KNOXVILLE UTILITIES BOARD

DESIGN GUIDE FOR CONSTRUCTION APPROVAL FOR WASTEWATER LOW PRESSURE SEWER SYSTEMS

2ND EDITION
OCTOBER 2008

Knoxville Utilities Board

Introduction to Design Guide for Wastewater Systems

The purpose of this document is to assist developers and design firms with successfully completing wastewater designs for proposed developments. This guide offers a standard set of templates that are proposed for wastewater system designs and outlines the minimum submittal information considered to be required by KUB for new systems such as subdivisions, extensions, upgrades, etc. The purpose of this guide is to improve the efficiency of reviews by reducing the number of re-submittals by the developer's design firm.

As a general rule, the first submittal of a proposed low pressure sewer system should include only two paper copies of the design and appropriate stamped calculations (also send a copy of the storm water and grading plans with the proposal) to KUB. One copy will be marked and kept by KUB, and the second will be returned to the designer with comments for revisions. Once the plans are ready for approval, KUB will notify the designer to submit the required number of copies and a Compact Disc (CD) with the proposed wastewater drawings attached as well as all required easement as applicable.

Documents contained in the Sections

Several items located in this package can help assist designers in document submittal requirements when preparing proposed wastewater plans and calculations. This guide is divided into several sections. The sections include parts A through E, focusing on required checklists that are used to approve general wastewater design projects, Sections F though I focusing on required checklists that are used to approve wastewater as-built submittals, and the latter sections give various wastewater design examples that relate to the previous checklist requirements mentioned.

<u>Proposed Construction Approval for Wastewater Gravity Drawing Requirements (Sections A-H)</u>
There are sets of wastewater design checklists that are used to review the plans in order to improve the efficiency of the review process. It is important that the designer view the checklist items before project submittal to KUB. If an item on the checklist is not identified in the project submittals, the plans will not be approved and will have to be corrected. Note that Sections A-H should be used for gravity wastewater sewer designs. The "Required Documents for Wastewater Submittals" page outlines all the required checklist items relevant to the type of design.

<u>Additional Resources for Construction Approval of Wastewater Gravity Systems</u>
KUB has provided numerous hyperlinks through our webpage to further assist is receiving approved plans. These additional resources include example designs, electronic KUB Border, electronic version of required construction notes, etc. Contact Engineering New Service for additional details of accessing this information.

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CHART A-1: Review Process -General Low Pressure Sewer

Comment Number	First Date: _____	Second Date: _____	Review Criteria
1			The stormwater/grading plan(s) are submitted during initial review and if grading or stormwater changes.
2			If submitted design plans are of a project with multiple phases, all prior phases and their respective easements and final subdivision plans must already be approved, accepted, and recorded if this phase will connect to an earlier phase.
3			Design plans are 24" x 36" (D Size) drawings
4			Provided KUB border is used.
			Title Block at the bottom of each sheet must include:
5			- Project name (Public or Private)
6			- Engineer's company, address and phone number
7			- Engineer's stamp (signed and dated)
8			- Developer's name, address, and phone number
9			North Arrow on all sheets
10			Vicinity Map (Upper right-hand corner)
11			Location, station number, and elevation of nearest TDOT or Knoxville survey control marker
12			City of Knoxville or TDOT survey marker is to be included on all site plan sheets. Elevations shall be related to City of Knoxville or TDOT elevation data. Elevations will not be assumed.
13			Property units given in table format.
14			Print out LandViewer drawing showing all utilities (i.e., water, sewer, gas, electric, storm, etc.). Date and initial in the printout and include in the project file.
15			Checklist of "potential permit documents" attached to first set of reviewed plans.
16			Reviewer dates and signs office copy of plans (KUB only)

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CHART B-1: Review Process - General Low Pressure Sewer (Plan View)

Comment Number	First Date: _____	Second Date: _____	Review Criteria
17			Plan & profile can be any scale used from a standard engineering scale, such as 1"=5' (profile), 1"=20', 1"=50', 1"=100', etc.
18			All existing public utilities and associated easements are shown where appropriate (i.e. water, sewer, gas, electric, storm, etc.)
19			Bold all proposed wastewater utilities and features and reduce line weight for other utilities in order to clarify the project's items of interest.
20			Represent existing wastewater mains by dashed lines. (Refer to provided drawing legend.)
21			Represent proposed wastewater mains by solid continuous lines (Refer to provided drawing legend.)
22			Station 0+00 is located at the downstream end of the wastewater main and is on the left side of each drawing sheet.
23			Location where project/phase completion will occur is clearly shown (i.e. E.O.L..)
24			Clearly label lines throughout proposed project
25			Clearly indicate the location and station number of all important appurtenances. Manholes (existing and proposed) are described by the line stationing (i.e., MH STATION 0+50) and the KUB MH number for existing manholes.
26			Clearly label each proposed pipe's material and size. Include pipe length on profile view.
27			Clearly indicate locations of storm water mains, catch basins and detention ponds (existing and proposed).
28			All stormwater mains not running parallel to sewer mains are shown in profile view.

CHART B-2: Review Process - General Low Pressure Sewer (Profile View)

Comment Number	**First** Date: _____	**Second** Date: _____	**Review Criteria**
29			Plan & profile can be any scale used from a standard engineering scale, such as 1"=5' (profile), 1"=20', 1"=50', 1"=100', etc.
30			All existing public utilities and associated easements are shown where appropriate (i.e. water, sewer, gas, electric, storm, etc.)
31			Bold all proposed wastewater utilities and features and reduce line weight for other utilities in order to clarify the project's items of interest.
32			Represent existing wastewater mains by dashed lines. (Refer to provided drawing legend.)
33			Represent proposed wastewater mains by solid continuous lines (Refer to provided drawing legend.)
34			Station 0+00 is located at the downstream end of the wastewater main and is on the left side of each drawing sheet.
35			Location where project/phase completion will occur is clearly shown (i.e. E.O.L..)
36			Clearly label lines throughout proposed project
37			Clearly indicate the location and station number of all important appurtenances. Manholes (existing and proposed) are described by the line stationing (i.e., MH STATION 0+50) and the KUB MH number for existing manholes.
38			Clearly label each proposed pipe's material and size. Include pipe length on profile view.
39			Clearly indicate locations of storm water mains, catch basins and detention ponds (existing and proposed).
40			All stormwater mains not running parallel to sewer mains are shown in profile view.

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CHART C-1: Low Pressure Sewer Review Process - Site Plan View

Comment Number	First Date: _____	Second Date: _____	Review Criteria
	Plan View General:		
41			Rights-of-way (ROW), edges of pavement, driveways and property lines are shown and labeled.
42			Existing and proposed streets and street names are shown (actual street names used) if known.
43			Future development in adjacent parcels is addressed in the design by either providing easements for future extensions or extending utilities to allow immediate access for future phases.
44			Show all building footprints and other proposed structures such as pool, garage, clubhouse, etc., on drawing plan that impact the design.
45			Existing houses shall be given consideration during the design of the proposed wastewater system. Finished floor elevations (FFE) and basement elevations for existing houses shall be shown on drawings as required.
46			Ensure that figure numbers from KUB's Standards and Specifications are used for appropriate appurtenances.
47			Show vegetation.
	Main & Lateral Locations:		
	First	**Second**	
			DO INSTALL IN
48			Street right-of-ways
49			Easements
			DON'T INSTALL IN
50			Paved areas
51			Berms or any crossing detention basins.
52			Wastewater mains shall not be installed in the same trench with other utilities unless approved by KUB Engineering in writing prior to the preparation of design plans
	Horizontal Separation:		
53			Horizontal separation between water and wastewater mains is at least 10 feet
	Manholes:		
54			Clearly indicate stub out elevations and locations for <u>future</u> laterals and wastewater mains at manholes.
	Laterals:		
55			Clearly present the proposed locations of all proposed laterals
56			Each customer (lot or unit) shall have its own sewer lateral connection.

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CHART D-1: Low Pressure Sewer Review Process - Profile View

Comment Number	First Date: _____	Second Date: _____	Review Criteria
	Vertical Separation:		
57			Vertical separation must be labeled between wastewater mains and all utilities to include water and stormwater lines.
58			Wastewater and water mains have at least 18 inches of vertical separation measured from outside pipe to outside pipe.
59			Minimum vertical separation shall be greater than or equal to 24 inches between the outside of sanitary sewer mains and the outside of storm water sewer mains.
	Wastewater Main Depth:		
60			Minimum depth of cover for gravity wastewater lines in roadways and other traffic-bearing areas is 48 inches for PVC, HDPE, and CCFMP and 30 inches for Ductile Iron. In non-traffic-bearing areas (easements), the minimum cover is 30 inches no matter the pipe material.
61			Investigate options to shallow deep mains.
62			Where applicable indicate fill compaction specifications that meet KUB standards.
	Material:		
63			When ductile iron pipe must be used on a portion of a new sewer line segment, the entire length of sewer must be installed with Ductile Iron pipe. No flexible couplings will be permitted on new construction to convert to PVC between manholes.
64			Polyvinyl chloride (PVC) pipes and fittings shall meet or exceed an SDR 26 for pipe from 4 inches to 15 inches in diameter for gravity sewer excluding clean-outs until they are available in SDR 26.
65			HDPE pipes and fittings shall be a minimum of SDR 17 with DIP outside pipe diameters, external green stripe, and heat fusion welded joints for gravity sewer.

CHART E-1: Low Pressure Sewer Drawing Requirements (Plan View)

Comment Number	First Date: _____	Second Date: _____	Review Criteria
66			LPS pipe 4 inches and smaller shall be HDPE SDR - 11; LPS pipe larger than 4 inches shall be HDPE SDR 17.
67			LPS mains shall be sized through E/One Design Assistant for Low Pressure Sewer Systems Software or KUB approved equal. **NOTE**: Use C of 150 in design software.
68			Zone assignments for the E/One Software should take into account increases in simultaneous operations and the effects on max flow rates per zone.
69			All the spreadsheets used for hydraulic calculations in the E/One Design Assistant (or KUB approved equal) Software are submitted with the proposed LPS design.
70			Air Release Valves shall be placed at peak elevation points that produces a significant crest.
71			Clearly indicate the locations of every flushing station in the proposed design.
72			A flushing station should be located at the end of every LPS main.
73			Wherever pipe must be deflected from a straight line (in either the vertical or horizontal plane) in order to avoid obstructions, or wherever long radius curves are permitted, the amount of deflection shall not exceed the pipe manufacturer's recommendations and details should indicate the allowable deflection to the pipe.
74			Acceptable HDPE pipe diameters for LPS are 1¼", 2", 3", and 4".
75			Thrust/Restraint blocking shown (where appropriate).

CHART E-2: Low Pressure Sewer Drawing Requirements (Profile View)

Comment Number	First Date: _____	Second Date: _____	Review Criteria
76			LPS pipe 4 inches and smaller shall be HDPE SDR - 11; LPS pipe larger than 4 inches shall be HDPE SDR 17.
77			LPS mains shall be sized through E/One Design Assistant for Low Pressure Sewer Systems Software or KUB approved equal. **NOTE**: Use C of 150 in design software.
78			Zone assignments for the E/One Software should take into account increases in simultaneous operations and the effects on max flow rates per zone.

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79			All the spreadsheets used for hydraulic calculations in the E/One Design Assistant (or KUB approved equal) Software are submitted with the proposed LPS design.
80			Air Release Valves shall be placed at peak elevation points that produces a significant crest.
81			Clearly indicate the locations of every flushing station in the proposed design.
82			A flushing station should be located at the end of every LPS main.
83			Wherever pipe must be deflected from a straight line (in either the vertical or horizontal plane) in order to avoid obstructions, or wherever long radius curves are permitted, the amount of deflection shall not exceed the pipe manufacturer's recommendations and details should indicate the allowable deflection to the pipe.
84			Acceptable HDPE pipe diameters for LPS are 1¼", 2", 3", and 4".
85			Thrust/Restraint blocking shown (where appropriate).

CHART E-3: Low Pressure Sewer Drawing Requirements (Plan View Only)

Comment Number	**First** Date: _____	**Second** Date: _____	**Review Criteria**
86			All the "Zones" that are used in the LPS calculations (done by E/One Design Assistant) are identified clearly as to their extent in the design plan (e.g. Zone # 3) view.
87			Clearly indicate the approximate location, material, and size of every LPS mains, service laterals, and E/One (or KUB approved equal) grinder pumps in the proposed design.
88			Horizontal separation between water and LPS mains is at least 10 feet.
89			Every proposed lot or unit will have its own Model Extreme E/One grinder pump (or KUB approved equivalent) which produces a flow rate of 11 gpm.
90			Consideration of the combination of existing and proposed grinder pumps on the same Force Main are found in calculations used with the E/One Sewer Design Assistant Software and on the design plans.
91			All residential LPS service laterals are 1¼ inch HDPE SDR-11 pipe and are clearly indicated in the plans.
92			At least one set of wastewater hydraulic calculations stamped by registered P.E. are submitted with calculations..

Chart E-4: Low Pressure Sewer Drawing Requirements (Profile View Only)

Comment Number	First Date: _____	Second Date: _____	Review Criteria
93			All the "Zones" that are used in the LPS calculations (done by E/One Design Assistant) are identified clearly in the on the profile view. (e.g. Zone # 3)
94			LPS mains shall have at least 36 inches of cover and LPS laterals at least 24 inches.
95			Wastewater mains have at least 18 inches of vertical separation from water mains.
96			LPS pipes shall have continuous slopes between high and low points to eliminate the formation of air pockets. Mains shall have a minimum of 60 inches of cover at high points to facilitate installation of air release valves. (See KUB Standards and Specifications 02536)
97			Crown of low pressure main must be installed at the same elevation as the crown of the receiving gravity sewer.
98			Low-pressure sewer mains shall be connected to manholes. If the depth of the manhole is greater than 10 feet, low-pressure sewer mains and laterals may be connected directly to a manhole using an internal drop approved by OWNER.

Chart F-1: Low Pressure Sewer Drawing Notes (Plan View Only)

Comment Number	First Date: _____	Second Date: _____	Review Criteria
99			A note that states that the contractor must be certified to weld/fuse HDPE pipe for low pressure sewer projects.
100			A note that states, "Low Pressure Sewer Service Laterals shall be 1¼ inch HDPE SDR-11 from main to transition fitting. Change to 1¼ inch SCH-40 PVC from transition fitting to grinder pump (See KUB Standards and Specifications, Fig. 2-02532-B)."
101			A note that indicates an E/One check valve installation on the 1¼ inch PVC lateral, that is within 24 inches of the HDPE transition fitting.
102			A note that indicates that the backfill material that is within one foot of the pipe shall not exceed 3/4 inch. (TDOT #57 Stone)
103			A note that states, "All pipe shall be installed with a 12-gauge solid copper wire for locating purposes. (See KUB Standards and Specifications 02536, Pg. 3)"
104			A note that states, "Polyethylene pipe (HDPE) and fittings shall be made of High Density, Extra High Molecular Weight polyethylene with a standard thermoplastic material designation of PE3408."
105			A note that states, "Polyethylene pipe (HDPE) shall have a co-extruded green cover or extruded green stripes designating use for sanitary sewer. Color print lines are not an acceptable method for designation of low-pressure sewer mains. Pipe with extruded green stripes shall have a minimum of three equally spaced stripes."

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106			A note that states, "Proper installation of LPS found in KUB's Standards and Specifications Section 02536 shall be fully understood and implemented."
107			A note that states, "Thrust/restraint blocks shall be installed in locations shown on the plans or in accordance with the pipe manufacturer's recommendations or as required by OWNER. Thrust/restraint blocks shall be considered an integral part of the low pressure sewer main installation."

CHART G-1: Review Process - Easements

Comment Number	**First** Date: _____	**Second** Date: _____	**Review Criteria**
108			All required easements and/or subdivision plats shall be submitted, approved, and recorded before the new wastewater system will be accepted.
109			The deed instrument number shall be clearly indicated on the plans. If multiple instrument numbers exist for the development, then each instrument number shall be listed.
110			Easements are indicated on plans for sewer laterals which cross private property to serve another lot if approved by KUB.
111			With project easements, a 15-foot wide permanent utility easement exists 7.5 feet on either side of all water & wastewater mains as installed, plus an additional 10 foot utility construction & maintenance easement as required, necessary to install and maintain mains.
112			If a joint permanent easement (JPE) with utilities is used rather than public Right of Way then the JPE must include "with utilities" to remove the requirement for a utility easement.

CHART H-1: Review Process - Road & Water Crossings

Comment Number	**First** Date: _____	**Second** Date: _____	**Review Criteria**
113			Clearly indicate road bores (casing, carrier pipe sizes, and materials) on both the plan and profile view.
114			Ductile iron pipe with concrete encasement at all joints or HDPE is used for wastewater transport beneath waterways that have a continuous flow of water or as described in the approved ARAP permit.

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CHART I-1: Review Process - Abandonment & Removals

Comment Number	First Date: _____	Second Date: _____	Review Criteria
115			Clearly label abandoned lines throughout proposed project
116			Abandoned sewer pipes 12 inches and larger shall be filled with flowable fill if not completely removed from the ground
117			Abandoned sewer pipes located under existing/proposed buildings are filled with flowable fill if not removed completely from the ground regardless of size.
118			When manholes are abandoned, a note indicates that Part 3.09, Section 02530 of KUB Standards and Specifications have been met for manhole abandonment

CHART J-1: Review Process - Wastewater Construction Notes

Comment Number	First Date: _____	Second Date: _____	Review Criteria
119			Road right-of-ways shall be graded and sloped to required specifications or as approved by KUB prior to staking and installing wastewater mains.
120			The Developer's Authorized Representative shall stake the proposed wastewater main layouts, property corners, and easement locations, etc…prior to construction to allow ample time for KUB's inspectors to inspect the layouts prior to construction. KUB will determine if staking may be required prior to approval of plans.
121			Construction materials must meet KUB specifications. KUB representatives must approve materials submittals prior to construction.
122			Wastewater main installation must be inspected by KUB. Contact KUB field services at least three (3) working days prior to construction at 558-2786. Trenches shall be left open and not backfilled until inspected by KUB.
123			Contact KUB field services at least three (3) working days prior to construction at 558-2786 to inspect from cleanout to structure when project is located outside of City of Knoxville Limits.
124			Contractor must have a valid State of Tennessee municipal utility license for construction of wastewater mains.
125			An A-lock or Z-lock gasket shall be provided for each wastewater main or lateral connecting to a new manhole. Each tap to an existing manhole must be mechanically cored and properly booted.
126			The contractor must install laterals installed across streets before any surface cover is finalized to include paving, concrete driveways, etc.

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127			Water stops shall be installed in sewer line trenches no more than 500 feet apart to prevent water from draining through the gravel bedding. The stops shall consist of compacted clay at least three (3) feet thick from the bottom of the trench to the top of the trench. The stops shall be cut a minimum depth of two (2) feet into both walls of the trench. The preferred location of a water stop is upstream of each manhole. All stream crossings shall include water stops on both sides of crossing.
			****NOTE: ONLY INCLUDE NOTE THE FOLLOWING WHERE APPLICABLE**
			Manhole and Main Line Abandonment Procedures:
128			A. Cut all pipes on the outside of the manhole, and plug with brick and mortar.
129			B. Brick and mortar all pipe openings inside the manhole including drop connections and laterals
130			C. Remove the manhole ring, lid, and grade rings. Disposal of all manhole materials shall be at the discretion of the Owner. Precast cones and risers shall also be removed if they are exposed.
131			D. Manholes shall be fill with backfill material as specified in Section 02321, Unclassified Excavation and Backfilling for Utilities.
132			E. Lines to be abandoned that enter an existing manhole to remain shall be cut on the outside of the manhole and inlets shall be plugged with brick and mortor to ensure a watertight structure.
133			F. Abandoned pipe 12 inches and larger shall be filled with flowable fill if not completely removed from the ground.
134			G. Abandoned pipe underneath existing/proposed buildings shall be filled with flowable fill if not completely removed from the ground.

CHART J-2: Review Process - General Wastewater Notes

Comment Number	**First** Date: _____	**Second** Date: _____	**Review Criteria**
135			All sanitary sewer lines and appurtenances shall be installed in accordance with the Knoxville Utilities Board's Standard Sewer System Specifications and Details.
136			Location of all existing utilities is approximate. Contractor shall field locate all existing utilities prior to excavation.
137			All pipe shall be installed in the presence of the Owner.
138			Utilities shall be installed after grading has been completed and approved before any surface cover is finalized to include paving, concrete driveways, etc.
139			Trench design and safety for pipeline construction is solely the responsibility of the contractor and shall conform to all applicable local, state, and OSHA regulations.
140			Requirements for proper trench and backfill operations must meet or exceed City of Knoxville, Knox County, and TDOT Standards.

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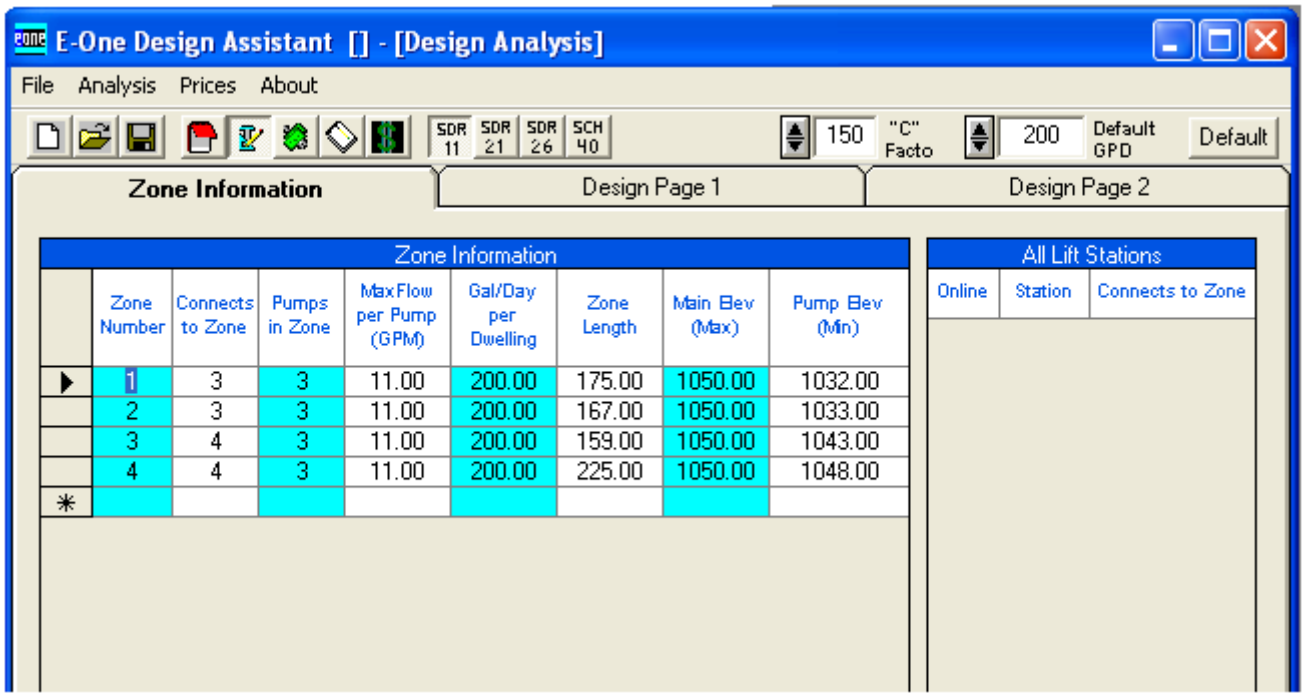
141			After completing each section of the sewer, all debris and construction materials shall be removed from the work site as well as smoothly grading the disturbed ground surface on the project site.
142			The Contractor shall obtain plastic warning tape for wastewater mains and bury it one foot above the entire length of each lateral. A 3/8-inch diameter steel rebar shall be driven into the ground at the end of each lateral and painted green. The buried end of the rebar shall be bent to form a hook.
143			Sanitary sewer flow control (Section 02542 of KUB Standards and Specifications) requirements are fully understood and implemented in the wastewater project.
144			The appropriate KUB representative before construction must approve any field changes to approved plans.
145			A copy of the latest approved set of utility plans designated by the KUB RED stamp must be present during all times of construction of the appropriate utilities.

SECTION K: Low Pressure Sewer E/One Software Calculation Example

Using the E/One Low Pressure Sewer System Design Assistant Software, the following screen shots were taken to produce the appropriate sizes of force mains required to properly generate continuous scour velocity in the sewer system. Please refer to the reference Low Pressure Sewer System example drawing for a layout of this proposed system.

Under the Design Icon (which is the tab punched in next to the red notebook tab) the following information from the design of the low-pressure sewer system is typed into the program for the software to calculate the appropriate diameters of the proposed force main. The needed information that the software requests is the Number of Pumps per Zone, Zone Lengths, and Elevations specific to the design. All the other values are calculated for the user automatically, but can be modified if needed.



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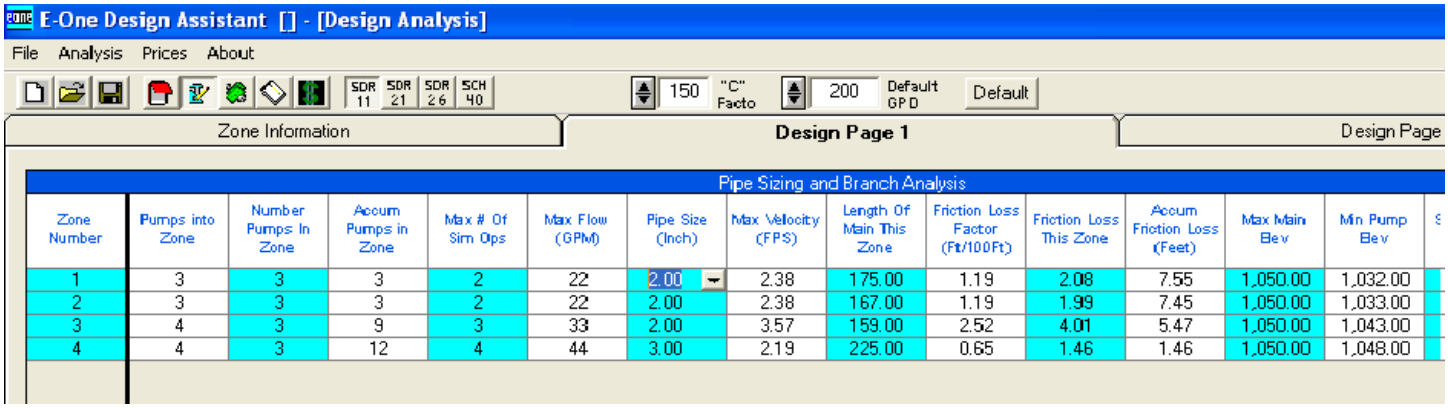
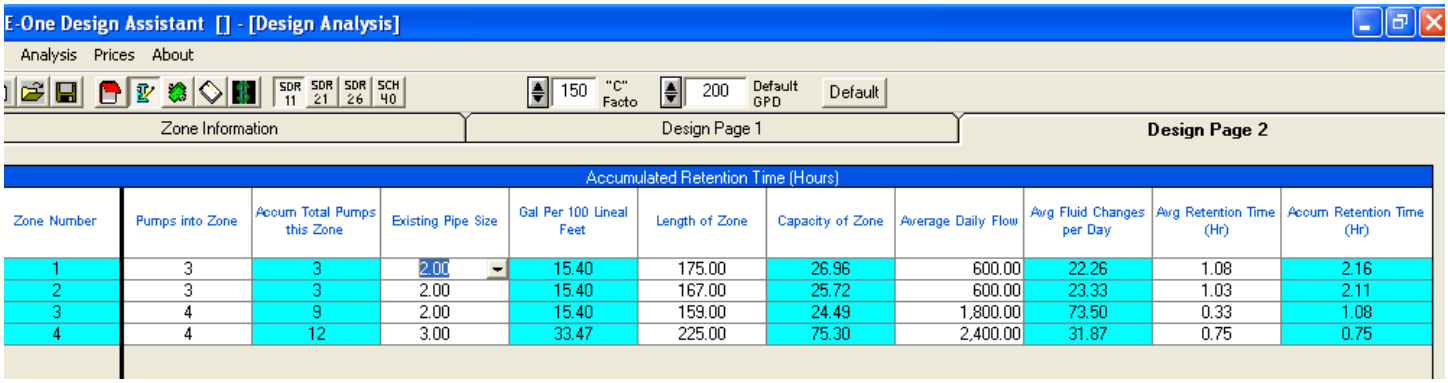
Design Page 1 under the Design Icon Tab is the first set of calculations that the E/One Design Assistant Software produces for the appropriate sizes of force mains proposed in the design.



Pipe Sizing and Branch Analysis

Zone Number	Pumps into Zone	Number Pumps In Zone	Accum Pumps in Zone	Max # Of Sim Ops	Max Flow (GPM)	Pipe Size (Inch)	Max Velocity (FPS)	Length Of Main This Zone	Friction Loss Factor (Ft/100Ft)	Friction Loss This Zone	Accum Friction Loss (Feet)	Max Main Elev	Min Pump Elev
1	3	3	3	2	22	2.00	2.38	175.00	1.19	2.08	7.55	1,050.00	1,032.00
2	3	3	3	2	22	2.00	2.38	167.00	1.19	1.99	7.45	1,050.00	1,033.00
3	4	3	9	3	33	2.00	3.57	159.00	2.52	4.01	5.47	1,050.00	1,043.00
4	4	3	12	4	44	3.00	2.19	225.00	0.65	1.46	1.46	1,050.00	1,048.00

Design Page 2 under the Design Icon Tab is the second and final set of calculations that the E/One Design Assistant Software produces for the design of the proposed low-pressure sewer system.



Accumulated Retention Time (Hours)

Zone Number	Pumps into Zone	Accum Total Pumps this Zone	Existing Pipe Size	Gal Per 100 Lineal Feet	Length of Zone	Capacity of Zone	Average Daily Flow	Avg Fluid Changes per Day	Avg Retention Time (Hr)	Accum Retention Time (Hr)
1	3	3	2.00	15.40	175.00	26.96	600.00	22.26	1.08	2.16
2	3	3	2.00	15.40	167.00	25.72	600.00	23.33	1.03	2.11
3	4	9	2.00	15.40	159.00	24.49	1,800.00	73.50	0.33	1.08
4	4	12	3.00	33.47	225.00	75.30	2,400.00	31.87	0.75	0.75

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First Calculations Printout From E/One LPS Software

CHART K-1: First Calculations Printout from E/One LPS Software

PRELIMINARY PRESSURE SEWER –
PIPE SIZING AND BRANCH ANALYSIS

This Spreadsheet was calculated using Pipe Diameters for:
SDR 11 HDPE

Zone Number	Connects to Zone	Number of Pumps in Zone	Accum Pumps in Zone	Gal/Day per Core	Max Flow per Core	Max Sim Ops	Max Flow (GPM)	Pipe Size (Inches)
1.00	3.00	3	3	200	11	2	22	2.00
2.00	3.00	3	3	200	11	2	22	2.00
3.00	4.00	3	9	200	11	3	33	2.00
4.00	4.00	3	12	200	11	4	44	3.00

Zone Number	Max Velocity (FPS)	Length of Main this Zone	Friction Loss this Zone	Accumulated Friction Loss (Feet)	Max Main Elevation	Minimum Pump Elevation	Static Head (Feet)	Total Dynamic Head (ft)
1.00	2.38	175	2.09	7.55	1050	1032	18	25.55
2.00	2.38	167	1.99	7.45	1050	1033	17	24.45
3.00	3.57	159	4.01	5.47	1050	1043	7	12.47
4.00	2.19	225	1.46	1.46	1050	1048	2	3.46

CHART K-2: Second Calculations Printout from E/One LPS Software

PRELIMINARY PRESSURE SEWER - ACCUMULATED RETENTION TIME (HR)

This Spreadsheet was calculated using Pipe Diameters for: SDR 11 HDPE

Zone Number	Connects to Zone	Accumulated Total of Pumps this Zone	Existing Pipe Size	Gallons per 100 Lineal Feet	Length of Zone
1.00	3.00	3	2.00	15.40	175
2.00	3.00	3	2.00	15.40	167
3.00	4.00	9	2.00	15.40	159
4.00	4.00	12	3.00	33.47	225

Zone Number	Capacity of Zone	Average Daily Flow	Average Fluid Changes per Day	Average Retention Time (HR)	Accumulated Retention Time (HR)
1.00	26.96	600	22.26	1.08	2.16
2.00	25.72	600	23.33	1.03	2.11
3.00	24.49	1800	73.50	0.33	1.08
4.00	75.30	2400	31.87	0.75	0.75