also be used to reduce runoff velocity leaving or entering locations described above. Reducing runoff velocity will increase infiltration of storm runoff, thereby reducing runoff volume and pollutant loading (by increasing the propensity for sediment deposition and decreasing the propensity for pollutant transport).

Engineered soils are generally used in permanent, post-construction applications where a variety of plant material including legumes, grasses, shrubs and trees can be utilized.

Engineered soil is ideal as part of a Low Impact Development design plan or to assist in point accrual in LEED Green Building Certification programs (Filtrexx® Tech Link #3301 and #3306).

ADVANTAGES AND DISADVANTAGES

Advantages

- Engineered soil is used to filter pollutants and infiltrate storm water entering or leaving areas where storm water may pass, collect, drain, or be stored.
- Engineered soils reduce peak runoff flows and runoff volumes by increasing soil porosity, water holding capacity, and infiltration rates.
- Engineered soils store and maintain more water on-site helping to reduce storm pressure and maintain base flows to receiving waters.
- Engineered soils have the ability to bind and adsorb soluble nutrients, metals, and hydrocarbons in storm water runoff, thereby reducing loading to nearby receiving waters.
- Engineered soils can remove pathogens and pesticides from storm runoff preventing pollution of receiving water bodies.
- Engineered soils remove pollutants from storm water through plant uptake.
- Engineered soils slow down runoff velocity, thereby increasing sediment deposition, reducing the erosive energy of runoff and the potential for soil erosion, and reducing pollutant transport.
- Engineered soils increase biological activity and diversity in the soil complex.
- Microorganisms in engineered soils have the ability to degrade organic pollutants and cycle captured nutrients into beneficial and/or less toxic forms.
- Engineered soils can establish vegetation in difficult areas.
- Humus colloids and organic matter in engineered soils provide physical structure for seed, establishing seedlings, and live stakes.
- Humus colloids and organic matter in engineered soils provide increased water holding capacity and reduced water evaporation to aid in seed germination and the potential for reduced irrigation.
- Engineered soils can increase ground water recharge by increasing infiltration and percolation.
- Engineered soils are a good option for arid and semiarid regions where germination, moisture management, and irrigation can be difficult.
- Engineered soils provide organic nutrients that slow release for optimum efficiency to establishing vegetation.
- Engineered soils provide organic nutrients that are less prone to runoff transport and pollution of surface waters relative to mineral nutrients supplied by fertilizers.
- Engineered soils buffer soil pH creating favorable conditions for biological activity, nutrient availability and vegetation growth.
- Engineered soils increase soil organic matter which may reduce runoff and erosion, and increase plant sustainability through improved soil quality over the long term.
- Engineered soils can be easily designed and incorporated as one treatment in a treatment train approach to watershed storm water management.
- Slope protection, rolled erosion control blankets, and turf reinforcement mats can easily be used with engineered soils to prevent soil erosion and help stabilize vegetation.
- Engineered soils are organic, all natural, biodegradable, and locally manufactured.
- Engineered soils can be used as a integrated management practice for Low Impact Development design and for possible point accrual in LEED Green Building Certification programs.
- Engineered soil may assist in qualification for LEED® Green Building Rating and Certification credits under LEED Building Design & Construction (BD+C), New Construction v4. Awarded credits may be possible from the categories of Sustainable Sites, Water Efficiency,

ADVANTAGES	LOW	MED	HIGH
Installation Difficulty		✓	
Runoff Volume Reduction			✓
Soluble Pollutant Control			✓
Sediment Control			✓
Vegetation Establishment			✓
Runoff Velocity Reduction		✓	

Materials & Resources, and Innovation. *Note: LEED is an independent program offered through the U.S. Green Building Council. LEED credits are determined on a per project basis by an independent auditing committee. Filtrexx neither guarantees nor assures LEED credits from the use of its products. LEED is a trademark of the U.S. Green Building Council.*

Disadvantages

- If an engineered soil does not use Filtrexx® GrowingMedia™, performance may be diminished.
- If not installed correctly, maintained or used for a purpose or intention that does not meet specifications, performance may be diminished.
- If vegetation does not establish or cover density is low, performance may be diminished.
- Engineered soils should not be the only form of site or watershed storm water management.
- Engineered soils should not be used without structural reinforcement in areas of concentrated runoff flow.
- Engineered soils should not be used without structural reinforcement on slopes greater than 4:1
- Engineered soils should not be used on slopes greater than 3:1
- Engineered soils may need to be reapplied if significant runoff occurs prior to vegetation establishment or where vegetation fails.
- Engineered soils require sufficient land area for optimum performance.
- Engineered soil performance is generally lower prior to vegetation establishment and maturity.
- Engineered soil installation is a land disturbing activity and can increase sediment loading if appropriate sediment control measures are not established during construction phase.

GROWINGMEDIA™ CHARACTERISTICS

Filtrexx® Engineered Soils use only Filtrexx® GrowingMedia™ which is a composted material that is specifically designed for water absorption, infiltration, and establishment and sustainability of vegetation growth. GrowingMedia can be third party tested and certified to meet minimum performance criteria defined by Filtrexx International. Performance parameters include: percent cover of vegetation, water holding capacity, pH, organic matter, soluble salts, moisture content, biological stability, maturity bioassay, percent inert material, bulk density and particle size distribution. For

Roadside Applications of a Engineered Soil

information on the physical, chemical, and biological properties of GrowingMedia™ refer to Specifications in Section 5.2.

PERFORMANCE

QA/QC material testing of GrowingMedia to ensure specifications are met is conducted by the Soil Control Lab, Inc. Although little research has been conducted on Engineered soil, performance testing and scientific research on organic soil amendments, Compost Erosion Control Blankets, and Compost Filter Socks has been conducted in recent years. Conservative assumptions can be made regarding engineered soils in light of performance associated with the previously mentioned practices. For performance on these practices see Filtrexx® Compost Erosion Control Blanket, Filtrexx® Sediment Control (SiltSoxx™), and supporting technical and research reports in the Appendices. Filtrexx International is undergoing research to quantify the performance of Engineered soils to aid design professionals in the future. For a summary of current results from performance testing see Table 3.1.
Note: the Contractor is responsible for establishing a working storm water management system and may, with approval of the Engineer, work outside the minimum construction requirements as needed. Where the Engineered soil fails, it shall be repaired or replaced with an effective alternative.

DESIGN CRITERIA

Function

Engineered soils are effective at filtering pollutants from storm runoff under sheet flow, subsurface flow, and shallow concentrated flow conditions due to physical trapping and runoff velocity reduction by established vegetation. Large particles are removed in greater efficiencies than suspended particles. Maintenance is a key consideration, as sediment build-up will significantly reduce the ability of the Engineered soil to remove pollutants from storm runoff. Pollutant load reduction has been correlated to soil water absorption and infiltration characteristics, soil pollutant adsorption and 'fixing capacity', slope degree, area of the engineered soil, area draining to the engineered soil, and vegetation type, cover, and density.

Humus content within the compost GrowingMedia has the ability to chemically adsorb and bind soluble pollutants such phosphorus, ammonium-nitrogen, heavy metals, and petroleum hydrocarbons, making them unavailable for plant or animal uptake (Filtrexx® Tech Link #3307 and #3308). Additionally, many plants have the ability to take up excess nutrients and pollutants trapped in the Engineered soil, while microorganisms can decompose and/or incorporate these pollutants, making them less toxic to aquatic ecosystems. Organic matter supplied in GrowingMedia increases the water holding and infiltration properties of the soil/vegetation complex and increases diversity and population of microorganisms that can decompose and incorporate captured pollutants.

Planning Considerations:
Engineered soils should be used as one treatment in a treatment train approach to storm water management. Engineered soils should be strategically located for connectivity of infiltration zones, vegetation, and wildlife habitat and corridors in the watershed. Runoff control and runoff diversion practices may be designed to help prevent seed washing and soil erosion prior to vegetation establishment and to protect seedlings prior to maturity. Preconstruction meetings should be conducted to educate construction site personnel about the devices/practices used and acceptable traffic patterns that avoid running over engineered soils with vehicles and heavy equipment. Vehicular traffic and heavy equipment may reduce the effectiveness of engineered soils and contribute to soil compaction, which may increase runoff and erosion and reduce vegetation establishment.

On-site composite soil sampling and testing should be completed prior to plant selection and construction of engineered soil. Tests should include infiltration rate, organic matter content, bulk density, pH, and nutrient characterization. Tests may reveal additional amendment requirement for lime, gypsum, or specific nutrient. Additionally, if soil will be engineered to achieve a specific infiltration rate or organic matter content, evaluation of preexisting soil conditions will be necessary. Consult your local cooperative extension service for soil testing.

Vegetation Selection:
Successful planning for any vegetation establishment project should consider climate, prevailing weather, temperature, sun exposure, prolonged moisture exposure, available moisture/irrigation requirements, topography, soil type, soil pH, soil amendments, nutrient requirements, drought tolerance, time/coordination with construction phases, site preparation/coordination with construction phases, protection from erosion and sedimentation, runoff velocity potential, and seed mix/plant selection (Fifield, 2001).

Permanent vegetation is usually specified for areas that have undergone final clearing and grading and may require soil stabilization. Perennial grasses are typically specified and if possible native grasses and varieties should be utilized (Fifield, 2001; USDA-NRCS, 2004) as these will be better adapted to local climate, native soil, and hydrology. Plant material selection should include a variety ecological stands, including legumes and densely planted deep rooted grasses, mid story shrubs, and tall woody tree species. If Engineered soils will be exposed to prolonged moisture, wetland species may be required. *Generally, tall and sturdy grasses are better at sediment removal than low growing, flexible grasses and legumes* (Grismer et al., 2006; USDA-NRCS, 2004). *Additionally, deep rooted grasses will be more stable under high sheet flow conditions or where concentrated flows may accumulate.* Local landscape architects, NRCS, or cooperative extension should be consulted and used as resources for seed and plant selection. Many state erosion and sediment control and storm water management manuals have specifications for seed and plant selection, seeding rates, and planting requirements. VegSpec, a design program created by the USDA-NRCS, may be a helpful tool for seed and plant selection. It can be accessed at http://plants.usda.gov

Runoff Conditions:
Engineered soils should not be used in areas where runoff velocities will damage or undermine vegetation. *For most grasses a maximum runoff velocity of 4 ft/sec (1.2 m/sec) or a maximum hydraulic shear stress of 2 lbs/ft² (10 kg/m²) is recommended* (MD Storm Water Design Manual, 2000).

Preparation and Application:
Soils shall be cleared of large stones, roots, sticks,

clumps, trash, and other debris prior to tillage. Care should be taken to avoid destruction of tree roots, existing vegetated buffers, and unnecessary tillage and soil disturbance. Sediment control devices should be installed around the perimeter of the Engineered soil construction/installation area (See Section 1.1. Sediment Control). If soil is severely compacted soil ripping may be necessary prior to application and incorporation. Two passes with a roto-tiller may be required to prepare and loosen soil to a depth of 6-8 in (150-200mm).

A 2-4 in (50-100mm) GrowingMedia blanket ((270-540 cubic yds/ac (513-1060 cubic m/ha)) should be applied to 100% of the soil surface using a pneumatic blower, spreader, or similar equipment. After application the entire area should be roto-tilled or disked and harrowed to a minimum depth of 6 in. (150mm) (2-3 in [50-75mm] of GrowingMedia) and a maximum depth of 12 in (300mm). (3-4 in [75-100mm] of GrowingMedia). As an alternative, 4 in. (100mm) of subsoil may be scarified prior to incorporation. If this method is chosen, incorporation with roto-tiller should be 6-8 in (150-200mm) and GrowingMedia application should be 2-3 in (50-75mm). Shallow tillage (2-4 in, 50-100mm) may be utilized around tree roots. GrowingMedia application should be reduced to 1 in (25mm). for shallow till applications. Additional amendments such as lime or gypsum should be included during tillage.

Alternatively, if a target soil organic matter content is known (typically 5%), and test results are available for soil and compost organic matter and bulk density, the quantity of compost needed to achieve the organic matter goal can be calculated (see Organic Matter Content section). This calculation should include any Compost Vegetated Cover (Temporary Seeding) or Compost Erosion Control Blanket applications. Specifications for these practices can be found in Sections 1.7 and 1.8 of the Filtrexx® Design Manual.

Several passes with a rototiller may be required to sufficiently mix the materials within the soil profile. After tillage, a ½-1 in (15-25mm) seeded Compost Erosion Control Blanket should be applied to the surface for erosion control. If seedlings, tubers, and live stakes are specified they should be planted after seeding. The entire area should be thoroughly watered after seeding and planting. Fine grading, raking, and hand rolling may be done after seeding. Additional irrigation may be required until vegetation is well established.

To protect from ground water contamination and saturation of vegetation, Engineered soils should be at least 2 to 4 ft (0.6-1.2 m) from ground water resources (USEPA, 2006).

Water Holding Capacity:
Engineered soils are designed to increase the organic content of the existing soil. Increasing soil organic content will increase the water holding capacity of the soil. Native soil organic matter contents typically range from 0.5 to 5.0%. Hot and humid climate zones, and areas where rainfall-runoff events are high generally have soils with lower soil organic content. Consequently, it can be difficult to maintain soil organic matter levels in these regions. For every 1% of soil organic matter, the soil will hold approximately 16,500 gal (2206 cubic ft, 62 cubic m) of water per acre ft (1233 cubic m) of soil (Breedlove, 2006). Alternatively, GrowingMedia typically holds approximately 1.6 oz (45 g) of water per 3.6 oz (100 g) of GrowingMedia (dry weight); 1 gal (0.004 cubic m) of water per 20 lbs (9 kg) of GrowingMedia (dry wt) or per 30 lbs (14 kg) of GrowingMedia (wet wt). This equates to approximately 40 gal (0.15 cubic m) of water per cubic yard (0.76 cubic m) of GrowingMedia and 5,400 gal (722 cubic ft, 20 cubic m) of water per acre inch (0.01 ha meter, 103 cubic m) of GrowingMedia, and 10,800 gal (1444 cubic ft, 41 cubic m) of water for a 2 in (50mm) GrowingMedia; An acre inch (0.01 ha meter) of GrowingMedia requires approximately 135 cubic yards (103 cubic meters) of material.

Organic Matter Content:
Soil organic matter content for Engineered soils designed to manage storm water and planted with turf grass is typically 5%. Average organic matter content of GrowingMedia is approximately 25% (or 50% by dry weight; average water content of GrowingMedia is 50%) and weighs approximately 1000 lbs per cubic yard (593 kg/cubic m) (wet weight). Soil weighs approximately 2000 lbs per cubic yard (1187 kg/cubic m) (wet weight). For each 1% of organic matter increase 80 lbs (36 kg) of GrowingMedia (20 lbs [9 kg] of organic matter) should be added to 1 cubic yard (0.76 cubic m) of soil.

Alternatively, if you assume the top 6 in (150mm) of soil weighs approximately 1000 tons/acre (2250 Mg/ha) (dry weight) you need to add 10 tons (9 Mg) of organic matter to increase soil organic matter 1%. 10 tons of organic matter (9 Mg) (dry weight) is equivalent to 40 tons (36 Mg) of GrowingMedia (wet weight), or 80 cubic yards (61 cubic m) (wet weight). As a conservative estimate, one should assume a 25% decline in organic matter after the first year of application. This can very between 10-50% depending on the climate zone. Once vegetation is mature and healthy, soil organic matter levels may stabilize.

If soil and GrowingMedia test results for organic matter content and bulk density are available, and the targeted soil organic matter content is known, the following equation can be used to determine GrowingMedia application rate (WDOE, 2005):

CR = D x (SBD x [SOM% - FOM%]) / (SBD x [SOM% - FOM%] – CBD x [COM% - FOM%])

Where:

CR = compost application rate (to determine final soil organic matter content goal)
D = depth of finished incorporation (in)
SBD* = soil bulk density (lbs/ cubic yard, dry wt.)
SOM% = initial soil organic matter content (%)
FOM% = final target soil organic matter content (%)
CBD** = compost bulk density (lbs/cubic yd, dry wt.)
COM% = compost organic matter (%)

Assumptions: This equation calculates compost rate using an additive approach. For example, a 3 in (75mm) compost rate incorporated to an 8 in (200mm) depth will be a final mix containing 3/8 compost and 5/8 soil by volume. Organic matter measurements are based on the commonly used "loss-on-ignition" method.

* SBD: to convert Soil Bulk Density in g/cm3 units to lb/cubic yard, multiply by 1697.
** CBD: to convert Compost Bulk Density from lb/cubic yard "as is" to lb/cubic yard dry weight, multiply by solids content.

Infiltration Rate:
Meyer et al. (2000) found that by incorporating 15 to 30 tons/ac (18-36 Mg/ha) of compost into the top 4-8 in (100-200mm) of soil, infiltration rates were approximately 0.125-0.158 cm/sec.

Slope Degree:
Engineered soils *should not be used on slopes greater than 3:1.* Soil tillage and deep soil disturbance on steep slopes can lead to instability and mass sliding once soils have reached saturation. Slopes less than 2% may pond water once the soil has reached field capacity. Slopes greater than 6% typically form rills of concentrated runoff, which can increase erosion (USEPA, 2006). Slopes greater than 4:1 should select deep rooted vegetation and consider using slope stabilization practices, such as Slope protection or rolled erosion control blankets.

Design Options:
To maintain sheet flow conditions, reduce runoff velocity, and to act as a pretreatment system for sediment removal a shallow gravel trench (level spreader) may be constructed directly upslope from the Engineered soil (USEPA, 2006). The gravel trench should be a minimum of 12 in (300mm) wide and 12 in (300mm) deep and filled with pea gravel. Alternatively, a 12 or 18 in (300 or 450mm) Filtrexx® Sediment Control (SiltSoxx™) will provide the same function. Ponding depth should not exceed 12 in (300mm) (USEPA, 2006). Polypropylene shall be specified as the required Soxx™ material for any permanent application. At the down slope base of the engineered soil another Soxx may be installed to slow runoff velocity and increase the potential for settling of suspended solids and infiltration. Filtrexx® Slope Interruption may be installed across the runoff flow path of the Engineered soil to increase infiltration and settling of solids. Refer to Filtrexx Design Manual Section 1.1 and 1.5 for standard specifications and design information for these practices.

Establishing & Sustaining Vegetation:
Although Engineered soils increase water holding capacity and reduce evaporation, irrigation may be required to ensure successful vegetation establishment. In arid and semi-arid regions, or hot and dry weather, regular irrigation may be required. Runoff diversion devices may be utilized to prevent storm runoff from washing seed prior to germination and establishment and reduce erosion prior to stabilization.

Grasses should be mowed and maintained between 4 and 10 in. (100 and 250mm) high. Taller grasses typically have a higher sediment removal efficiency and sediment storage capacity than low growing or low maintained grasses.

Engineered soils supply humus, organic matter, beneficial microbes, and slow release organic nutrients that can contribute to increased soil quality, fertility, and plant health.

Soil Amendment Function:
Engineered soils amend the soil which can provide the following functional benefits: increased soil structure, increased soil aggregates, increased soil aeration, increased infiltration and percolation, increased moisture holding capacity, increased activity of beneficial microbes, increased availability of nutrients, decreased runoff volume and velocity, decreased erosion, and increased plant health and sustainability.

Organic vs. Fertilizer Nutrients:
Although most specification and design manuals include fertilizer recommendations or requirements for vegetation, mineral nutrients from fertilizers may not be preferable where vegetation sustainability and water quality are a concern. Engineered soils provide organic nutrients which are slow release, provide plant micronutrients, and are less likely to be transported in storm runoff to receiving waters – which can lead to pollution and eutrophication of waterways (Faucette et al, 2005).

Weed Establishment:
Invasive weed growth has been more closely associated with mineral fertilizer than organic fertilizer fertility practices (Faucette et al, 2004). Vegetation practices should always be inspected for invasive and noxious weeds.

INSTALLATION

1. Engineered soils shall meet Filtrexx® Engineered Soil Specifications and use Filtrexx® GrowingMedia™.
2. Contractor is required to be a Filtrexx® Certified℠ Installer as determined by Filtrexx International, (440-926-2607). Certification shall be considered current if appropriate identification is shown during time of bid or at time of application. Look for the Filtrexx® Certified℠ Installer Seal.
3. Engineered soils will be placed at locations indicated on plans as directed by the Engineer.
4. Engineered soils shall be installed down slope and around areas contributing overland and subsurface storm water flows.
5. Engineered soils shall not be installed in areas of concentrated runoff flow without soil stabilization or armoring devices.
6. Engineered soils shall not be installed on slopes greater than 3:1.
7. Engineered soils installed on slopes greater than 4:1 may include slope stabilization practices.
8. Engineered soils should not be installed in wet or frozen soils or prior to seasons where growing vegetation is difficult.
9. Care should be given to existing root systems of trees and shrubs during construction of Engineered soil.
10. Seed shall be thoroughly mixed with the GrowingMedia prior to construction of Engineered soil or surface applied with GrowingMedia at time of application.
11. Engineered soils shall be applied evenly to 100% of the area where Engineered soil is required.
12. Land surface shall be cleared of debris, including rocks, roots, large clods, and sticks prior to Engineered soil installation or tillage.
13. Soil may be prepared prior to GrowingMedia application by roto-tilling the native soil.
14. If soil is too dense for roto-tiller soil ripping map be used as a prerequisite.
15. Subsoil may be scarified to a depth of 4 in. (100mm) prior to GrowingMedia™ application.
16. GrowingMedia™ shall be evenly applied to the soil surface at a depth of 2-4 in (50-100mm) or 270-540 cubic yards/ac (513-1026 cubic meters/ha) using a pneumatic blower, spreader,or similar device (small installations may be done manually) and thoroughly roto-tilled into the native soil (several passes my be required); or
17. GrowingMedia shall be mixed with native soil prior to construction using a loader, soil mixer, or similar equipment.
18. Soil incorporation and tillage shall be to a minimum of 6 in (150mm) (unless restricted by tree roots or other natural constraints) and a maximum of 12 in (300mm); or
19. If subsoil is scarified to 4 in (100mm)., soil incorporation should be 6-8 in (150-200mm).
20. Engineered soil shall be thoroughly watered after installation and allowed to settle for 1 week.
21. Fine grading and hand rolling of engineered soil may be required after installation.

INSPECTION

Routine inspection should be conducted within 24 hrs of a runoff event for the first year after installation, until permanent vegetation has established, or as designated by the regulating authority. If rilling occurs or vegetation does not establish, the area of application should be reapplied with an Engineered soil. If failure continues, the use of runoff diversion devices, compost erosion control blankets, rolled erosion control blankets, or soil stabilizers should be considered until vegetation has been established. Vegetation practices should always be inspected for noxious or invasive weeds. Periodic infiltration rate tests may be performed to ensure the system is performing correctly. If sediment accumulation is 25% of the height of the vegetation, sediment removal is recommended.

MAINTENANCE

1. The Contractor shall maintain the engineered soil in a functional condition at all times and it shall be routinely inspected.
2. Heavy equipment should be limited on and near the engineered soil to prevent compaction that will reduce infiltration and permeability.
3. If soil complex becomes compacted, or infiltration and permeability rates diminish significantly, engineered soil shall be reinstalled or replaced with a functioning alternative.
4. Engineered soil shall be maintained until a minimum uniform cover of 70% of the applied area has been vegetated, permanent vegetation has established, or as required by the jurisdictional agency.
5. Engineered soils may need to be irrigated in hot and dry weather and seasons, or arid and semi-arid climates to ensure vegetation establishment.
6. Where engineered soil fails, rilling occurs, or vegetation does not establish the Contractor will repair or provide an approved and functioning alternative.
7. If Engineered soil is damaged by storm water runoff prior to vegetation establishment, temporary runoff diversion devices installed above the engineered soil may be required.
8. No additional fertilizer or lime is required for vegetation establishment and maintenance.
9. No disposal is required for this product/practice.
10. Regular mowing of grass vegetation on Engineered soil to a minimum height of 4 in (100mm) and a maximum height of 10 in (250mm) will deter invasive weeds, allow sunlight to kill captured pathogens, and provide maximum sediment removal efficiency and sediment storage capacity in the vegetation.
11. Organic debris and clippings should be left on-site to maintain soil organic content.
12. Sediment shall be removed if it reaches 25% of the height of the vegetation (mowed) to prevent diversion of storm runoff and reduction of vegetation health and cover.

METHOD OF MEASUREMENT

Bid items shall show measurement as 'Filtrexx® Engineered Soil per square ft, per square yd, per square meter, per hectare, or per acre installed.

Engineer shall notify Filtrexx of location, description, and details of project prior to the bidding process so that Filtrexx can provide design aid and technical support.

ADDITIONAL INFORMATION

For other references on this topic, including additional research reports and trade magazine and press coverage, visit the Filtrexx website at www.filtrexx.com

Filtrexx International, Technical Support
61 N Clev-Mass Rd, Ste E, Akron, OH 44333
877-542-7699 | 234-466-0810 (fax)
www.filtrexx.com | info@filtrexx.com
Call for complete list of international installers.

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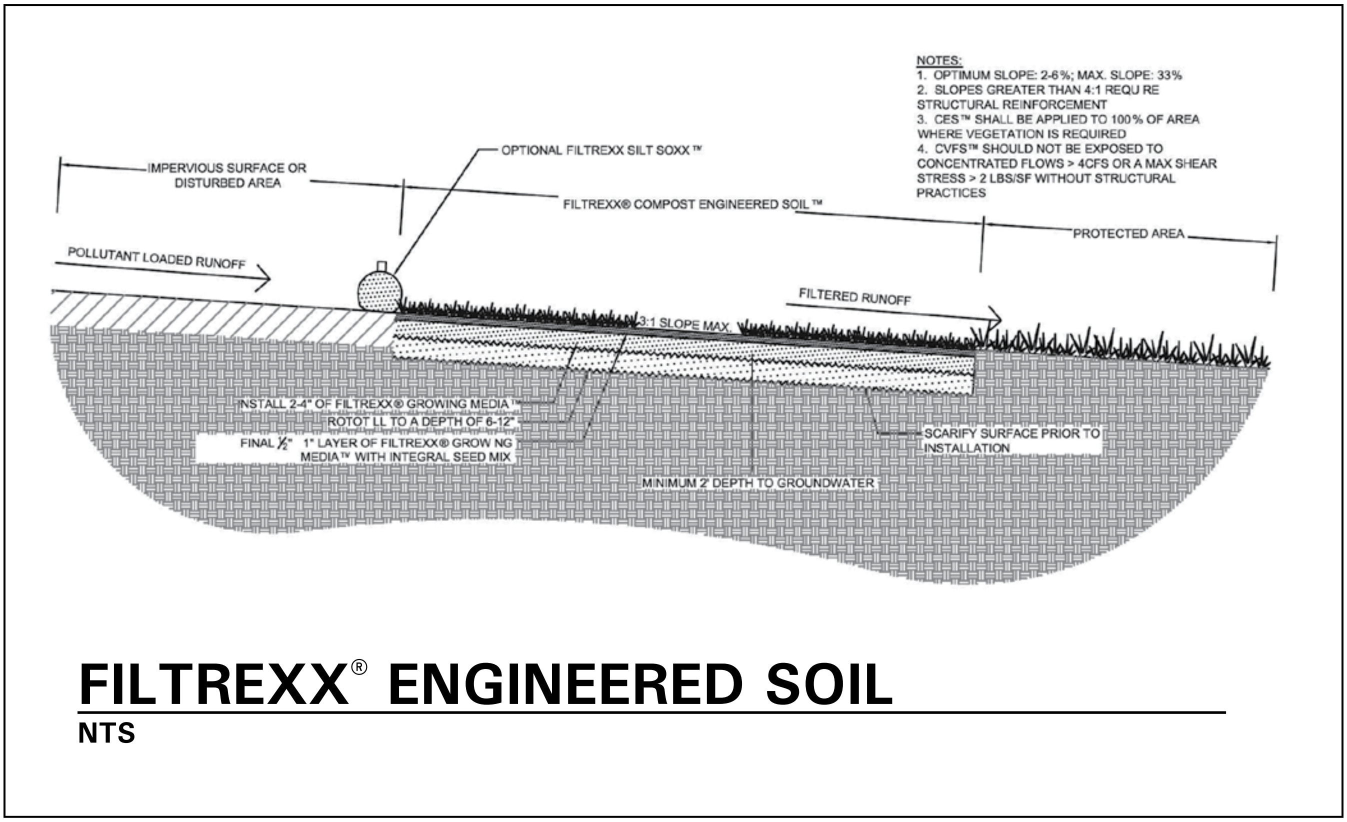
TABLES & FIGURES:

Table 3.1. Filtrexx® Engineered Soil Performance and Design Specifications Summary

Reference / Performance & Design	Harrison et al, 1997	Meyer et al., 2001	Reinsch et al., 2005	Mukhtar et al., 2004
Runoff Volume Reduction	53%	44-77%	69%	32%
Infiltrate Rate		0.125-0.158 cm/sec		
Rainfall Absorption	43%	86-95%	88%	
Water storage Increase	40%			
Pollutant & Removal Efficiency	Total P = 20%	TS = 53-59%	TS = 96%	TS = 73% TSS = 65% TKN = 72% NH4-N = 54% Total P = 76% Dissolved P = 89%
Compost Application Rate	1:2, 1:3, 1:4 (soil:compost)	40-80 Mg/ha	2 in (50mm)	25% or 1:3 (compost:soil)
Depth of Tillage	Mixed off-site	4-8 in (100-200mm)		3 in (75mm)
Vegetation Type	Turf grass	Wheatgrass & needlegrass	Fescue	
Vegetation Cover		69-70%		
Rainfall Intensity -Duration	0.3-0.6 in (8-15mm)/hr for 2-8 hr	4 in (100mm)/ hr for 30 min.	2.6 in (66mm)/ hr for 45 min	3.6 in (91mm) /hr for 35 min
Soil Type		Gravelly clay-loam, gravelly sandy-loam	Clay	Clay
Slope		10-16%	3:1	3:1
Research Institution	University of Washington	Colorado State University	University of Nebraska	Texas A&M University

Figure 3.1. Engineering Design Drawing for Filtrexx® Engineered Soil



5.2

filtrexx® SUSTAINABLE TECHNOLOGIES

SECTION 5: SUPPORT PRACTICES

Filtrexx® GrowingMedia™

PURPOSE & DESCRIPTION

Composted products used for Filtrexx GrowingMediaTM shall be weed free and derived from a well-decomposed source of organic matter. The composted products shall be produced using an aerobic composting process meeting USEPA CFR 503 regulations (In Canada: M.O.E. 101, C.C.M.E. Type "A" and Type "AA" regulations), including time and temperature data indicating effective weed seed, pathogen and insect larvae kill. The composted products shall be free of any refuse, contaminants or other materials toxic to plant growth. Non-composted products will not be accepted. Test methods for the items below should follow USCC TMECC guidelines for laboratory procedures:

Section

A. PH – 5.0-8.0 in accordance with TMECC 04.11-A, "Electrometric pH Determinations for Compost"

B. Moisture content of less than 60% in accordance with standardized test methods for moisture determination.

C. GrowingMedia to be used with Filtrexx® Soxx™ where seeding and/or live stakes are specified; on low grade slopes where vegetation establishment is the priority; or where rainwater absorption, water holding capacity, runoff reduction and infiltration are the priority shall meet the following particle size distribution. Examples include Soxx for Runoff Diversion, Channel Protection, Bank Stabilization, Severe Slope Stabilization, Vegetated Retaining Walls, Vegetated Gabion, Filtration System, Compost Vegetated Cover, Compost Erosion Control Blanket™, Compost Storm Water Blanket™, Compost Engineered Soil, Compost Bioretention System, Green Roof GrowingMedia.

Particle Sizes - 100% passing a 2 in (50mm) sieve, 99% passing a 1 in (25mm) sieve, minimum of 60% passing a ½ in (12.5mm) sieve in accordance with TMECC 02.02-B, "Sample Sieving for Aggregate Size Classification".

D. Material shall be relatively free (<1% by dry weight) of inert or foreign man made materials.

E. A sample shall be submitted to the Engineer for approval prior to being used and must comply with all local, state and federal regulations.

Option A: Erosion Control
For vegetated non Soxx applications where slope grades are greater than 3:1, where sheet runoff rate or velocity may be high, or rainfall rate/intensity may be high.

Substitution for Section C. Particle Size of GrowingMedia shall use the following particle size distribution specification: 99% passing a 1 in (25mm) sieve, maximum of 50% passing a 1/2 in (12.5mm) sieve.

Option B: Non-vegetated Temporary Erosion Control
For non-vegetated non Soxx applications where slope grades are greater than 3:1, where sheet runoff rate or velocity may be high, or rainfall rate/intensity may be high.

Substitution for Section C. Particle Size of GrowingMedia shall use the following particle size distribution specification: 99% passing a 3 in (75mm) sieve and a maximum of 30% passing a 1/2 in (12.5mm) sieve.

Rationale for Options: Research conducted at The University of Georgia and Auburn University (Faucette et al, 2006; Faucette, 2006) to evaluate the performance of particle sizes in compost erosion control blankets found that distributions with predominantly small particles absorbed more rainfall, reduced a greater volume of runoff, increased the delay of runoff commencement, and exhibited greater vegetation growth, relative to compost erosion control blankets with large particle sizes. However, compost erosion control blankets with distributions of predominantly large particles slowed runoff rate and reduced soil loss prior to vegetation establishment over compost erosion control blankets with smaller particles sizes.

ADDITIONAL INFORMATION

For other references on this topic, including additional research reports and trade magazine and press coverage, visit the Filtrexx website at www.filtrexx.com

Filtrexx International, Technical Support
61 N Clev-Mass Rd, Ste E, Akron, OH 44333
877-542-7699 | 234-466-0810 (fax)
www.filtrexx.com | info@filtrexx.com
Call for complete list of international installers.

REFERENCES CITED & ADDITIONAL RESOURCES

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Appendix "B" – Pre-Development Analysis

Summary for Subcatchment BASIN 1: STDY PNT 1

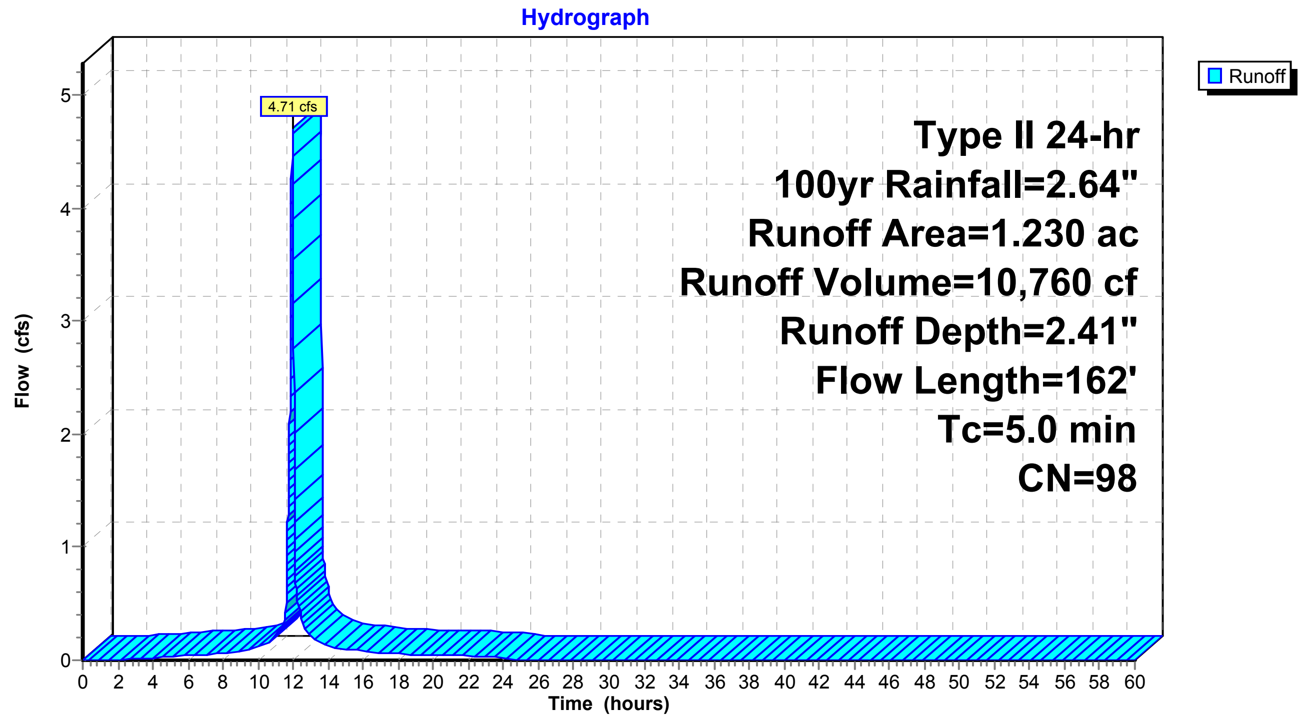
Runoff = 4.71 cfs @ 11.96 hrs, Volume= 10,760 cf, Depth= 2.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100yr Rainfall=2.64"

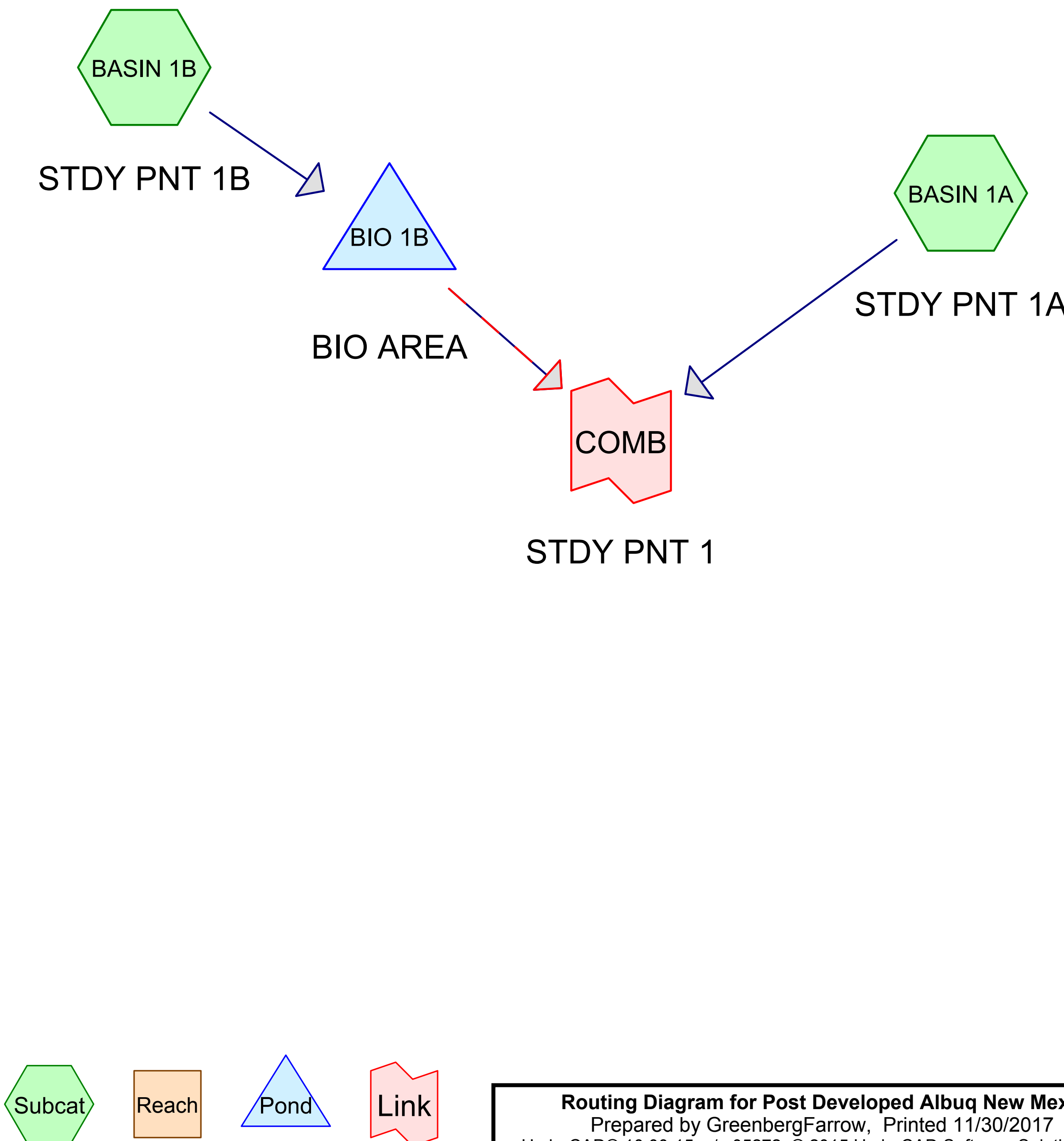
	Area (ac)	CN	Description
*	1.230	98	pavement
	1.230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	162		0.54		**Direct Entry, pavment**

Subcatchment BASIN 1: STDY PNT 1



Appendix "C" – Post Development Analysis



Routing Diagram for Post Developed Albuq New Mexico
Prepared by GreenbergFarrow, Printed 11/30/2017
HydroCAD® 10.00-15 s/n 05272 © 2015 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
11,326	96	LANDSCAPE GRAVEL (BASIN 1B)
5,663	96	Landscape Gravel (BASIN 1A)
31,799	98	PAVEMENT (BASIN 1B)
4,792	98	pavement (BASIN 1A)
53,579	**97**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
0	HSG D	
53,579	Other	BASIN 1A, BASIN 1B
53,579		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Subc Num
0	0	0	0	11,326	11,326	LANDSCAPE GRAVEL	
0	0	0	0	5,663	5,663	Landscape Gravel	
0	0	0	0	31,799	31,799	PAVEMENT	
0	0	0	0	4,792	4,792	pavement	
0	**0**	**0**	**0**	**53,579**	**53,579**	**TOTAL AREA**	

Time span=0.00-60.00 hrs, dt=0.01 hrs, 6001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

SubcatchmentBASIN 1A: STDY PNT 1A Runoff Area=0.240 ac 45.83% Impervious Runoff Depth=2.30"
Tc=5.0 min CN=97 Runoff=0.90 cfs 2,005 cf

SubcatchmentBASIN 1B: STDY PNT 1B Runoff Area=0.990 ac 73.74% Impervious Runoff Depth=2.30"
Tc=5.0 min CN=97 Runoff=3.73 cfs 8,273 cf

Pond BIO 1B: BIO AREA Peak Elev=5,363.50' Storage=3,711 cf Inflow=3.73 cfs 8,273 cf
Primary=0.08 cfs 5,282 cf Secondary=2.09 cfs 2,991 cf Outflow=2.17 cfs 8,273 cf

Link COMB: STDY PNT 1 Inflow=2.76 cfs 10,278 cf
Primary=2.76 cfs 10,278 cf

Total Runoff Area = 53,579 sf Runoff Volume = 10,278 cf Average Runoff Depth = 2.30"
31.71% Pervious = 16,988 sf 68.29% Impervious = 36,590 sf

Summary for Subcatchment BASIN 1A: STDY PNT 1A

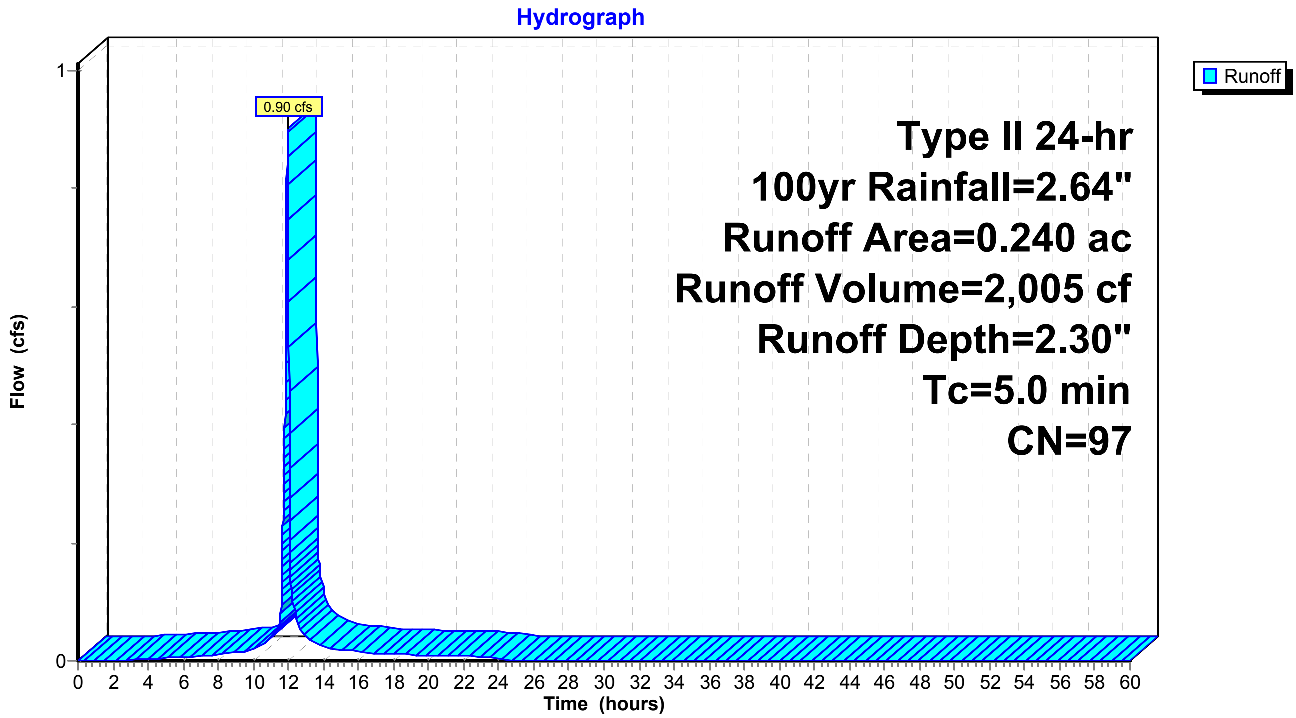
Runoff = 0.90 cfs @ 11.96 hrs, Volume= 2,005 cf, Depth= 2.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100yr Rainfall=2.64"

	Area (ac)	CN	Description
*	0.110	98	pavement
*	0.130	96	Landscape Gravel
	0.240	97	Weighted Average
	0.130		54.17% Pervious Area
	0.110		45.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, GRASS**

Subcatchment BASIN 1A: STDY PNT 1A



Summary for Subcatchment BASIN 1B: STDY PNT 1B

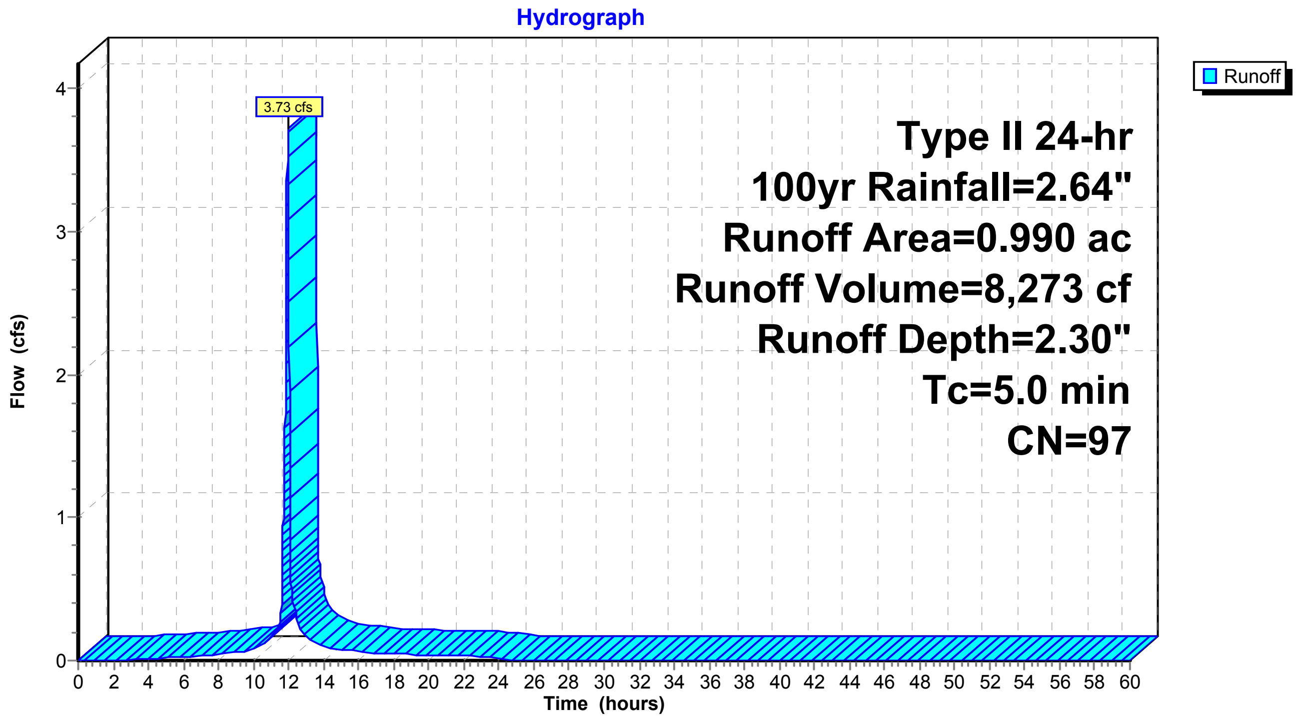
Runoff = 3.73 cfs @ 11.96 hrs, Volume= 8,273 cf, Depth= 2.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100yr Rainfall=2.64"

	Area (ac)	CN	Description
*	0.730	98	PAVEMENT
*	0.260	96	LANDSCAPE GRAVEL
	0.990	97	Weighted Average
	0.260		26.26% Pervious Area
	0.730		73.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, PAVEMENT AND PIPE**

Subcatchment BASIN 1B: STDY PNT 1B



Summary for Pond BIO 1B: BIO AREA

Inflow Area = 43,124 sf, 73.74% Impervious, Inflow Depth = 2.30" for 100yr event
Inflow = 3.73 cfs @ 11.96 hrs, Volume= 8,273 cf
Outflow = 2.17 cfs @ 12.03 hrs, Volume= 8,273 cf, Atten= 42%, Lag= 4.5 min
Primary = 0.08 cfs @ 12.03 hrs, Volume= 5,282 cf
Secondary = 2.09 cfs @ 12.03 hrs, Volume= 2,991 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs
Peak Elev= 5,363.50' @ 12.03 hrs Surf.Area= 2,319 sf Storage= 3,711 cf

Plug-Flow detention time= 387.3 min calculated for 8,273 cf (100% of inflow)
Center-of-Mass det. time= 387.3 min (1,153.9 - 766.6)

Volume	Invert	Avail.Storage	Storage Description
#1	5,360.00'	3,720 cf	**BIO RET AREA (Conic)** Listed below

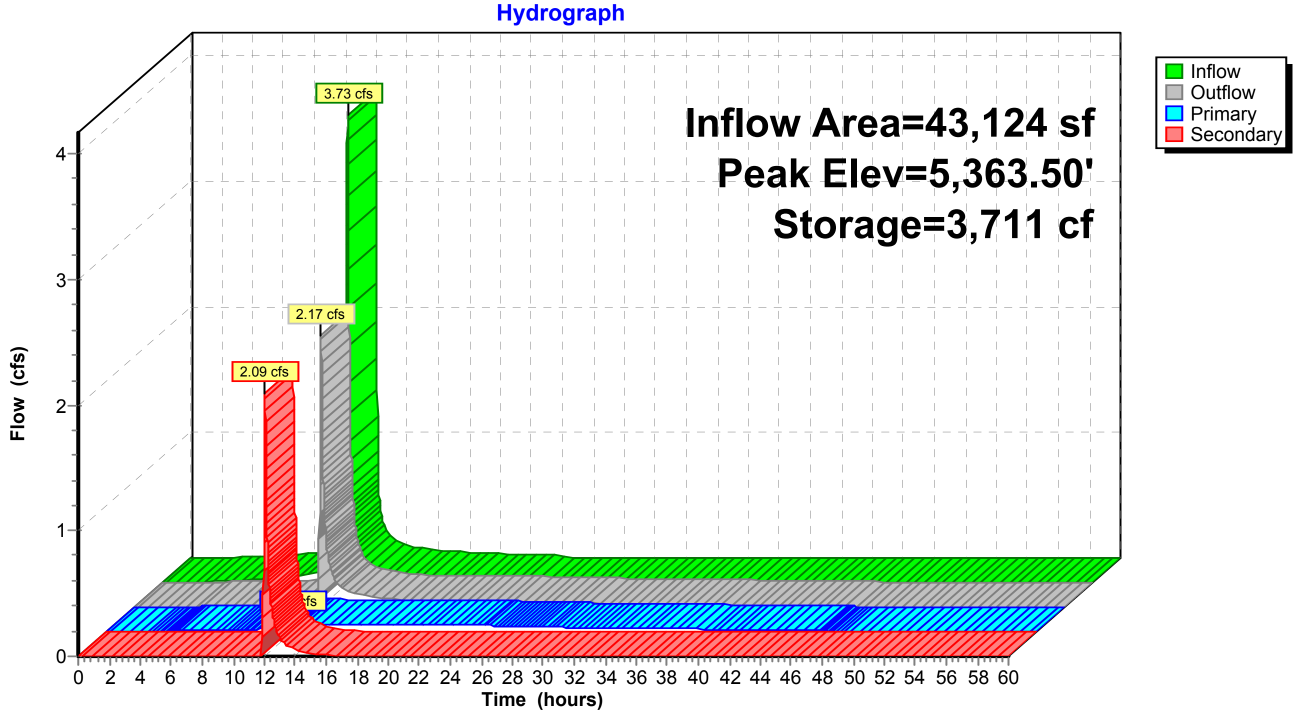
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
5,360.00	279	0	0	279
5,361.00	620	438	438	628
5,362.00	1,030	816	1,255	1,050
5,363.00	1,856	1,423	2,678	1,887
5,363.50	2,323	1,043	3,720	2,361

Device	Routing	Invert	Outlet Devices
#1	Primary	5,360.00'	**1.400 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 0.00' Phase-In= 0.10'
#2	Secondary	5,363.00'	**2.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.08 cfs @ 12.03 hrs HW=5,363.50' TW=0.00' (Dynamic Tailwater)
└─**1=Exfiltration** (Controls 0.08 cfs)

Secondary OutFlow Max=2.09 cfs @ 12.03 hrs HW=5,363.50' TW=0.00' (Dynamic Tailwater)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 2.09 cfs @ 2.11 fps)

Pond BIO 1B: BIO AREA

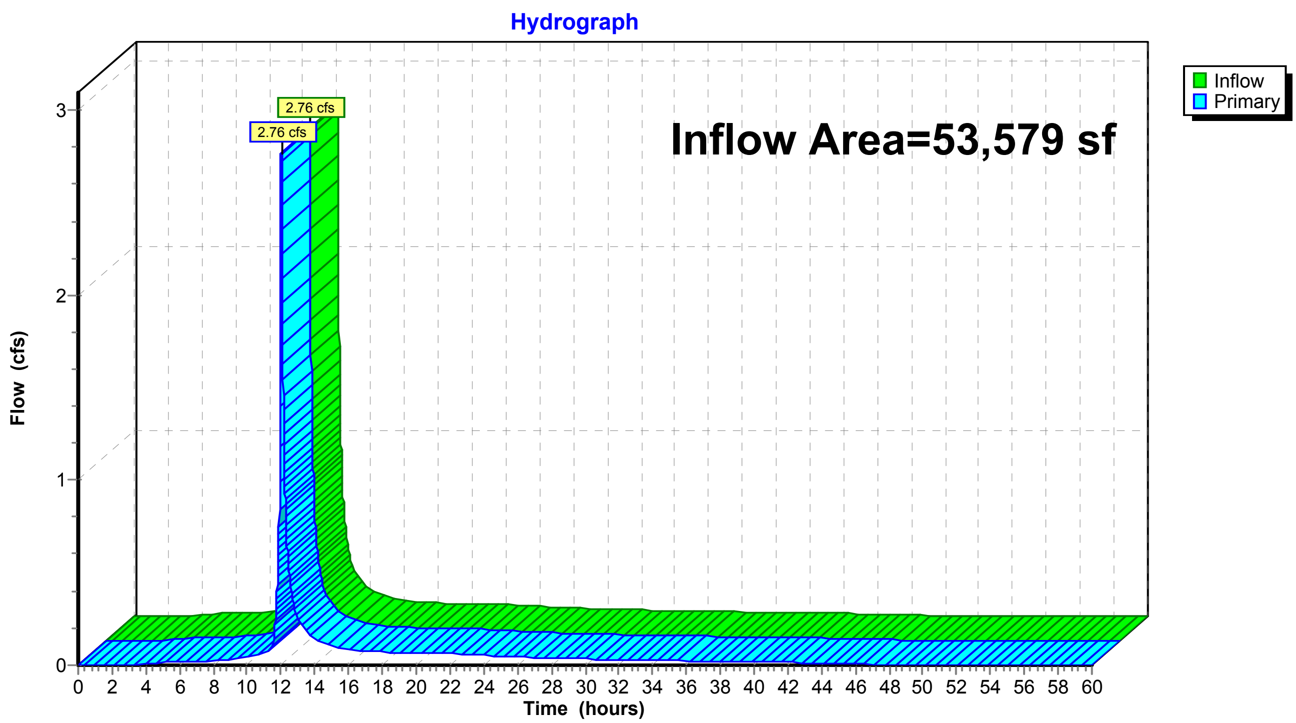


Summary for Link COMB: STDY PNT 1

Inflow Area = 53,579 sf, 68.29% Impervious, Inflow Depth = 2.30" for 100yr event
Inflow = 2.76 cfs @ 12.01 hrs, Volume= 10,278 cf
Primary = 2.76 cfs @ 12.01 hrs, Volume= 10,278 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-60.00 hrs, dt= 0.01 hrs

Link COMB: STDY PNT 1



Appendix "D" – Miscellaneous Information

Map Scale: 1:1,070 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 15 30 60 90

Feet: 0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico
Survey Area Data: Version 11, Sep 26, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 15, 2014—May 17, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico (NM600)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
EtC	Embudo-Tijeras complex, 0 to 9 percent slopes	4.9	100.0%
Totals for Area of Interest		**4.9**	**100.0%**

Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico

EtC—Embudo-Tijeras complex, 0 to 9 percent slopes

Map Unit Setting

- *National map unit symbol:* 1vwt
- *Elevation:* 4,850 to 6,500 feet
- *Mean annual precipitation:* 7 to 10 inches
- *Mean annual air temperature:* 58 to 60 degrees F
- *Frost-free period:* 170 to 195 days
- *Farmland classification:* Not prime farmland

Map Unit Composition

- *Embudo and similar soils:* 50 percent
- *Tijeras and similar soils:* 35 percent
- *Estimates are based on observations, descriptions, and transects of the mapunit.*

Description of Embudo

Setting

- *Landform:* Terraces
- *Landform position (three-dimensional):* Tread
- *Down-slope shape:* Concave
- *Across-slope shape:* Linear
- *Parent material:* Alluvium derived from igneous and sedimentary rock

Typical profile

- *H1 - 0 to 4 inches:* gravelly fine sandy loam
- *H2 - 4 to 20 inches:* gravelly sandy loam
- *H3 - 20 to 60 inches:* stratified gravelly loamy coarse sand to very gravelly loamy sand

Properties and qualities

- *Slope:* 0 to 5 percent
- *Depth to restrictive feature:* More than 80 inches
- *Natural drainage class:* Well drained
- *Runoff class:* Very low
- *Capacity of the most limiting layer to transmit water (Ksat):* High (2.00 to 6.00 in/hr)
- *Depth to water table:* More than 80 inches
- *Frequency of flooding:* Rare
- *Frequency of ponding:* None
- *Calcium carbonate, maximum in profile:* 7 percent
- *Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
- *Sodium adsorption ratio, maximum in profile:* 2.0

- *Available water storage in profile:* Low (about 3.4 inches)

Interpretive groups

- *Land capability classification (irrigated):* None specified
- *Land capability classification (nonirrigated):* 7e
- *Hydrologic Soil Group:* A
- *Ecological site:* Sandy (R042XA051NM)
- *Hydric soil rating:* No

Description of Tijeras

Setting

- *Landform:* Fan remnants
- *Down-slope shape:* Linear
- *Across-slope shape:* Linear
- *Parent material:* Alluvium derived from igneous and sedimentary rock

Typical profile

- *H1 - 0 to 4 inches:* gravelly fine sandy loam
- *H2 - 4 to 14 inches:* sandy clay loam
- *H3 - 14 to 19 inches:* gravelly sandy loam
- *H4 - 19 to 60 inches:* stratified very gravelly sand to very gravelly sandy loam

Properties and qualities

- *Slope:* 1 to 9 percent
- *Depth to restrictive feature:* More than 80 inches
- *Natural drainage class:* Well drained
- *Runoff class:* Medium
- *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)
- *Depth to water table:* More than 80 inches
- *Frequency of flooding:* None
- *Frequency of ponding:* None
- *Calcium carbonate, maximum in profile:* 5 percent
- *Salinity, maximum in profile:* Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
- *Sodium adsorption ratio, maximum in profile:* 2.0
- *Available water storage in profile:* Low (about 5.2 inches)

Interpretive groups

- *Land capability classification (irrigated):* None specified
- *Land capability classification (nonirrigated):* 7c
- *Hydrologic Soil Group:* B
- *Ecological site:* Sandy (R042XA051NM)

Hydric soil rating: No

NOAA Atlas 14, Volume 1, Version 5
Location name: Albuquerque, New Mexico, USA*
Latitude: 35.1785°, Longitude: -106.6273°
Elevation: 4994.77 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.167** (0.142-0.197)	**0.216** (0.183-0.255)	**0.290** (0.246-0.344)	**0.349** (0.294-0.411)	**0.429** (0.361-0.505)	**0.492** (0.412-0.580)	**0.559** (0.464-0.657)	**0.629** (0.519-0.740)	**0.725** (0.592-0.854)	**0.802** (0.651-0.943)
10-min	**0.254** (0.216-0.300)	**0.329** (0.279-0.388)	**0.442** (0.375-0.523)	**0.530** (0.448-0.626)	**0.652** (0.548-0.769)	**0.749** (0.626-0.882)	**0.850** (0.706-1.00)	**0.957** (0.789-1.13)	**1.10** (0.902-1.30)	**1.22** (0.990-1.44)
15-min	**0.315** (0.268-0.372)	**0.407** (0.346-0.481)	**0.548** (0.464-0.649)	**0.658** (0.555-0.775)	**0.809** (0.680-0.953)	**0.928** (0.777-1.09)	**1.05** (0.875-1.24)	**1.19** (0.979-1.40)	**1.37** (1.12-1.61)	**1.51** (1.23-1.78)
30-min	**0.424** (0.361-0.501)	**0.549** (0.465-0.648)	**0.738** (0.625-0.873)	**0.886** (0.748-1.05)	**1.09** (0.915-1.28)	**1.25** (1.05-1.47)	**1.42** (1.18-1.67)	**1.60** (1.32-1.88)	**1.84** (1.51-2.17)	**2.04** (1.65-2.40)
60-min	**0.525** (0.447-0.620)	**0.679** (0.576-0.802)	**0.913** (0.774-1.08)	**1.10** (0.925-1.29)	**1.35** (1.13-1.59)	**1.55** (1.30-1.82)	**1.76** (1.46-2.07)	**1.98** (1.63-2.33)	**2.28** (1.86-2.68)	**2.52** (2.05-2.96)
2-hr	**0.627** (0.525-0.764)	**0.804** (0.673-0.982)	**1.07** (0.888-1.30)	**1.27** (1.06-1.54)	**1.57** (1.29-1.89)	**1.81** (1.48-2.17)	**2.06** (1.67-2.47)	**2.32** (1.88-2.78)	**2.69** (2.15-3.23)	**2.99** (2.37-3.60)
3-hr	**0.672** (0.566-0.813)	**0.854** (0.718-1.03)	**1.12** (0.944-1.35)	**1.34** (1.12-1.61)	**1.63** (1.36-1.96)	**1.87** (1.55-2.24)	**2.12** (1.75-2.54)	**2.40** (1.95-2.87)	**2.77** (2.24-3.32)	**3.08** (2.47-3.70)
6-hr	**0.783** (0.665-0.939)	**0.989** (0.842-1.19)	**1.28** (1.09-1.53)	**1.50** (1.28-1.79)	**1.82** (1.53-2.16)	**2.06** (1.73-2.45)	**2.32** (1.93-2.76)	**2.59** (2.14-3.07)	**2.96** (2.43-3.51)	**3.26** (2.66-3.88)
12-hr	**0.858** (0.741-1.00)	**1.08** (0.934-1.26)	**1.38** (1.18-1.60)	**1.61** (1.38-1.87)	**1.92** (1.64-2.23)	**2.16** (1.84-2.50)	**2.41** (2.04-2.79)	**2.67** (2.24-3.09)	**3.02** (2.52-3.55)	**3.31** (2.73-3.92)
24-hr	**0.968** (0.845-1.12)	**1.21** (1.06-1.40)	**1.52** (1.33-1.75)	**1.77** (1.54-2.03)	**2.10** (1.82-2.41)	**2.35** (2.03-2.70)	**2.61** (2.25-3.00)	**2.88** (2.47-3.31)	**3.24** (2.76-3.72)	**3.53** (2.99-4.05)
2-day	**1.01** (0.884-1.15)	**1.26** (1.11-1.44)	**1.58** (1.39-1.80)	**1.83** (1.60-2.08)	**2.17** (1.89-2.46)	**2.42** (2.10-2.75)	**2.69** (2.32-3.05)	**2.96** (2.54-3.35)	**3.31** (2.83-3.76)	**3.59** (3.06-4.08)
3-day	**1.11** (1.00-1.24)	**1.39** (1.25-1.54)	**1.71** (1.54-1.90)	**1.97** (1.77-2.18)	**2.31** (2.07-2.56)	**2.57** (2.29-2.85)	**2.84** (2.52-3.14)	**3.10** (2.75-3.44)	**3.45** (3.04-3.83)	**3.72** (3.26-4.14)
4-day	**1.22** (1.12-1.33)	**1.51** (1.38-1.65)	**1.84** (1.69-2.01)	**2.11** (1.93-2.29)	**2.46** (2.25-2.67)	**2.72** (2.49-2.96)	**2.99** (2.72-3.24)	**3.25** (2.95-3.53)	**3.59** (3.25-3.91)	**3.85** (3.47-4.19)
7-day	**1.39** (1.27-1.50)	**1.71** (1.58-1.86)	**2.08** (1.91-2.25)	**2.36** (2.17-2.54)	**2.72** (2.50-2.93)	**2.99** (2.75-3.22)	**3.25** (2.99-3.50)	**3.50** (3.22-3.77)	**3.82** (3.51-4.12)	**4.05** (3.71-4.37)
10-day	**1.52** (1.41-1.65)	**1.89** (1.74-2.04)	**2.30** (2.12-2.48)	**2.62** (2.42-2.82)	**3.04** (2.80-3.27)	**3.35** (3.08-3.60)	**3.66** (3.36-3.93)	**3.96** (3.63-4.26)	**4.35** (3.97-4.67)	**4.62** (4.22-4.98)
20-day	**1.88** (1.73-2.05)	**2.33** (2.15-2.54)	**2.82** (2.60-3.06)	**3.19** (2.94-3.45)	**3.65** (3.36-3.94)	**3.98** (3.66-4.29)	**4.30** (3.95-4.63)	**4.59** (4.21-4.93)	**4.94** (4.54-5.32)	**5.19** (4.76-5.59)
30-day	**2.24** (2.06-2.42)	**2.77** (2.55-2.99)	**3.32** (3.06-3.58)	**3.72** (3.43-4.00)	**4.22** (3.88-4.52)	**4.56** (4.20-4.89)	**4.88** (4.50-5.23)	**5.18** (4.76-5.55)	**5.52** (5.08-5.91)	**5.75** (5.29-6.15)
45-day	**2.74** (2.53-2.96)	**3.38** (3.13-3.65)	**4.01** (3.71-4.31)	**4.46** (4.12-4.78)	**4.98** (4.62-5.34)	**5.33** (4.94-5.70)	**5.63** (5.23-6.02)	**5.88** (5.47-6.28)	**6.14** (5.73-6.53)	**6.26** (5.88-6.65)
60-day	**3.15** (2.92-3.40)	**3.89** (3.60-4.19)	**4.61** (4.28-4.96)	**5.12** (4.76-5.51)	**5.73** (5.33-6.15)	**6.14** (5.71-6.58)	**6.50** (6.06-6.97)	**6.81** (6.35-7.30)	**7.13** (6.68-7.64)	**7.31** (6.87-7.82)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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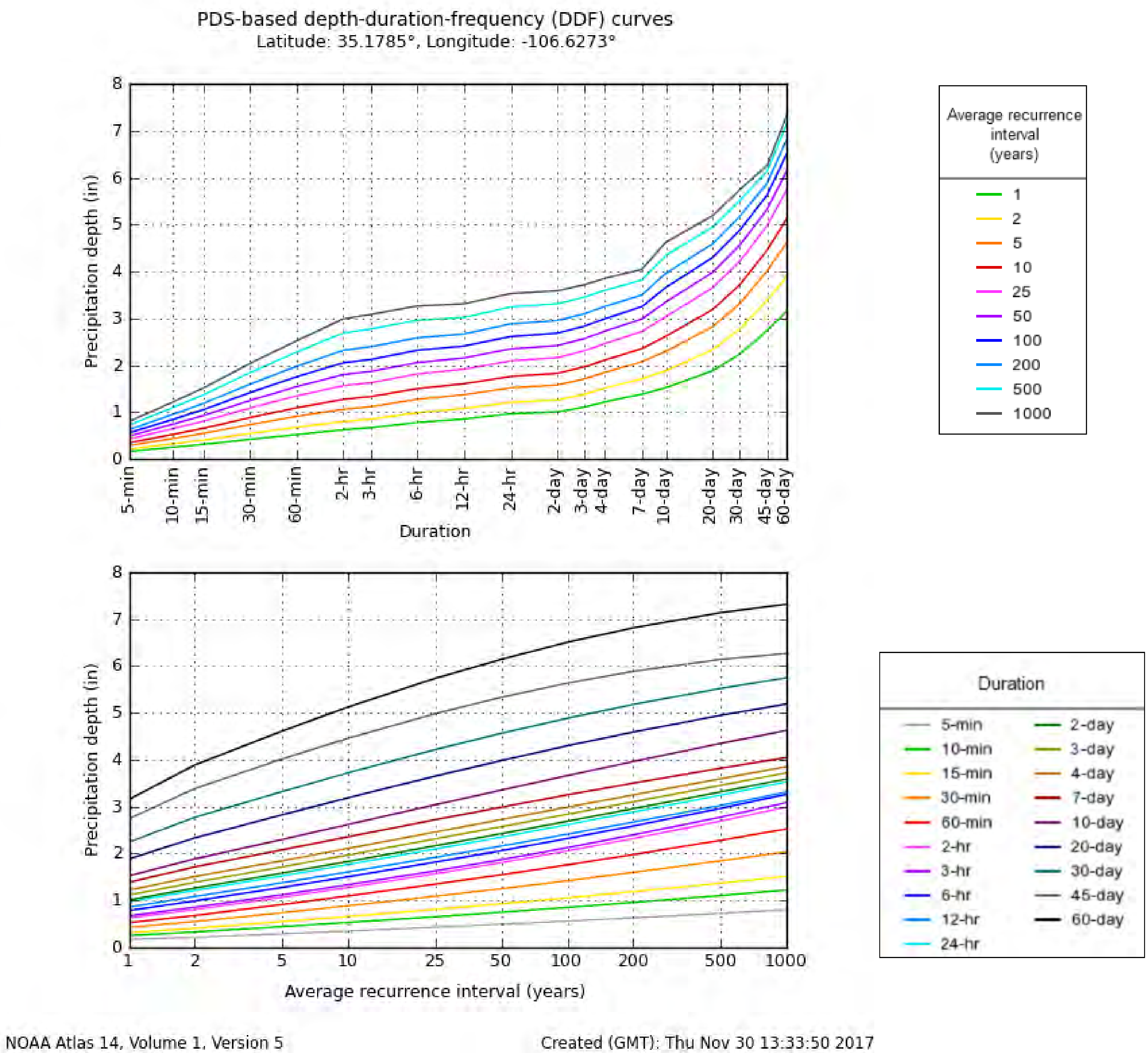
PF graphical



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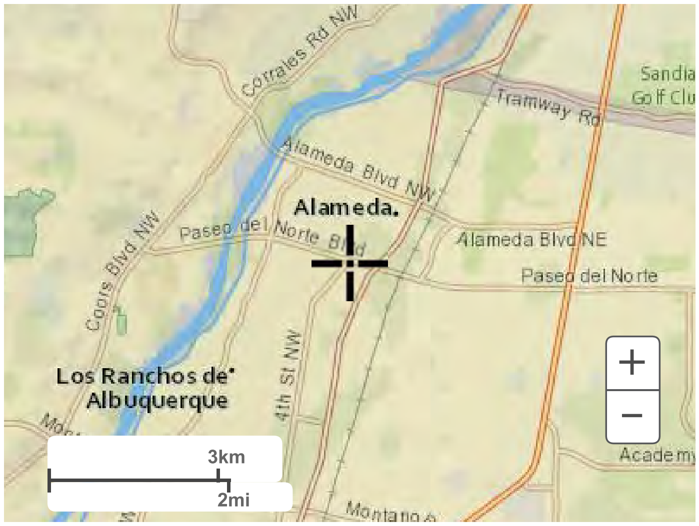

Large scale terrain

Large scale map

Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Table 3–1 — Runoff Curve Numbers for Arid and Semiarid Rangelands[1]

Source: USDA SCS, TR–55, 1986

Cover Description		Curve Numbers for Hydrologic Soil Group –			
Cover Type	Hydrologic Condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and	Poor		80	87	93
low growing brush, with brush the	Fair		71	81	89
minor element.	Good		62	74	85
Oak–aspen—mountain brush mixture of oak	Poor				
brush,	Fair		66	74	79
aspen, mountain mahogany, bitter brush, maple,	Good		48	57	63
and other brush.			30	41	48
Piñon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush,	Poor	63	77	85	88
greasewood, creosotebush, blackbrush, bursage,	Fair	55	72	81	86
palo verde, mesquite, and cactus.	Good	49	68	79	84

[1] Average runoff condition.

[2] Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3] Curve numbers for group A have been developed only for desert shrub.

Table 3-2 — Runoff Curve Numbers for Cultivated Agricultural Lands[1]

Source: USDA SCS, TR-55, 1986

Cover Description			Curve Numbers for Hydrologic Soil Group –			
Cover Type	Treatment[2]	Hydrologic Condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & Terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or	SR	Poor	66	77	85	89
		Good	58	72	81	85
broadcast legumes or	C	Poor	64	75	83	85
		Good	55	69	78	83
rotation meadow	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition.

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 3-3 — Runoff Curve Numbers for Other Agricultural Lands[1]
Source: USDA SCS, TR-55, 1986

Cover Description		Curve Numbers for Hydrologic Soil Group –			
Cover Type	Hydrologic Condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush–weed–grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30[4]	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30[4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition.

[2] Poor: <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3] Poor: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 3–4 — Runoff Curve Numbers Urban Areas[1]

Source: USDA SCS, TR–55, 1986

Cover Description		Curve Numbers for Hydrologic Soil Group –			
Cover Type and Hydrologic Condition	Average Percent Impervious Area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right–of–way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right–of–way)		98	98	98	98
Paved; open ditches (including right–of–way)		83	89	92	93
Gravel (including right–of–way)		76	85	89	91
Dirt (including right–of–way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1– to 2–inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Vacant lands (CN's are determined using cover types similar to those in **Table 3–3**).					

[1] Average runoff condition.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figure 3.9.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using Figure 3.9 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure 3.9, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

PART A - PROCEDURE FOR 40 ACRE AND SMALLER BASINS

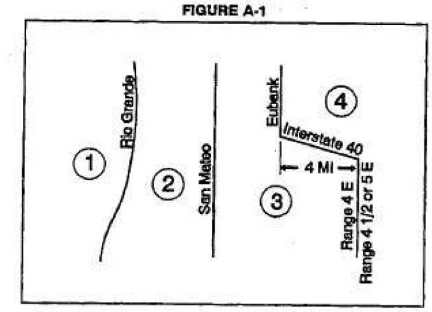
A simplified procedure for projects with sub-basins smaller than 40 acres has been developed based on initial abstraction/uniform infiltration precipitation losses and Rational Method procedures. For this procedure, Bernalillo County has been divided into four (4) Precipitation Zones.

A.1 PRECIPITATION ZONES

Bernalillo County's four precipitation zones are indicated in TABLE A-1 and on FIGURE A-1.

TABLE A-1. PRECIPITATION ZONES	
Zone	**Location**
1	West of the Rio Grande
2	Between the Rio Grande and San Mateo
3	Between San Mateo and Eubank, North of Interstate 40; and between San Mateo and the East boundary of Range 4 East, South of Interstate 40
4	East of Eubank, North of Interstate 40; and East of the East boundary of Range 4 East, South of Interstate 40

FIGURE A-1



Where a watershed extends across a zone boundary, use the zone which contains the largest portion of the watershed.

A.2 DESIGN STORM

The principal design storm is the 100-year 6-hour event defined by the NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Vol. IV - New Mexico. Assume an AMC II condition (a normally dry watershed). For design of retention or detention ponds, storms of 24-hour or longer duration many be required. The 24-hour event is defined by the NOAA Atlas 2. The 4-day and 10-day events can be obtained using the procedures in S.C.S. TSC Technical Note-Hydrology, PO-6 (Rev. 2) The 100-year 60-minute depth is computed by the following formula from Table 11 of NOAA Atlas 2:

$P_{60} = 0.494 + 0.755 * (P_{360} * P_{360} / P_{1440})$ (a-1)

TABLE A-2. DEPTH (INCHES) AT 100-YEAR STORM					
Zone	P_{60}	P_{360}	P_{1440}	P_{4days}	P_{10days}
1	1.87	2.20	2.66	3.12	3.67
2	2.01	2.35	2.75	3.30	3.95
3	2.14	2.60	3.10	3.95	4.90
4	2.23	2.90	3.65	4.70	5.95

The 2-year 60-minute depth is computed by the following formula from NOAA Atlas 2:

$P_{60-2} = -0.011 + 0.942 * (P_{360-2} * P_{360-2} / P_{1440-2})$ (a-2)

Based on fitting a logarithmic curve to the values in Table 12 of NOAA Atlas 2, the 12- minute (0.2 hour) depth was computed to be 50.24 percent of the 60-minute depth:

$P_{12} = 0.5024 * P_{60}$ (a-3)

For certain applications (e.g., street drainage, low flow channels and sediment transport) storms of greater frequency than the 100-year storm must be considered. To estimate precipitation at return periods other than 100 years, multiply the 360-minute or 1440-minute 100-year precipitation amounts by the factors in TABLE A-3.

TABLE A-3. RETURN PERIOD FACTORS	
Return Period (years)	**Factor**
50	0.900
25	0.800
10	0.667
5	0.567
2	0.434

Example A-1
Find the 10-year, 6-hour storm depth for Zone 2. P_{360-10} = 2.35 * 0.667 = 1.57 inches

Example A-2
Find the 2-year, 1-hour storm depth for Zone 3. P_{360-2} = 2.60 * 0.434 = 1.128 inches P_{1440-2} = 3.10 * 0.434 = 1.345 inches P_{60-2} = -0.011 + 0.942* (P_{360-2}* P_{360-2} / P_{1440-2}) = -0.011+ 0.942*(1.128*1.128/1.345) = 0.880 inches

A.3 LAND TREATMENTS

All land areas are described by one of four basic land treatments or by a combination of the four land treatments.

Land treatments are given in TABLE A-4.

TABLE A-4. LAND TREATMENTS	
Treatment	**Land Condition**
A	Soil uncompacted by human activity with 0 to 10 percent slopes. Native grasses, weeds and shrubs in typical densities with minimal disturbance to grading, ground cover and infiltration capacity.
B	Irrigated lawns, parks and golf courses with 0 to 10 percent slopes. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes greater than 10 percent and less than 20 percent.
C	Soil compacted by human activity. Minimal vegetation. Unpaved parking, roads, trails. Most vacant lots. Gravel or rock on plastic (desert landscaping). Irrigated lawns and parks with slopes greater than 10 percent. Native grasses, weeds and shrubs, and soil uncompacted by human activity with slopes at 20 percent or greater. Native grass, weed and shrub areas with clay or clay loam soils and other soils of very low permeability as classified by SCS Hydrologic Soil Group D.
D	Impervious areas, pavement and roofs.
Most watersheds contain a mix of land treatments. To determine proportional treatments, measure respective subareas. In lieu of specific measurement for treatment D, the areal percentages in TABLE A-5 may be employed.	

TABLE A-5. PERCENT TREATMENT D (Impervious)	
Land Use	**Percent**
Commercial*	90
Single Family Residential N=units/acre, N6	7*Sq.Rt.((N*N)+(5*N)) (a-4)
Multiple Unit Residential Detached* Attached*	 60 70
Industrial Light* Heavy*	 70 80
Parks, Cemeteries	7
Playgrounds	13
Schools	50
Collector & Arterial Streets	90
*Includes local streets	

TABLE A-5 does not provide areal percentages for land treatments A, B and C. Use of TABLE A-5 will require additional analysis to determine the appropriate areal percentages of these land treatments.

Backyard retention ponds, and other small on-site ponding, may have the effect of reducing runoff from impervious areas. Where it can be clearly demonstrated that backyard and small on-site retention ponding currently exist, impervious and/or pervious areas which drain to such ponds can be given credit towards their determination of peak rates of runoff and runoff volumes from the development.

A.4 ABSTRACTIONS

Initial abstraction is the precipitation depth which must be exceeded before direct runoff begins. Initial abstraction may be intercepted by vegetation, retained in surface depressions, or absorbed on the watershed surface. Initial abstractions are shown in TABLE A-6.

TABLE A-6. INITIAL ABSTRACTION (IA)	
Treatment	**Initial Abstraction (inches)**
A	0.65
B	0.50
C	0.35
D	0.10

Infiltration is the only significant abstraction after the initial abstraction. After initialabstraction is satisfied, treat infiltration as a constant loss rate as specified in TABLE A-7.

TABLE A-7. INFILTRATION (INF)	
Treatment	**Loss Rate (inches/hour)**
A	1.67
B	1.25
C	0.83
D	0.04*
* Treatment D infiltration rate is applicable from 0 to 3 hours; use uniform reduction from 3 to 6 hours, with no infiltration after 6 hours.	

Runoff from a previous event can saturate a channel bed, rendering it minimally pervious for several days. Do not anticipate additional bed losses for design purposes.

A.5 EXCESS PRECIPITATION & VOLUMETRIC RUNOFF

Excess precipitation, E, is the depth of precipitation remaining after abstractions are removed. Excess precipitation does not depend on watershed area. Excess precipitation is determined by subtracting the initial abstraction and infiltration from the design storm hydro graph. FIGURE A-2 illustrates the development of excess precipitation. The curved line plots cumulative precipitation. Precipitation intensities (in/hr) are shown as a histogram. Initial abstraction is area A. The horizontal line is at a height corresponding to the infiltration rate. Infiltration loss is area B. The remaining histogram, area C, is excess precipitation.