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PLACES Associates, Inc.

Certified WBE

August 17, 2021 By hand delivery

Holden Planning Board
Holden Town Hall
1196 Main Street
Holden, MA 01520

Re: Holden Pine Tree
Revised Definitive Subdivision Plans
Bailey Road and Salisbury Street
Places Project No. 7602

Dear Board Members:

On behalf of our client, Holden Pine Tree LLC, please find enclosed the revised plans and materials for the Definitive Subdivision "Salisbury Pine Tree Estates." Included as part of these revised application materials are:

1. Copies of this cover letter and supporting documentation.
2. 3 Copies of the Drainage Analysis
3. 6 Reduced-scale (11" x17") Plan sets
4. 3 Full sized (24" x 36") Plan sets
5. 1 Flash Drive with pdf files of the above.

Please advise if additional materials are required.

SUMMARY OF REVISIONS:

The revisions to the plan set were technical in nature. Revisions to drainage included the reduction of some pipe slopes to address the velocities, providing runoff calculations at the property lines to abutters on both Bailey and Salisbury Street as well as extending some of the drainage easements. Changes to the sewer lines included adjusting several slopes and details. All changes are identified in details below.

RESPONSE TO REVIEW COMMENTS:

To facilitate review, we have maintained the same numbering system as the Engineering review dated July 16, 2021;(those comments are provided in **bold text**), we have eliminated all resolved comments and have added Places' new response in red text.

1. Provide proof of an agreement between Holden Pine Tree LLC and Holden Realty for the proposed improvements and easements in the area of Salisbury St., including but not limited to use of the roadway and utilities. The Applicant indicated that this agreement will be coordinated with their legal counsel and will be provided prior to the close of the public hearing. **This comment remains until the agreement is provided for review.** This will be provided by our client's legal counsel under separate cover, not by this office.

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2. The Traffic report indicated that the level of service (LOS) for Main St at Salisbury will decrease front B to C as a result of the project. The traffic report also indicates that there will be increased delays. The traffic report shall address mitigations for the change in the LOS or increases in delays. Per Green International Comment 6 and 25-We recommend that a monitoring program and timings optimization be completed by the Applicant. Green International recommended that a monitoring program be implemented at both site driveways and at the intersection of Main Street and Salisbury Street. There should be two programs performed; the first within six (6) months of SO-percent occupancy of the development, and the second within six (6) months of *100-percent* occupancy of the development. The monitoring programs shall be performed to determine if traffic signal optimization is required due to project impacts. As maybe determined by each program, the Applicant shall work with the Massachusetts Department of Transportation (MassDOT) to provide them an optimized traffic signal timing plan at the Main Street and Salisbury Street intersection. Both programs and any necessary traffic timing optimization plans shall be performed by a Massachusetts Registered Professional Engineer and performed at the Applicant's cost. As noted at the public hearings, our client agrees to the recommendations for pre and post monitoring as specified in the Green International review.

3. The "Traffic Impact and Access Study" prepared by MDM Transportation Consultants, Inc. (MDM) states in the Executive Summary on Page 1, that this study was "...developed in conformance with the guidelines for preparation of traffic studies as jointly issued by the Commonwealth of Massachusetts Executive Office of Energy & Environmental Affairs/Massachusetts Department of Transportation (EEA/MassDOT)." Those guidelines for the preparation of a traffic study include a study of multiple transportation modes, including bicycle and pedestrian. Specifically, the guidelines state:

   - *Section 1.i.h.: "any development projects near schools, in particular residential developments that my house schoolchildren, should consider provision of safe and convenient connections to the schools."*
   - *Section 1.IV.C. I -2.' "I. The TIA should include on assessment of the mode split assumptions, as well as the proponent's plan to maximize travel choice, promote non-SOV modes, and achieve the assumed mode shares.*
     - *If a facility is impacted by a proponent's trips and the facility has as access or accommodation deficiency in the mode under review (bicycle, pedestrian, transit) the proponent must assess options to facilitate safe, convenient, and attractive* access via these modes.

   E. In locations where pedestrian facilities are not available, the proponent shall evaluate and document pedestrian needs, desire lines, and opportunities to provide pedestrian infrastructure.
     - *in locations where bicycle facilities are not available, the proponent shall evaluate and document bicycle needs, desire lines, and opportunities to provide bicycle infrastructure.*

As previously communicated to the Applicant, the close proximity of the Dawson Elementary School rear driveway shall be taken into consideration. The design and construction of a sidewalk on Bailey Road between the proposed subdivision and the school should be evaluated. If the evaluation determines that a sidewalk(s) on Bailey Road would create a safer transportation experience for the proposed development and surrounding area, it should be included with the project. **This comment remains. Based on the recommendations from Green International from Comment 22, an amount of $ 200,000.00 should be used as the foundation to determine appropriate funding toward a sidewalk on Bailey Rd. The Applicant in response to this comment, has agreed to contribute some amount of funds towards a sidewalk on Bailey Road from Henry Way to Hubbard Road. The DPW recommends that the Applicant contact the Department to discuss an appropriate amount to be contributed towards the sidewalk on Bailey Rd. At a minimum, an amount equivalent to savings realized by only constructing a sidewalk on one side of the roadways of the subdivision should be considered.**
This office is in receipt of the decision filed at the Worcester Registry of Deeds relative to the approval of the adjacent subdivision, Sunshine Ridge, Bk 65465, Pg. 79. In that decision the Planning Board granted the applicant a waiver for the sidewalk on one side of the road, in lieu of a monetary value of $ 5,400 which

is correlated to the Engineering New Report Construction cost index and the length of the sidewalk. We anticipate that the Planning Board will hold us to a similar standard and reference.

Please also note, that the newly proposed subdivision, Sunshine Ridge, has no connection to any sidewalk system. Our project connects to the existing sidewalk on Salisbury Street, which the Town has previously determined to be in very good condition. (Town of Holden Complete Streets Prioritization Evaluation Matrix, item 7, Sidewalk from Main Street to Dawson School along Salisbury Street, has a function rating of "A".

8. **Provide a cross-section of Basin B series and the crossing.** This cross section is shown on sheet 22-B.

9. Reinforced concrete easement bounds shall be added to each corner of the easement areas. Several corners were missing the bounds. It appears that some reinforced concrete bounds are missing included but not limited to Lot 16/ 15, Lot 36, Lot 11/12, and 1 Pine Tree. Also, use a different symbol for granite bound vs reinforced concrete bound. The plans have been modified to reflect the modified easements (Lotting Plans Sheets 1-4.

15. **We recommend as a condition of approval that the deed of the lots be designed with a stormwater system included, but not limited to swale, flared ends and basins be provided with language stating the purpose and limitations of the use of these areas.**
We do not object to this requirement, but believe these items are already to be specified in both the easement grant and the Homeowner's Association requirements and therefore will be addressed as part of those document requirements and processes.

21. A Homeowners Association (HOA) shall be established for the operation and maintenance of the storm water piping, structures, detention and infiltration basin system located outside of the right of way. Acknowledge. **We recommend that this comment be included as a condition of approval.** This will be provided by our client's legal counsel under separate cover, not by this office.

22. Utility easement rights shall be provided to the Homeowners Association around the infiltration basin for the operation, maintenance and access of the storm water system. The Town shall be provided easement access rights. Acknowledge. **We recommend that this comment be included as a condition of approval.** This will be provided by our client's legal counsel under separate cover, not by this office.

23. **The access road to the BMP shall be clearly shown on the plan and it shall be no less than 10' wide.** Plans revised – see Site Plans sheets 7-10.

24. Subdivision Rules and Regulations Section IV.B. 11 requires house numbers to be included in the Plans. Acknowledge. **We recommend that this comment be included as a condition of approval. The street and unit number shall be approved by the DPW prior to the construction of each phase.** We agree.

Stormwater Report:

26. All wetland areas should be evaluated for volume, peak how and maximum storage height. This comment is partially satisfy. **We agree with the calculations and assumptions used to address this comment regarding surface water flows to the wetlands. The assumptions regarding groundwater flow appear reasonable. We defer to the Conservation Commission for any additional analysis that they may request**

32. Confirm that any wetlands will not be degraded by the changes in how volumes. **See response to comment C.26.**

Water & Sewer:

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36. The water supply calculations take into account flow only from Baily Road, calculations shall be submitted with flow only front Salisbury Street for Phase 1 as Phase 1's water supply comes in only from Salisbury Street. **No additional information has been submitted since October 2019, which is what the previous comments were based on. This comment remains.**
Please see attached updated calculations. Unlike the flows from Bailey Road which have a large diameter water main, the flows from Salisbury Street are fed by a 4" water line, in which sufficient pressure appears to exist, the flow rate is restricted by the size of the line. Based on our calculations, the quad units located at the end of the first phase have sufficient fire supply flows, as they are allowed a 50% reduction in demand because they are required by code to have a sprinkler system. The proposed duplex (lot 21) and single family home (Lot 20) are not required to have sprinkler systems and do not benefit from the reduction of fire flow demands. Our calculations depict that without sprinkler systems, the existing water line off of Salisbury Street would not be sufficient to meet requirements for these two structures. Based on this assessment, we have advised our clients that these two lots must be built with sprinkler systems or their construction must occur after the extension of the water line from Bailey Road, which is part of Phase II.

We ask the Board to make this a condition of the overall phasing plan and project's approval.

41. **The design for the low pressure sewer system shall be completed now and on file. If future changes are necessary, they will be reviewed at that time.** We have received correspondence from our subconsultant, Mr. Henry Albro, from F.R Mahoney, Inc. who has indicated that he is in the process of developing a pressure sewer system design for these lots, as of the date of this letter. We anticipate that this "DRAFT" design will be completed and presented to the DPW/Sewer Dept. prior to the close of the public hearing. We ask that the design be considered a DRAFT as this system will be built in the last phase of the project and new technologies are likely to be able to re-designed into this system.

43. **This comment remains. Additional information is required to support that flowing 50% full is acceptable as good engineering practice.** The plans have been revised to provide slopes less than 8.2% which is the maximum slope for an 8" sewer flowing at 80% capacity with a velocity less than 10 fps. See plan and profile sheets.

Comments from March 30

General:

The applicant contends that since the development is proposed to be constructed in phases, that there is no need for supplemental inspection services. As the applicant acknowledges, the phased growth requirements pertain to building construction, not necessarily subdivision infrastructure construction. If the applicant intends to only fully install the infrastructure in accordance with the phasing plan presented, then we agree that a third party inspection may not be necessary. However, if the subdivision infrastructure will be installed in a different schedule than proposed, or involving simultaneous work in different phases, then third party inspection, in lieu of subdivision inspection fees will be required. We request that any approvals be conditioned on requiring all infrastructure, excepting final pavement, be completed in one phase, prior to commencement of subsequent phases.

It is the anticipation of this office that the infrastructure for the project will be installed in an incremental fashion to meet the phasing plan presented. Because of the unit phasing requirement of Zoning, Section XV, we are not allowed more than 20% of the total unit count to be built in one phase at a time. In each case both the length of road and unit counts are the equivalent of a single family home subdivision. Each phase will require a minimum of one year to build. The phasing summary is:

Phase 1	Pine Tree,	1,100'	19 units.
Phase 2	Henry's	700'	19 units
Phase 3	Henry's to Pine Tree int.	700'±	20 units
Phase 4	Pine Tree to Henry's int.	700'±	20 units
Phase 5	Pine Tree to cul-de-sac	400'±	18 units

The reviewer suggests that if the construction of the infrastructure and roadway were to be installed in single continuous phase that they would not need supplemental, outside inspectors. The Holden Conservation Commission has made it clear that they will not support the development of the project as a single phase, where

the entire site would be required to be clear-cut and graded to support that type of construction. We also would not recommend it as being practical.

Our office is the review engineer for Towns of Bolton, Boxborough, Hubbardston and Stow. In our capacity we are required to review the installation of subdivision roads and infrastructure. In none of these cases would we be recommending or requiring a full-time inspector for a segmented project of this size. Our office is capable of providing part-time inspection to meet the requirements of those town's and their DPW's and Planning Board. It is our anticipation that the construction of the various project phases taking a year at one time is a reasonable timeframe to inspection roadway and utility construction as a standard part of doing business, not with extra outside forces.

We did not and do not want to seek a waiver from the requirements of Subdivision requirements Section VI, Inspectors and ask that the requirements of that section be adhered to as written.

Roadway:

46. Add a crosswalk/ADA ramps at the Pine Tree Road and Salisbury St intersection on Pine Tree. **Add clearly to the Plans the ramp location for the northerly side of this crosswalk.** There is no sidewalk on the northerly side.

Stormwater:

48. The stone reinforced swale on Lot 3/4 is not in the easement area and it shall be. Also, appears that access to this swale for maintenance purposes is not provided. **This comment has been partially addressed. The access road shall be clearly shown on the plans.** See Site Plans – sheets 7-10.

51. It appears that no freeboard is provided for Basin C for the 100-yr storm event. A minimum 1-ft of free board shall be provided for all basins from their peak storage elevations. This comment applies to Basins D and B. **This comment has partially been addressed. A cross-section for Basin B series shall be provided.** See Sheet 22B. Basin C has a 100 year elevation of 789.35. The top of berm is 790.35.

58. The maximum flow velocity shall be 10 ft/sec. Confirm that this standard is met particularly within the cross country PT to Basin A and where the road follows a 10% slope. Also, add the drainage pipe for Profile Sheet at Henry Way Station 5+ 50. The slopes have been adjusted to meet a maximum velocity of 10 fps.

Water & Sewer

55. Provide 10-ft of horizontal separation between water and sewer mains. **On sheet 20, the "Typical Street-24' Wide" detail shows a separation of 7' from water and sewer. Additionally, the detail on sheet 24, "Water and Sewer in Same Trench" shows provisions for less than 10' separation.** The cross section detail was revised and the "Sewer and Water in the Same Trench"was removed. See sheet 23.

66. There does not appear to be a detail for the termination manhole for the force main. **The termination manhole shall have a minimum of 10' of gravity sewer upstream before the force main flow enters the manhole to prevent splashing within the manhole.** Force Main Discharge Detail modified to address this – see sheet 23.

71. There is one sewer service shown to lot 39, but no other sewer services shown. Explain. **This comment has been satisfactorily address for lot 39. Based on the phasing plan, it appears that this is a similar situation as lots 22 and 23 with the buildings being perpendicular to the road.** The plans were revised to indicate a private sewer manhole to service the buildings which were perpendicular to the roads. Lots 1,2,3, 22 and 23 now show a private sewer line to allow direct access from each unit.

72. There are number of sections of sanitary sewer that have slopes that will generate velocities well over 10 ft/s as outlined in TR- 16. These sections shall be re-evaluated to determine where additional manholes and drops shall be added to lessen the slopes. Sewers have been revised to reflect no slopes greater than 8.2% to keep all velocities for sewer lines flowing 80% full to less than 10 fps.

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Comments from July 16, 2021:

73. **Revise the easement for Basin A to include the entire footprint of the basin.** The plans previously showed the remaining portion of Lot 17 as a drainage easement – the plan has been modified to outline Basin A.
74. Provide an easement on Lot 23 for the grass swale. Added.
75. Revise the station for the STU in Henry Way and label the DMH PT 4+60 as STU in the profile. Revised.
76. Revise the symbol for double catchbasins on the site plan where applicable. Revised.
77. Revise drainage manhole detail to include stone envelope around the pipe. Revised.
78. Add to the Plans material specification/gradation for the core material of the berm for the basins. Added.
79. Add to the Stormwater Report the storage capacity per elevation for Basin A. Added.
80. Show on the plans the level spreader for Basin B-3 (back of 124 Bailey Rd). Added.
81. Update Sheet 13, there is a plan covering the profile sheet. Layer turned off.
82. Provide confirmation that Basin A can retain the volume of runoff equal to 1" multiplied by the total post construction impervious surface area. This comment applies to the B Basin series. See sediment forebay sizing for Basin A. For B series, the calculations for the 90% TSS removal are a combination of the stormwater treatment unit removal and the storage of the remaining runoff- see drainage calculations.
83. Provide a long term O&M inspection form for the BMPS. See attached chart as part of the cover letter attachements.
84. The "building sewer trench" detail on sheet 23 shall show a complete envelope of washed, crushed stone, not just a bedding, 12" of stone is required on top of the pipe. Revised.
85. A ductile iron restrained length schedule shall be added to sheet 24 for the typical pipe sizes shown in the plans (8" and 6" ductile iron). The restraint chart has been added to sheet 24 for a MegaLug system by Ebba Iron.

Comments Received from Conservation Commission:

1. For the watershed contributing to the analysis point 6P (pre-development)/60P (post), there should be an intermediate analysis point located at the border of the project with the lot at 114 Bailey Road, to show that flows do not increase where the project discharges directly to this abutter. This has been added to the drainage calculations in chart form and has been shown in the calculations as the flow into Reach 5R in both Pre and Post.

2. For water to discharge at the boundary with 114 Bailey Road, water would pond in a depression located on the project site, and extending onto abutting property to the south. Such storage could attenuate flows to the north. The routing diagrams furnished in the hydrologic calculations indicate that the modeling does not account for this storage under existing conditions.

   As a result, the analysis may be overestimating existing flows to the north under existing conditions. The pre-development modeling should be revised to account for this ponding, to confirm that the project will not increase discharges onto the directly abutting property to the north.

   Note that if groundwater conditions result in seasonal filling of the depression, then the volume normally occupied by groundwater should not be included in the stormwater ponding analysis – under either pre- or post-development conditions.
   In addition to assessing impacts on peak rates, the modeling should document that this pond will not be any deeper under proposed conditions during each of the design storms, as additional

depth of ponding could affect wetlands regulated under local Bylaw, as well as impact abutting properties.

The average elevation of the wetland flags for the "Bailey Wetland" was 776.5. The drainage calculations did not account for any storage below elevation 777 to accommodate the potential for the wetlands to be ponded with groundwater. No excavation adjacent to the pond or to the basin to the north of the isolated wetlands will be below elevation 777, which is higher than the depression's base flood elevation.

As evidenced by the recent sitewalk conducted by the Holden Conservation Commission, where the walk was conducted after multiple days of torrential rain and the surface of the ground was wet, but not ponding water. This isolated wetland (under the Town of Holden's Wetlands Bylaws only, not under the Wetlands Protection Act); has been observed to pond only in the spring when partial frozen ground conditions and groundwater recharge combine to create a surface water condition.

Comment dated August 11, 2021 from the Town Engineer

Demonstrate the abutters on the south side of Salisbury St, downstream of Basin D-3 will not be negatively impact by the proposed discharge. Create a new POA in the vicinity of the location highlighted below for Pre and Post calculations.

This area has been addressed in the "Pine Tree Supplemental Abutter Calculations" showing no increase in the rate of runoff for the 25 year design storm.

Question from Planning Board member:

We have been asked by Mr. Carlson to define the earthwork volumes required to be cut and filled to develop this project. Our AutoCADD 2019 Civil 3D program was used to assess the volumes to be cut and filled. This take-off is a gross take off using the existing conditions surface and comparing it to the proposed grading plan as presented to the Board. Detailed assessments of road base, utility trench and related details are not incorporated into the assessment, except in a general way. However the volumes of proposed excavation for foundations, basins and similar excavations have been taken into account for the overall finished surface comparison.

The gross volume of earth to be moved is estimated at 86,580 cubic yards of which 55,920 cubic yards will be re-used as select fill materials. The estimated surplus is 30,160 cubic yards. A phase by phase breakdown is provided in the attached chart. We note that each phase is anticipated to require one year to build, removing these various volumes from 4,325 to 15,130 cubic yards will occur over time.

We anticipate that phases 1 and a portion of phase 3 will need to be initially clear cut to allow for the stockpiling of the excess cut from phase 1. The material from phase 1 will be mostly sands and gravels that will be able to be used for roadway base, trench filling and other select fill materials in the following phases and will not need to leave the site. Phase 2 will also generate some minor amounts of fill to be re-used. The materials leaving the site will likely be the dense till encountered in phases 3 & 4. Phase 5 is a fill dependent phase, as such it will need to be cleared during phase 4 to allow the placement of some of the surplus materials.

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We believe that we have addressed the previous review comments and understand that the Town will have additional review comments due to the scope of the plan revisions. Please contact this office directly if additional copies are needed or if we can answer any questions.

We thank the Board and other agents of the Town of Holden for your patience in the provision of these plans. This is a large and complex project which when modified has a compounding effect on the overall project.

Very truly yours,
Places Associates, Inc.
BY:

William E. Murray, RLA

Enc: As noted, see table of contents.

Cc: Gail M. Hanny, Salisbury Pine Tree
Paul Haverty, Esq.

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Table of contents for Holden Pine Tree Definitive Subdivision; review comments:

Response Cover Letter, Dated August 17, 2021

Attachments to Response Cover Letter:

Water & Sewer:

1. Fire Flow Calculations for Phase 1, off of Salisbury Street
2. Standard Flow Capacity Calculation for Sewer Flows (max. 10 fps @ 80% capacity)
3. Ebba Iron- Restraint length values for 6" and 8" waterlines, various configurations

Erosion & Sedimentation Control:

1. Long term O&M inspection form for the BMPS

Project Cut & Fill Summary – by phase

1. Salisbury Pine Tree Earthwork Volume Calculations – by construction phase.

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Water & Sewer

1. Fire Flow Calculations – Phase 1 off Salisbury St.
2. Standard Flow Calculation for Sewer(10 fps /80%full)
3. Ebba Iron-Restraint length values for 6" & 8" waterlines

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FIRE FLOW - OFF SALISBURY
PROJECT NO. 7602 PINETREE PHASE 1
SHEET NO. 1 OF 3
CALCULATED BY PTB
CHECKED BY
SCALE
DATE 3/13/21

AVAILABLE FIRE FLOW AT STATION 11+00 PINETREE ROAD

ELEVATION = 814.5 FT
1,125 feet of 8" DICL PIPE

PRESSURE LOSS AT HYDRANT DUE TO ELEVATION CHANGE

EX. Hydrant FEL	772
PROP. Hydrant FEL	814.5
Elevation change	42.5'

change in psi = 0.434 psi / feet elev. change

42.5' x 0.434 psi = **18.5 psi**

Pressure Loss: Darcy-Weisbach Equation

$$h_f = \frac{f L V^2}{2 D g}$$ where

h_f = pressure loss
f = friction coeff
L = length of pipe ft
D = diameter of pipe ft
g = gravity ft/sec²

From previous calculations (5/25/21)

V = 6.08 ft/s

f = 0.032

$$h_f = \frac{(0.032)(1125)(6.08)^2}{2(0.667)(32.2)} = 30.0 \text{ ft.}$$

300' x 0.434 psi = **13.0 psi loss**

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PROJECT NO. 7602 PINE TREE PHASE 1
SHEET NO. 2 OF 4
CALCULATED BY PJB
CHECKED BY
SCALE
DATE 8/13/21

Total psi loss = 18.5 psi + 13.0 psi

= 31.5 psi

69 psi − 31.5 psi = 37.5 psi at proposed hydrant

$$Q = 964\left(\frac{105-20}{105-37.5}\right)^{0.54} = 1091.8 \text{ gpm}$$

Available Fire Flow = 1091.8 gpm

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PROJECT NO. 7602 - PINETREE - PHASE 1
SHEET NO. 3 OF 4
CALCULATED BY PJB
CHECKED BY
SCALE
DATE 3/13/21

PHASE 1: FIRE FLOW REQUIREMENTS FOR LOTS 20 & 21 WITHOUT AUTOMATIC SPRINKLER PROTECTION

MINIMUM REQUIRED FIRE FLOW PER HOLEN TOWN BYLAWS CHAPTER 7.3 SUBDIVISION REGULATIONS SECTION VI.E.2 WATER

$$F = 18 \times C \times (A)^{0.5}$$

where:

F = REQUIRED FIRE FLOW
C = 1.5 FOR WOOD FRAME CONSTRUCTION
A = TOTAL FLOOR AREA

PROPOSED DWELLINGS ON LOTS 20 & 21 ARE 52' x 32' - 2 STORY

$A = 52' \times 32' \times 2$ STORIES $= 3328$ SF

$F = 18 \times 1.5 \times (3328)^{0.5} = 1,558$ gpm

RM ZONING REQUIRES A 25% INCREASE IN THE CALCULATED F.

$1558 \times 0.25 = 390$ gpm

TOTAL REQUIRED FIRE FLOW = 1,558 gpm + 390 gpm

= 1,948 gpm

THE AVAILABLE FIRE FLOW IS 1,091.8 gpm (SEE SHEET 1 OF 3)

SEE CALCULATIONS WITH AUTOMATIC SPRINKLER PROTECTION SHEET 4 OF 4.

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PROJECT NO. 7602 PINE TREE PHASE 1
SHEET NO. 2 OF 4
CALCULATED BY PJB
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FOR SPRINKLERED STRUCTURES F MAY BE REDUCED BY 50%.

LOTS 20 & 21 F = 1,558 gpm
× 50% REDUCTION
= 779 gpm

✓ MINIMUM FIRE FLOW REQUIREMENT IS MET WITH SPRINKLERED STRUCTURES

✓ FOR PHASE 1 4-UNIT STRUCTURES (32' × 96' × 3 STORIES)

A = 32' × 96' × 3 STORIES = 9216 SF

C = 1.0 for ordinary construction

$F = 18 \times 10 \times (9216)^{0.5} = 1,728$ gpm

STRUCTURES ARE SPRINKLERED SO F MAY BE REDUCED BY 50%

1,728 × 50% = 864 gpm ✓ MEETS CRITERA

MINIMUM FIRE FLOW REQUIREMENT IS MET.

Roughness Comparators

Partially FULL Pipe Flow Calculator and Equations

Fluid Flow Table of Contents
Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This engineering calculator determines the Flow within a partially full pipe (&e1/2 fullusing the Manning equation. This calculator can also be used for uniform flow in a pipe, but the Manning roughness coefficient needs to be considered to be variable, dependent upon the depth of flow.

Partially Full Pipe Flow Calculations - U.S. Units

II. Calculation of Discharge, Q, and average velocity, V
for pipes more than half full

Instructions: *Enter values in blue boxes. Calculations in yellow*

Inputs

Pipe Diameter, **D** =	8	in
Depth of flow, **y** =	5.97	in

(must have y ≥ D/2)

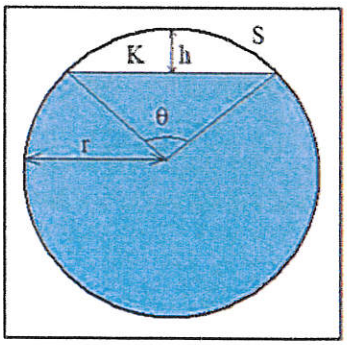
Full Pipe Manning roughness, n_{full} =	0.013	
Channel bottom slope, **S** =	0.0822	ft/ft

Calculations

n/n_{full} =	1.126875	
Partially Full Manning roughness, **n** =	0.015	

Calculations

Pipe Diameter, **D** =	0.6666666	ft
Pipe Radius, **r** =	0.3333333	ft
Circ. Segment Height, **h** =	0.169	ft
Central Angle, **q** =	2.11	radians
Cross-Sect. Area, **A** =	0.28	ft^2
Wetted Perimeter, **P** =	1.4	ft
Hydraulic Radius, **R** =	0.20	ft
Discharge, **Q** =	2.79	cfs
Ave. Velocity, **V** =	10.00	ft/sec
pipe % full $[(A/A_{full})*100\%]$ =	80.0%	



Partially Full Pipe Flow Parameters
(More Than Half Full)

r = D/2

h = 2r - y

(hydraulic radius)

R = A/P

(Manning Equation)

$Q = (1.49/n)(A)(R^{2/3})(S^{1/2})$

V = Q/A

P

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = 2\pi r - r*\theta$$

Equation used for n/n_{full}: $\mathbf{n/n_{full} = 1.25 - (y/D - 0.5)*0.5}$ (for $0.5 \le y/D \le 1$)

Max slope for 8" sewer is 8.2% to keep velocity < 10fps

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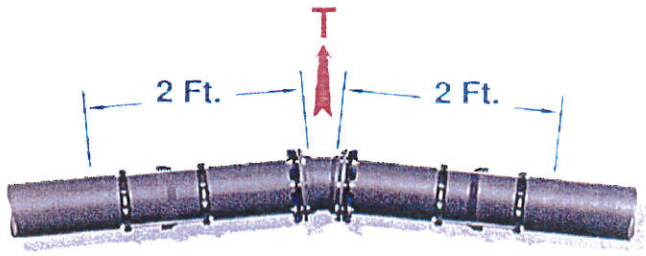
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Horizontal Bend	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	8 In.	11.25°					2 Ft.	

Site Name:

Site Notes:



ALL JOINTS WITHIN THE CALCULATED LENGTH MUST BE RESTRAINED
IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

H =	5	Depth of Bury
S_F =	1.5	Safety Factor
P =	150	Internal Pressure
θ =	11.25	Bend Angle

Pipe Derived Variables

A =	64.33	Cross Sec. Area of Pipe
D =	0.75	Outside Pipe Diameter
W_P =	24	Weight of Pipe
W_W =	24	Weight of Water in Pipe

Defined Variables

f_C =	0.00	Cohesion Modifier Coefficient
c =	0	Cohesion of Soil
f_Φ =	1.00	Friction Angle Modifier
Φ =	31	Internal Friction Angle of Soil
γ =	100	Soil Density
K_N =	1.00	Trench Compaction Modifier

Calculations for Horizontal Bend

$W_E = \gamma \cdot D \cdot H$ =	375.000	Normal Force Due to Soil
$W = 2W_E + W_P + W_W$ =	798.000	Normal Force Acting on Pipeline
$K_P = \tan^2((\pi / 180) \cdot (45 + (\Phi / 2)))$ =	3.124	Rankin Passive Pressure Coeff.
$H_C = H + (D / 2)$ =	5.375	Depth From Surface to Pipe Center
$\sigma_h = \gamma \cdot H_C \cdot K_P + 2c\sqrt{K_P}$ =	1679.150	Horizontal Passive Soil Pressure
$A_P = \pi \cdot (D / 2)$ =	1.178	Area Based on Half of Circumference
$R_S = K_N \cdot \sigma_h \cdot D$ =	1259.363	Bearing Resistance of Pipelines
$F_S = A_P \cdot f_C \cdot c + W \cdot \tan((\pi / 180) \cdot f_\Phi \cdot \Phi)$ =	479.487	Frictional Resitance
$L = (S_F \cdot P \cdot A \cdot \tan((\pi / 180) \cdot (\theta / 2))) / (F_S + (R_S / 2))$ =	1.285	Minimum Restrained Length

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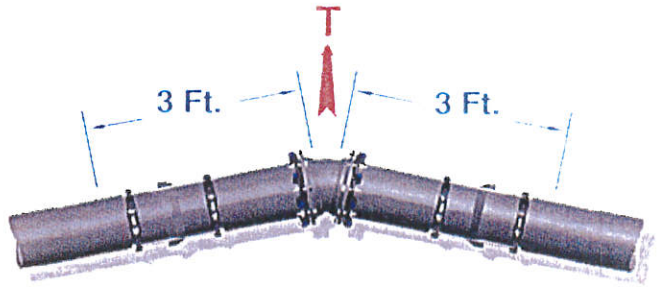
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Horizontal Bend	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	8 In.	22.5°					3 Ft.	

Site Name:

Site Notes:



ALL JOINTS WITHIN THE CALCULATED LENGTH MUST BE RESTRAINED
IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

H =	5	Depth of Bury
S_F =	1.5	Safety Factor
P =	150	Internal Pressure
θ =	22.5	Bend Angle

Pipe Derived Variables

A =	64.33	Cross Sec. Area of Pipe
D =	0.75	Outside Pipe Diameter
W_P =	24	Weight of Pipe
W_W =	24	Weight of Water in Pipe

Defined Variables

f_C =	0.00	Cohesion Modifier Coefficient
c =	0	Cohesion of Soil
f_Φ =	1.00	Friction Angle Modifier
Φ =	31	Internal Friction Angle of Soil
γ =	100	Soil Density
K_N =	1.00	Trench Compaction Modifier

Calculations for Horizontal Bend

$W_F = \gamma \cdot D \cdot H =$	375.000	Normal Force Due to Soil
$W = 2W_E + W_P + W_W =$	798.000	Normal Force Acting on Pipeline
$K_P = \tan^2((\pi / 180) \cdot (45 + (\Phi / 2))) =$	3.124	Rankin Passive Pressure Coeff.
$H_C = H + (D / 2) =$	5.375	Depth From Surface to Pipe Center
$\sigma_h = \gamma \cdot H_C \cdot K_P + 2c\sqrt{K_P} =$	1679.150	Horizontal Passive Soil Pressure
$A_P = \pi \cdot (D / 2) =$	1.178	Area Based on Half of Circumference
$R_S = K_N \cdot \sigma_h \cdot D =$	1259.363	Bearing Resistance of Pipelines
$F_S = A_P \cdot f_C \cdot c + W \cdot \tan((\pi / 180) \cdot f_\Phi \cdot \Phi) =$	479.487	Frictional Resitance
$L = (S_F \cdot P \cdot A \cdot \tan((\pi / 180) \cdot (\theta / 2))) / (F_S + (R_S / 2)) =$	2.596	Minimum Restrained Length

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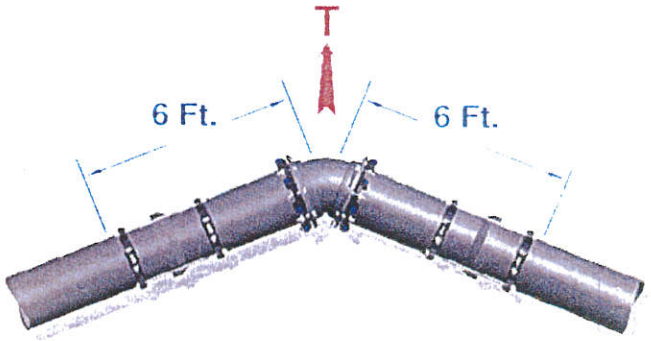
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Horizontal Bend	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	8 In.	45°					6 Ft.	

Site Name:

Site Notes:



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IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

H =	5	Depth of Bury
S_f =	1.5	Safety Factor
P =	150	Internal Pressure
θ =	45	Bend Angle

Pipe Derived Variables

A =	64.33	Cross Sec. Area of Pipe
D =	0.75	Outside Pipe Diameter
W_p =	24	Weight of Pipe
W_W =	24	Weight of Water in Pipe

Defined Variables

f_c =	0.00	Cohesion Modifier Coefficient
c =	0	Cohesion of Soil
f_Φ =	1.00	Friction Angle Modifier
Φ =	31	Internal Friction Angle of Soil
γ =	100	Soil Density
K_N =	1.00	Trench Compaction Modifier

Calculations for Horizontal Bend

$W_E = \gamma \cdot D \cdot H$ =	375.000	Normal Force Due to Soil
$W = 2W_E + W_P + W_W$ =	798.000	Normal Force Acting on Pipeline
$K_P = \tan^2((\pi / 180) \cdot (45 + (\Phi / 2)))$ =	3.124	Rankin Passive Pressure Coeff.
$H_C = H + (D / 2)$ =	5.375	Depth From Surface to Pipe Center
$\sigma_h = \gamma \cdot H_C \cdot K_P + 2c\sqrt{K_P}$ =	1679.150	Horizontal Passive Soil Pressure
$A_P = \pi \cdot (D / 2)$ =	1.178	Area Based on Half of Circumference
$R_S = K_N \cdot \sigma_h \cdot D$ =	1259.363	Bearing Resistance of Pipelines
$F_S = A_P \cdot f_C \cdot c + W \cdot \tan((\pi / 180) \cdot f_\Phi \cdot \Phi)$ =	479.487	Frictional Resitance
$L = (S_f \cdot P \cdot A \cdot \tan((\pi / 180) \cdot (\theta / 2))) / (F_S + (R_S / 2))$ =	5.405	Minimum Restrained Length

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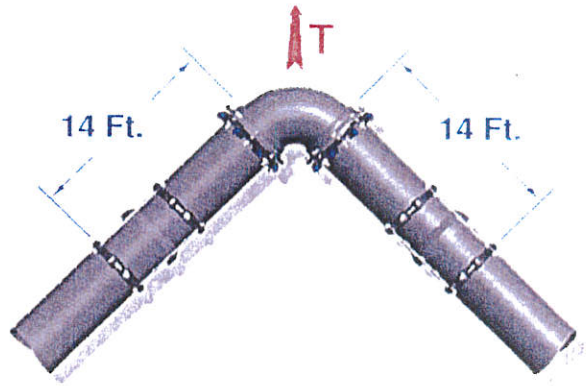
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Horizontal Bend	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	8 In.	90°					14 Ft.	

Site Name:

Site Notes:



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IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

H =	5	Depth of Bury
S_F =	1.5	Safety Factor
P =	150	Internal Pressure
θ =	90	Bend Angle

Pipe Derived Variables

A =	64.33	Cross Sec. Area of Pipe
D =	0.75	Outside Pipe Diameter
W_P =	24	Weight of Pipe
W_W =	24	Weight of Water in Pipe

Defined Variables

f_C =	0.00	Cohesion Modifier Coefficient
c =	0	Cohesion of Soil
f_Φ =	1.00	Friction Angle Modifier
Φ =	31	Internal Friction Angle of Soil
γ =	100	Soil Density
K_N =	1.00	Trench Compaction Modifier

Calculations for Horizontal Bend

$W_E = \gamma \cdot D \cdot H$ =	375.000	Normal Force Due to Soil
$W = 2W_E + W_P + W_W$ =	798.000	Normal Force Acting on Pipeline
$K_P = \tan^2((\pi / 180) \cdot (45 + (\Phi / 2)))$ =	3.124	Rankin Passive Pressure Coeff.
$H_C = H + (D / 2)$ =	5.375	Depth From Surface to Pipe Center
$\sigma_h = \gamma \cdot H_C \cdot K_P + 2c\sqrt{K_P}$ =	1679.150	Horizontal Passive Soil Pressure
$A_P = \pi \cdot (D / 2)$ =	1.178	Area Based on Half of Circumference
$R_S = K_N \cdot \sigma_h \cdot D$ =	1259.363	Bearing Resistance of Pipelines
$F_S = A_P \cdot f_C \cdot c + W \cdot \tan((\pi / 180) \cdot f_\Phi \cdot \Phi)$ =	479.487	Frictional Resitance
$L = (S_F \cdot P \cdot A \cdot \tan((\pi / 180) \cdot (0 / 2))) / (F_S + (R_S / 2))$ =	13.050	Minimum Restrained Length

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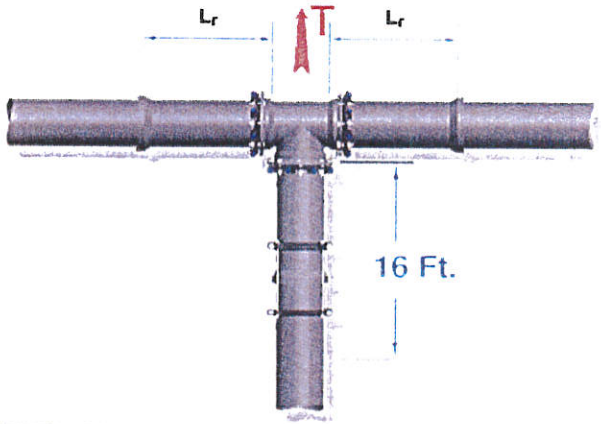
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Tee	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	6 In.		8 In.	5 Ft.			16 Ft.	

Site Name:

Site Notes:



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IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

H =	5	Depth of Bury
S_f =	1.5	Safety Factor
P =	150	Internal Pressure

Pipe Derived Variables

A =	37.39	Cross Sec. Area (Main)
A_b =	64.33	Cross Sec. Area (Branch)
D =	0.58	Outside Pipe Diameter
D_b =	0.75	Outside Diameter Branch
W_P =	24	Weight of Pipe
W_W =	24	Weight of Water in Pipe
L_r =	5	Min. restrained Length either side of Tee

Defined Variables

f_C =	0.00	Cohesion Modifier Coefficient
c =	0	Cohesion of Soil
f_Φ =	1.00	Friction Angle Modifier
Φ =	31	Internal Friction Angle of Soil
γ =	100	Soil Density

Calculations for Tee

$W_E = \gamma \cdot D \cdot H =$	375.000	Normal Force Due to Soil
$W = 2W_E + W_P + W_W =$	798.000	Normal Force Acting on Pipeline
$K_P = \tan^2((\pi / 180) \cdot (45 + (\Phi / 2))) =$	3.124	Rankin Passive Pressure Coeff.
$H_C = H + (D / 2) =$	5.290	Depth From Surface to Pipe Center
$\sigma_h = \gamma \cdot H_C \cdot K_P + 2c\sqrt{K_P} =$	1652.596	Horizontal Passive Soil Pressure
$A_P = \pi \cdot (D / 2) =$	0.911	Area Based on Half of Circumference
$(A_P)_b = \pi \cdot D_b =$	2.356	Area Based on Full Branch Circumference
$R_S = K_N \cdot \sigma_h \cdot D =$	958.506	Bearing Resistance of Pipelines
$F_{sb} = (A_P)_b \cdot f_C \cdot c + W \cdot \tan((\pi / 180) f_\Phi \cdot \Phi) =$	479.487	Frictional Resistance
$L_b = S_f(P \cdot A_b - R_S \cdot L_r) / F_{sb} =$	15.194	Minimum Restrained Length Branch

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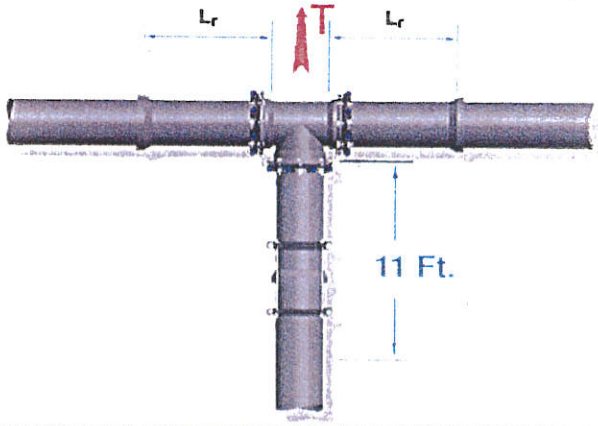
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Tee	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	8 In.		8 In.	5 Ft.			11 Ft.	

Site Name:

Site Notes:



ALL JOINTS WITHIN THE CALCULATED LENGTH MUST BE RESTRAINED
IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

H =	5	Depth of Bury
S_f =	1.5	Safety Factor
P =	150	Internal Pressure

Pipe Derived Variables

A =	64.33	Cross Sec. Area (Main)
A_b =	64.33	Cross Sec. Area (Branch)
D =	0.75	Outside Pipe Diameter
D_b =	0.75	Outside Diameter Branch
W_P =	24	Weight of Pipe
W_W =	24	Weight of Water in Pipe
L_r =	5	Min. restrained Length either side of Tee

Defined Variables

f_c =	0.00	Cohesion Modifier Coefficient
c =	0	Cohesion of Soil
f_Φ =	1.00	Friction Angle Modifier
Φ =	31	Internal Friction Angle of Soil
γ =	100	Soil Density

Calculations for Tee

$W_E = \gamma \cdot D \cdot H$ =	375.000	Normal Force Due to Soil
$W = 2W_E + W_P + W_W$ =	798.000	Normal Force Acting on Pipeline
$K_p = \tan^2((\pi / 180) \cdot (45 + (\Phi / 2)))$ =	3.124	Rankin Passive Pressure Coeff.
$H_C = H + (D / 2)$ =	5.375	Depth From Surface to Pipe Center
$\sigma_h = \gamma \cdot H_C \cdot K_p + 2c\sqrt{K_p}$ =	1679.150	Horizontal Passive Soil Pressure
$A_p = \pi \cdot (D / 2)$ =	1.178	Area Based on Half of Circumference
$(A_p)_b = \pi \cdot D_b$ =	2.356	Area Based on Full Branch Circumference
$R_S = K_N \cdot \sigma_h \cdot D$ =	1259.363	Bearing Resistance of Pipelines
$F_{sh} = (A_p)_b \cdot f_c \cdot c + W \cdot \tan((\pi / 180) f_\Phi \cdot \Phi)$ =	479.487	Frictional Resistance
$L_b = S_f(P \cdot A_b - R_S \cdot L_r) / F_{sh}$ =	10.488	Minimum Restrained Length Branch

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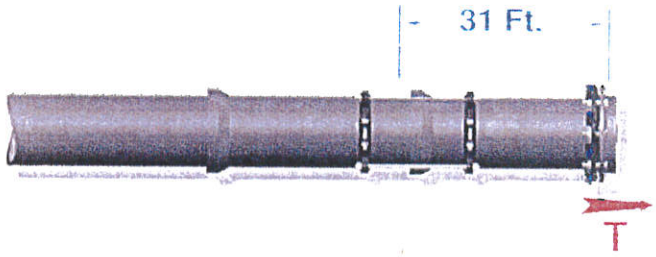
RESTRAINT LENGTH VALUES

Fitting Type	Pipe Material	Soil Type	Safety Factor	Trench Type	Depth of Bury	Test Pressure	Nominal Size	Bend Angle	Branch Size	Length Along Run	Reduced Size	Lowside Depth	Restraint Length	Restraint Length 2
Dead End	Ductile Iron	CL, Gran.Fill	1.5	5	5 Ft.	150 PSI	8 In.						31 Ft.	

Site Name:

Site Notes:



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IF YOUR DISTANCE BETWEEN FITTINGS IS LESS THAN OR EQUAL TO THE CALCULATED RESTRAINT LENGTH, RESTRAIN ALL JOINTS BETWEEN THOSE FITTINGS.

Defined Variables

$H =$	5	Depth of Bury
$S_f =$	1.5	Safety Factor
$P =$	150	Internal Pressure

Pipe Derived Variables

$A =$	64.33	Cross Sec. Area of Pipe
$D =$	0.75	Outside Pipe Diameter
$W_p =$	24	Weight of Pipe
$W_w =$	24	Weight of Water in Pipe

Defined Variables

$f_c =$	0.00	Cohesion Modifier Coefficient
$c =$	0	Cohesion of Soil
$f_\phi =$	1.00	Friction Angle Modifier
$\Phi =$	31	Internal Friction Angle of Soil
$\gamma =$	100	Soil Density

Calculations for Dead End

$W_E = \gamma \cdot D \cdot H =$	375.000	Normal Force Due to Soil
$W = 2W_E + W_p + W_W =$	798.000	Normal Force Acting on Pipeline
$(A_p)_b = \pi \cdot D =$	2.356	Area Based on Full Pipe Circumference
$F_{sb} = (A_p)_b \cdot f_c \cdot c + W \cdot \tan((\pi / 180)\, f_\phi \cdot \Phi) =$	479.487	Frictional Resistance
$L = S_F \cdot P \cdot A / F_{sb} =$	30.187	Minimum Restrained Length of Dead End

Erosion &Sedimentation Control

1. Long Term O & M Inspection Form

Salisbury Pine Tree

PROJECT LOCATION: Off Salisbury Street, Pine Tree Road, and Bailey Road, Holden, MA

STORMWATER ANAGEMENT BEST MANAGEMENT PRACTICES - INSPECTION SCHEDULE AND EVALUATION CHECKLIST

Best Management Practice	Inspection Frequency (1)	Date I	Inspector	Minimum Maintenance and Key Items to Check	Cleaning/Repair Needed yes__ no__ (list items)	Date of Cleaning /Repair	Performed By
Street Sweeping	4x per year			Vacuum sweeper			
Deep Sump and Hooded Catch Basins	4x per year			Vacuum Truck, remove sediments and debris			
Sediment Forebays	Inspect Monthly, Clean 4x per year			Mow grass to maintain grass height between 3 and 6 inches. After removing sediment, replace any damaged vegetation			
Infiltration Basins	2x annually			Mow as needed to keep grass under 6"; rake stone bottom; remove trash and debris, grass clippings and accumulated organic matter; contact professional if standing water is observed for 48 hours after rain event			
Level Spreader	Monthly			Inspect and repair as needed; remove accumulated debris			
VortSentry Water Quality device	4x per year			Revove Sediment and trapped pollutants per manufacturer Requirements			

Recommendations regarding frequency for inspection and maintenance of specific BMPs.

Stormwater Control Manager/Environmental Monitor: **Stamp/Signature**

Project Cut & Fill Summary Chart

1. Salisbury Pine Tree Earthwork Volume Calculations

SALISBURY PINE TREE EARTHWORK VOLUME CALCULATIONS*					
PHASE	**CUT****	**FILL**	**REUSED*****	**Net After Reuse**	**CUMMULATIVE NET PER PHASE**
1	+21300	-3735	+5500	+12065	+12065
2	+12000	-3675	+4000	+4325	+16390
3	+23750	-2120	+6500	+15130	+31520
4	+16300	-1930	+2500	+11870	+43390
5	+13230	-24460	+2000	-13230	+30160
TOTAL	+86580	-35920	+20500	+30160	+30160

*All volumes are in cubic yards (CY)

**Cut volumes include excavation for individual foundations as shown on the design drawings. Volumes may change if constructed foundations are different than as shown.

***Reused material is the excavated material suitable for on-site backfill work (foundations, road, stormwater facilities, etc.)

Total Surplus Volume = 30,160 CY