Section 6

Service to Thurston Highlands Master Planned Community

This section evaluates alternatives for providing wastewater service (collection, treatment, and disposal) to the proposed Thurston Highlands MPC, to be located within Yelm city limits as shown in Figure 2-2. As currently proposed, Thurston Highlands would include a mixture of residential and commercial development constructed over a period of up to 30 years.

Projected 2030 wastewater flows/loads generated within the MPC would be approximately 75 percent of the current flows/loads generated within the existing service area. Due to this significant loading increase, careful infrastructure planning is necessary to ensure that City planning and wastewater service goals, for both existing and future customers, will be met.

The subsections within this section present the following analyses:

1. Basis for MPC Service Analysis: Discusses the rationale for structuring this GSP to evaluate wastewater service for the Thurston Highlands MPC separately from the existing City of Yelm wastewater system.
2. Description of MPC and EIS Process: Summarizes the proposed Thurston Highlands MPC, development of the Environmental Impact Statement (EIS) for Thurston Highlands, and what the EIS says regarding wastewater service for Thurston Highlands, including potential impacts to the existing City wastewater system.
3. Wastewater Flow/Load Projections: Summarizes population and flow/loading projections for Thurston Highlands developed in Section 2 and identifies changes from the projections developed as part of the EIS process.
4. Business Case Evaluations: BCEs discuss wastewater collection, treatment, and disposal alternatives for serving the Thurston Highlands MPC and identify preferred alternatives based upon total life-cycle costs including benefit and risk costs.
5. Recommended Policies: Service area policies specific to development within the Thurston Highlands MPC to be implemented by the City in addition to applicable policies identified in Section 1.7.

6.1 Basis for MPC Service Analysis

The analysis in this section has been developed assuming that the wastewater system infrastructure serving the Thurston Highlands MPC will be physically separated from the existing City of Yelm wastewater system, but still owned and operated by the City as part of its wastewater utility.

Although technically feasible alternatives exist that combine the two systems, such as conveyance of wastewater flows generated within the MPC to the existing WRF, they are fatally flawed when evaluated with respect to City goals and current system limitations discussed below. Furthermore, the Thurston Highlands development will be entirely new and, considering the City's policy that "growth pays for growth," a separate infrastructure will provide a transparent basis for identifying costs that should be paid by the developer and not existing ratepayers.

Additional rationale for evaluating wastewater service for Thurston Highlands separately in this section is as follows:

- Analyses in this GSP have identified the limitations of the existing City wastewater system in terms of serving Thurston Highlands. These analyses include:
  - The analysis in Section 5 clearly shows that treatment capacity of the existing WRF is already limited with respect to nitrogen removal and production of reclaimed water.
  - Wastewater flows from Thurston Highlands cannot be conveyed to the existing WRF site using existing collection system piping. Previous planning documents projected the need for a dedicated 14-inch-diameter STEP conveyance pipeline (13,800 feet) from the boundary of the MPC to the existing WRF site at a project cost of over $4 million (in 2007 dollars).
  - It is unlikely that reclaimed water from the MPC will be able to be put to year-round beneficial use within the existing service area. As a result, wastewater flows from Thurston Highlands would increase the discharge of treated effluent to surface waters (Centralia Power Canal or Nisqually River). Per the Shoreline Permit (see Appendix 1C), the City will continue to assess the technical and financial feasibility of potential removal of the surface water discharge outfalls.
  - Costs for construction of the reclaimed water infrastructure required for beneficial reuse and disposal of flows from the MPC must be incorporated into the cost of MPC development, rather than making use of existing City infrastructure, facilities, and discharge permits.
- It is uncertain when, and at what rate, development of Thurston Highlands will occur. It is difficult to make definitive plans and commit City resources for such a significant impact when the timing is unknown.

6.2 Thurston Highlands MPC Background Documentation

This section describes Thurston Highlands MPC background documentation, including the 2006 development proposal and subsequent EIS and technical reports.

6.2.1 Thurston Highlands Proposal

The Thurston Highlands MPC is a mixed-use development proposal first submitted to the City of Yelm in April 2006[1] and subsequently evaluated in an EIS (see Section 6.2.2) as part of the environmental evaluation and public involvement process required by the State Environmental Policy Act (SEPA).

The objectives of the MPC proposal were to implement sustainable development consistent with the Washington State GMA while minimizing impacts to environmentally sensitive areas. The resulting preferred development scenario for the MPC includes the following:

- 5,000 homes to be provided in a mix of housing types and densities
- 825,000 ft^2 of commercial development
- 135,000 ft^2 of office space
- 400 acres of permanent open space
- A regional sports complex
- School sites (two to four elementary schools, plus one middle school)
- Onsite provisions for other public services (e.g., water supply, wastewater collection and treatment, stormwater management facilities, electrical power and communications, transit facilities, churches, and a possible fire station)
- Extension of Tahoma Boulevard through the site to SR 507

[1] Earlier versions of development plans were proposed to the City beginning in 1994, but none of these plans progressed beyond initial proposal stages. The history of development proposals for the Thurston Highlands site is discussed in detail in the Draft EIS (see Section 6.2.2).

A range of development densities were evaluated and described in the EIS, including traditional and urban village development alternatives. The traditional alternative is characterized by suburban development similar to what has occurred within the city of Yelm over the past several years: a curvilinear, gridded street system with an emphasis on single-family residential neighborhoods and small-scale neighborhood convenience commercial uses. Urban village development would create compact areas of high-density residential uses intermixed with commercial uses around a central village square.

The preferred development scenario described in the EIS blends characteristics of traditional development and an urban village concept as shown in Figure 6-1. The conceptual plan envisions that the eastern portion of the property (nearest to the city center) may be appropriate for an urban village development pattern, while the western portion may be appropriate for more traditional development.

6.2.2 Environmental Impact Statement

The City of Yelm received the Conceptual Master Site Plan Application for the Thurston Highlands MPC in April 2006. After an initial scoping period, during which the City met with various agency, tribal, and public stakeholders to help identify potential impacts of the MPC development, the City and the developer of Thurston Highlands began preparation of 12 technical reports to evaluate the impact of MPC development on the following environmental elements:

- Aesthetics
- Air quality
- Fiscal analysis
- Fish, wildlife, and habitats
- Geology and soils
- Grading, drainage, and utilities
- Infiltration effects (surface and groundwater)
- Light and glare
- Parks and recreation
- Surface water evaluation of Thompson Creek
- Transportation impact analysis
- Wetlands

The Draft EIS, supported by the technical reports, was published in June 2008 and comprised a summary of the MPC Master Plan, impacts of development on the environment, and potential impact mitigation measures. Issuance of this Draft EIS initiated a 45-day public comment period, during which stakeholders were invited to review and comment on the proposed action, alternatives, and analysis of potential environmental effects. Following the public comment period, which included two open house events hosted by the City of Yelm, a Final EIS was published in November 2008. The Final EIS comprised the Draft EIS, comments received and the City's responses, revised and updated sections of the Draft EIS, and all technical reports prepared for the project. EIS documentation can be found on the City's Community Development Department Web site (http://www.ci.yelm.wa.us/default.asp?dept=cdd) under the "Thurston Highlands" and "Permits" tabs at the left.

Wastewater collection, treatment, and disposal were evaluated in Section 3.19 (Utilities) of the EIS documentation (see Appendix 6A for the full text of Section 3.19). The EIS evaluation was based upon wastewater alternatives analysis presented in two sequential reports. The first report, Wastewater Technical Report (Parametrix, September 2007), was commissioned by the City to identify the potential impacts of the Thurston Highlands development. The developer financed a second report, Grading, Drainage, and Utilities Technical Report (KPFF, April 2008), specifically to support the analysis in the EIS. A summary of both of the technical reports analyses and conclusions are provided as follows:

- **Wastewater Technical Report (Parametrix, September 2007):**
  - Developed flow and loading projections for buildout conditions of Thurston Highlands, assuming both STEP and gravity collection systems. Projections were based upon a per capita value that included non-residential flows.
  - Evaluated both gravity and STEP collections systems (including costs) and determined them to be feasible, but the analysis did not identify a preferred alternative.
  - Determined that wastewater flows from buildout development within the MPC will exceed the existing capacity of the WRF. Costs were developed for necessary improvements at the existing WRF site assuming both gravity and STEP collection systems. No plans or cost estimates were developed for a new treatment facility separate from the existing WRF.
  - Evaluated infiltration sites throughout the UGA for up to 1.5 mgd of reclaimed water, identifying two favorable sites near the existing WRF site. Infiltration of reclaimed water within Thurston Highlands was determined to be less favorable, but still appeared to be feasible. The analysis of infiltration within Thurston Highlands was limited by the data available at the time.
- **Grading, Drainage, and Utilities Technical Report (KPFF, April 2008):**
  - Summarized alternatives evaluated in the 2007 Wastewater Technical Report (no new or modified alternatives were evaluated).
  - Updated wastewater flow projections to include non-residential flows, but used the same per capita residential flow developed previously. BOD, TSS, and ammonia loading projections were not evaluated.
  - Stated that the preferred collection system for Thurston Highlands would be evaluated in the City's GSP Update.
  - Identified an alternative for a satellite wastewater treatment facility, but did not provide further analysis.
  - Identified reclaimed water policies to be implemented within the Thurston Highlands MPC, specifically that reclaimed water distribution pipelines would be installed in all phases of the Thurston Highlands MPC, concurrent with the construction of other underground utilities, for the purpose of maximum flexibility or reuse when deemed appropriate by the City.

Neither technical report identified a recommended or selected alternative for wastewater collection and/or treatment. The intent of the reports was to identify feasible alternatives in order to evaluate potential impacts to the city and the environment due to development of the Thurston Highlands MPC.

It is beyond the scope of this GSP to discuss all of the potential wastewater impacts and mitigation measures identified in the EIS development process. However, Appendix 6A includes a tabular summary of these impacts and mitigation measures. In general, the conclusion of the EIS process was that there are no environmental impacts that cannot be addressed within the bounds of the GMA through proper planning and development. Because the Thurston Highlands MPC has been discussed as a potential project for many years, most recently in the City's Comprehensive Plan and Joint Plan with Thurston County (Yelm, 2009), population growth and the associated impacts anticipated as part of the Thurston Highlands MPC development have been planned for and addressed.

6.3 Thurston Highlands Population and Flow/Loading Projections

Population, flow, and loading projections for the Thurston Highlands MPC are presented in Section 2. This section summarizes these projections and identifies changes from the projections previously developed as part of the EIS process.

6.3.1 Population Projections

The population within the Thurston Highlands MPC is projected to develop at the same rate predicted in the 2007 TRPC Buildable Lands Report; however, the initial year of development is assumed to be delayed[2] until 2020. Table 6-1 shows the projected sewer service population within the future service area, including non-MPC, Thurston Highlands, and total population. Table 6-1 illustrates the significant effect Thurston Highlands has on the total population: nearly 25 percent of the total population by 2030.

Table 6-1. Future Service Area Sewered Population

Year	(1) Total residential population served by City sewer, not including Thurston Highlands MPC [a]	(2) Future Thurston Highlands MPC population [b,c]	(3) = (1) + (2) Total residential population served by City sewer
2010	6,348	0	6,348
2020	13,976	1,244	15,220
2030	20,094	5,195	25,288
2050 [d]	--	12,963	--

a. See Table 2-4.

b. Based on the TRPC 2007 Buildable Lands Report and the 2010 Water System Plan projections; development year delayed until 2020.

c. Population of 5,195 in 2030 for Thurston Highlands represents approximately 40% of buildout population.

d. For the purposes of the BCEs presented later in this section, buildout of the Thurston Highlands MPC is assumed to occur in 2050.

The population projections for Thurston Highlands in Table 6-1 vary only slightly from those used as a basis of analysis in the EIS. Population projections in the EIS were calculated from the number/type of residences multiplied by a per household population factor[3] from OFM (2006). The calculated population in the EIS for 5,000 single- and multi-family residences was 12,548 at project buildout in 2030. The 2007 TRPC projections for Thurston Highlands indicate a buildout population of 12,963 that occurs beyond 2030. Because of the delay in project development, Table 6-1 shows a population of approximately 40 percent of buildout by 2030, with complete buildout occurring in 2050.

6.3.2 Flow and Loading Projections

Flow and loading projections for Thurston Highlands in Section 2 of this GSP were developed assuming that wastewater generated within the MPC, both residential and non-residential, is similar to that from the existing service area, in terms of flow rate and of BOD, TSS, and TKN concentrations. This is based upon the assumption that the wastewater collection system within Thurston Highlands will utilize STEP technology. The BCE for wastewater collection system alternatives (STEP, grinder pump, and gravity) is presented in Section 6.4.1, and flow and loading projections for a gravity system are included in Section 6.5.

[2] Initial development was planned for 2008 through 2011 in the EIS, with the first homes occupied in 2009.

[3] 2.91 per single-family residence (3,000), 3.14 per duplex (546), 1.75 per three- and four-unit multi-family residences (509), and 1.28 per multi-family units greater than five residences (945).

Table 6-2 summarizes flow and loading projections for Thurston Highlands that were developed in Section 2.

Table 6-2. Projected Flow and Load from Thurston Highlands MPC (assuming STEP collection system)								
Year	Average day flow (mgd)	Max month flow (mgd)	Average annual BOD_5 (lb/d)	Average annual TSS(lb/d)	Average annual TKN (lb/d)	Maximum month BOD_5 (lb/d)	Maximum month TSS (lb/d)	Maximum month TKN (lb/d)
2010	0	0	0	0	0	0	0	0
2020	0.05	0.06	77	22	28	81	28	29
2030	0.22	0.28	322	93	117	336	116	122

Table 6-3 compares flow/loading projections for Thurston Highlands developed both by Parametrix (2007) and KPFF (2008) to the projections in this GSP. KPFF projections were utilized in the EIS. The projections are for STEP collection systems only, although the previous analyses also evaluated a gravity sewer alternative. Because this GSP assumes a delayed MPC development schedule starting in 2020, the previous projections were re-calculated using a proportionate level of development (assuming a 2030 MPC population of 5,195 versus buildout population of 12,963).

Table 6-3. Comparison of Previous and General Sewer Plan STEP System Flow/Loading Projections for Thurston Highlands [a]			
Parameter	Parametrix Technical Report (2007)	KPFF Technical Report (2008)	General Sewer Plan
Average day flow (mgd)	0.37	0.48	0.22
Maximum month BOD (lb/d)	727		336
Maximum month TSS (lb/d)	208		116
Maximum month TKN (lb/d)			122

a. Assuming 2030 population of 5,195.

As shown in Table 6-3, the previous flow/loading projections were much higher than those developed in this GSP. The flow differences can be attributed in part to the use of conservative assumptions, but also to the original inclusion of non-residential loading in the per capita calculation assumptions developed by Parametrix. When KPFF added non-residential flows without changing the per capita assumptions, it effectively "double-counted" the impact of non-residential development. To summarize:

- Parametrix developed per capita (gallons per person per day) flows for the entire collection system, which included contributions from non-residential connections.
- KPFF added non-residential flows without changing the per capita flow for residential connections.
- The flows developed for the GSP were based on separate estimates for residential and non-residential connections using actual flow records and commercial sampling. Per capita flows from residential connections do not include flow contributions from non-residential connections such as schools and commercial development. Flows from commercial and school connections were calculated on a square-foot and per-student basis, respectively (see Section 2).

BOD and TSS differences also resulted from combining residential and non-residential flows. Parametrix used per capita loading that is three times higher for BOD and two times higher for TSS than determined for this GSP based upon the commercial sampling program described in Section 2.5.2. The EIS also did not develop TKN loading projections, which is a key consideration in determining reclaimed water production capacity.

6.4 Wastewater System Alternatives for Service within Thurston Highlands

This section presents BCEs that evaluate alternatives for providing wastewater service (collection, treatment, and disposal) to the proposed Thurston Highlands MPC. BCE inputs were developed and reviewed with City staff. Results of the BCEs will be used to support the policies (see Section 6.6) to be implemented by the City with respect to wastewater service within the MPC.

6.4.1 Thurston Highlands Collection System

Section 3.5 presents a BCE of sewer collection system alternatives for system growth within the existing service area, not including the Thurston Highlands MPC. Of the three collection system alternatives evaluated (STEP, grinder pumps, and gravity sewer), the BCE supports continued use of the STEP collection system technology that currently makes up the City's sewer collection system (see Section 3.1). Gravity sewers were fatally flawed, and not evaluated in detail, because no areas of projected growth were large enough to justify the additional costs identified for gravity sewers.

The BCE for wastewater collection within Thurston Highlands evaluates the same technology alternatives: STEP, grinder pumps, and gravity sewers. In this case, gravity sewers are not fatally flawed due to the size and potential development density of Thurston Highlands. The potential sewer collection alternatives are as follows:

- **STEP:** STEP system technology is described with respect to the City's existing collection system in Section 3.1.
- **Grinder pumps:** Like a STEP system, wastewater flows are pumped from each individual sewer connection. However, grinder pumps are located in small-volume sumps that are not intended to store solids. The grinder pumps are designed to pump solids after grinding them to a size that will not cause problems in a small-diameter collection system.
- **Gravity sewer:** Wastewater flows by gravity either to intermediate pump stations or directly to the treatment facility.

6.4.1.1 Problem Statement

This BCE evaluates which collection system technology should be implemented to serve the future population of the Thurston Highlands MPC at the lowest combined capital and operating cost, while also accounting for risks and benefits of the technology.

This GSP includes Thurston Highlands population projections through 2030. In order to more accurately evaluate life-cycle costs for the collection system alternatives, this BCE evaluates a longer period (through buildout in 2050) with assumed Thurston Highlands populations as shown below. The number of connections reflects residential connections (three people per connection) and assumes that additional commercial connections would affect each alternative equally.

- 2020 population = 1,244 (415 residential connections)
- 2030 population = 5,195 (1,730 residential connections)
- 2040 population = 9,079 (3,030 residential connections)
- 2050 population = 12,963 (4,320 residential connections)

6.4.1.2 Identify and Analyze Alternatives

The advantages/disadvantages of STEP and grinder pump technology are evaluated in detail in Section 3.5 with respect to the existing collection system. Initial capital cost and risks that could potentially lead to increased capital costs are not considered in this BCE because Thurston Highlands will be served by a new collection system and treatment facility financed by the developer and designed with the selected collection system in mind. However, because City staff will maintain the collection system, advantages/disadvantages related to operation and maintenance of necessary facilities must still be considered.

6.4.1.2.1 Operation and Maintenance

Gravity collection systems, in general, require less maintenance than pressure systems (STEP and grinder pumps) because no pumps are located at individual sewer connections. However, it is anticipated that intermediate pump stations will be required for gravity sewers and these have their own O&M requirements as well as power costs.

6.4.1.2.2 Solids Handling

Because STEP tanks provide preliminary wastewater treatment, BOD and TSS loading at the treatment facility is lower for STEP systems as compared to grinder pump and gravity systems. Therefore, additional treatment capacity would be required for grinder pump and gravity systems. The capital costs related to treatment basin volume and higher-capacity equipment would be paid by the developer, but increased O&M costs of the higher-capacity treatment facility would be the responsibility of the City ratepayers. Similarly, the O&M costs of a headworks facility (screening and grit removal) required for a gravity collection system must be included in the BCE for the gravity alternative.

6.4.1.2.3 Hydraulic Capacity

I/I into gravity sewers will result in higher influent flows as compared to STEP and grinder pump systems, but not higher influent loading (BOD and TSS). The higher influent flow will necessitate a greater treatment capacity in terms of volume, and will result in higher operating costs (power, chemicals, etc.). At the same time, additional reclaimed water flows would represent a resource (benefit) that can be used for water rights mitigation and other purposes.

6.4.1.2.4 Power Outage Concerns

STEP and grinder pump collection systems are a considerable concern during power outages, as electrical power is required to convey wastewater from each connection to the treatment facility. Especially for grinder pump systems, even relatively brief interruptions in power service can result in an accumulation in wastewater flows that exceed the storage available at each connection. Extended power outages would require the City to coordinate contract pumping services to collect wastewater from individual connections. The City recently used this strategy during a 3- to 4-day outage in January 2012. Intermediate pump stations constructed as part of the gravity sewer alternative would be equipped with standby generators in the event of a power failure so that impacts of a power outage would be minimal compared to the other alternatives.

Table 6-4 summarizes the advantages and disadvantages of the collection system alternatives. STEP technology is used as a basis of comparison to the grinder pump and gravity sewer alternatives.

The advantages and disadvantages listed in Table 6-4 were evaluated in terms of risk and benefit costs and combined with O&M cost assumptions to compare overall costs of the Thurston Highlands collection system alternatives. The cost information and/or assumptions used as input values for the BCE are explained below.

Table 6-4. Advantages/Disadvantages of Alternative Collection Systems for Thurston Highlands		
Alternative	**Advantage**	**Disadvantage**
STEP collection system	City staff is familiar with STEP equipment and related O&M	Contract hauling of septage is required
Grinder pump collection system	No contract hauling of septage	New equipment learning curve and a second set of spare parts required
		More expensive pumps and greater maintenance/replacement frequency
		Potential grease accumulation issues in collection system
		Greater concern during power outages
		Higher influent loads results in higher treatment facility operating costs
		Increased WAS hauling costs
Gravity collection system	No maintenance of pumps at individual connections	Maintenance and power costs for regional pump stations
	No contract hauling of septage	Increased WAS hauling costs
	Less concern during extended power outages (standby generator provided at pump stations)	Headworks O&M
	Higher influent flows will result in greater reclaimed water resources	New equipment learning curve and additional spares required
		Higher influent flows and loads result in higher treatment facility operating costs

6.4.1.2.5 Capital Costs

The analysis does not include capital costs related to initial collection system equipment and installation. Capital costs related to differences in treatment plant design elements necessary for the different collection system alternatives are also not included in the BCE. It is assumed that initial capital costs are borne by the developer.

Preliminary STEP and gravity collection system layouts for the MPC were presented in the Wastewater Technical Report (Parametrix, 2007). Each collection system included a dedicated conveyance line from the MPC directly to the existing WRF. The gravity sewer system layout is shown in Figure 6-2. Because of the rolling topography within Thurston Highlands, the gravity collection system layout included eight sewer sub-basins, each served by an intermediate pump station. Most of the initial stage of development, near the eastern boundary of the MPC, would be served within a single sewer sub-basin. The STEP system layout is shown in Figure 6-3. The STEP system generally includes 2-, 3-, and 4-inch-diameter pipelines within the boundaries of the MPC and a larger 14-inch-diameter pipeline for conveyance to the existing WRF.

Preliminary project cost estimates were prepared for the STEP and gravity collection systems in the Wastewater Technical Report (Parametrix, 2007). Project costs for a gravity collection system for buildout development of Thurston Highlands, including eight regional pump stations, was estimated at approximately $29 million (2007 dollars). An equivalent STEP collection system had an estimated project cost of $37 million (2007 dollars).

6.4.1.2.6 Operation and Maintenance Costs

STEP Alternative

Consistent with the collection system growth BCE in Section 3.5.2, the City's O&M costs for the STEP collection system are estimated to be $57 per connection per year. These costs include scheduled (proactive) STEP tank and valve maintenance as well as reactive service calls. It is assumed that existing STEP O&M costs per connection used to estimate costs in Section 3 are applicable to a new STEP collection system installed for Thurston Highlands.

Septage hauling was calculated to be $41.66 per tank per year. Septage hauling costs assume a 1,200-gallon tank (actual pumped volume equal to 800 gallons) pumped at 5-year intervals at a cost of $0.24 per gallon with 8.5 percent tax.

Solids disposal costs at the WRF related to the transport of WAS to Tacoma and tipping fees for disposal vary depending upon the solids load of the influent at the WRF. WAS produced at the WRF was estimated using standard literature values for transformation of BOD/TSS to biomass. The total gallons of WAS produced was then multiplied by the WAS transport cost ($0.10 per gallon) and tipping fee ($0.0974 per gallon) to determine existing per connection fees related to WAS disposal.

As discussed in Section 4.11, the City will evaluate combined solids management alternatives for the City and MPC in approximately 2030. For this BCE, it is assumed that evaluation will result in the implementation of a combined solids handling program for both facilities that will reduce WAS handling costs 50 percent for the gravity and grinder pump alternatives and 33 percent for the STEP alternative, because STEP has lower WAS handling costs to begin with. Table 6-5 compares WAS volumes and disposal costs for STEP versus gravity and grinder pump collection systems.

Table 6-5. WAS Volume and Disposal Cost Comparison for Collection System Alternatives

	STEP collection system	Gravity and grinder pump collection systems
Annual WAS volume (gallons)	378,385	710,815
Annual hauling and disposal fee [a]	$74,700	$140,330
Hauling and disposal per connection [b] through 2030	$35.30	$66.30
Hauling and disposal per connection after 2030	$23.65	$33.15

a. *Total hauling and disposal fee of $0.1974 per gallon.*

b. *Assumed current population of 6,350 and three people per connection used to calculate per connection cost.*

Additional O&M costs include the electrical power required to run the STEP pumps. For the STEP alternative, it is assumed that these costs are borne by the homeowner.

Grinder Pump Alternative

As stated in Section 3.5.2.3, it is assumed that grinder pump O&M would utilize the same proactive maintenance schedule as the STEP alternative, but service calls would increase approximately 25 percent due to more demanding service conditions for the pumps and no buffer volume provided by the STEP tanks.

For the grinder pump alternative, there is no septage hauling cost. However, influent solids loadings for grinder pump collection systems are significantly higher than for STEP systems because no solids removal is taking place in the STEP tanks. Increased solids loading results in greater volume of WAS produced and higher WAS transport and disposal costs (see Table 6-5).

It was assumed that annual operating costs related to the increased WRF capacity (in 2050) necessary for the additional solids load of the grinder pump collection system alternative are equal to $15,000 per year (or 0.25 FTE) plus $10,000 for increased power and chemical usage. Total costs ($25,000) were applied in steps as the number of connections increases as summarized below to reflect new equipment (and associated staff time and power/chemical costs) coming online to serve additional connections:

- Initial system startup to 2,000 connections: $10,000
- 2,000 connections to 4,000 connections: $20,000
- 4,000 connections and above: $25,000

Consistent with the collection system analysis in Section 3, it was assumed for the grinder pump alternative that additional staff time ($15,000 per year or 0.25 FTE) would be dedicated to additional O&M related to grease accumulation. The cost of additional staff time was divided over 4,320 connections.

Additional O&M costs include the electrical power required to run the grinder pumps. For the grinder pump alternative, it is assumed that these costs are borne by the homeowner.

<u>Gravity Alternative</u>

As the number of system connections increases, the gravity sewer alternative will become more cost-effective. To simulate this effect, per connection system O&M costs were assumed to be equivalent to the STEP alternative for the first 1,000 connections and then were decreased incrementally for every additional 1,000 connections. These costs do not include operation and maintenance of the regional pump stations (see below). Gravity sewer O&M costs used in the BCE are as follows:

- Up to 1,000 connections (2020–24) = 1.0 * STEP O&M
- Between 1,000 and 2,000 connections (2025–32) = 0.9 * STEP O&M
- Between 2,000 and 3,000 connections (2033–39) = 0.8 * STEP O&M
- Between 3,000 and 4,000 connections (2040–47) = 0.7 * STEP O&M
- Over 4,000 connections (2048–50) = 0.6 * STEP O&M

For the gravity alternative, there is no septage hauling cost. However, influent solids loadings for gravity collection systems are significantly higher than for STEP systems because no solids removal is taking place in the STEP tanks. Increased solids loading results in greater volume of WAS produced and higher WAS transport and disposal costs (see Table 6-5).

For the present level of analysis, it was assumed that annual operating costs related to the increased WRF capacity (in 2050) necessary for the additional solids load of the gravity collection system alternative are equal to $15,000 per year (or 0.25 FTE) plus $10,000 for increased power and chemical usage. Total costs ($25,000) were applied in steps as the number of connections increases as summarized below to reflect new equipment (and associated staff time and power/chemical costs) coming online to serve additional connections:

- Initial system startup to 2,000 connections: $10,000
- 2,000 connections to 4,000 connections: $20,000
- 4,000 connections and above: $25,000

Additional O&M costs for the gravity collection system include the following:

- Regional pump stations will be owned and operated by the City. It is estimated that 0.1 FTE ($6,000 per year) and an additional $1,500 per year in electrical costs would be required to operate and maintain each pump station. It was assumed a new pump station comes online for every 540 connections based upon the eight pump stations identified in the Wastewater Technical Report (Parametrix, 2007).

- It was assumed that annual operating costs related to the increased WRF capacity (in 2050) necessary for the increased flows from a gravity collection system are equal to $15,000 per year (or 0.25 FTE) plus $30,000 for increased power and chemical usage. Total costs ($45,000) were applied in steps as the number of connections increases as summarized below to reflect new equipment (and associated staff time and power/chemical costs) coming online to serve additional connections:
  - Initial system startup to 2,000 connections: $18,000
  - 2,000 connections to 4,000 connections: $36,000
  - 4,000 connections and above: $45,000
- Additional O&M costs for the headworks necessary for the gravity sewer alternative include power costs, additional staff time, and screenings disposal. For the present level of analysis, annual staff time is assumed to be 0.25 FTE ($15,000). Power and disposal costs are assumed to be $2,500 annually.
- A vactor truck will be required for maintenance of the gravity collection system. Although the capital costs for the vactor truck will be provided by the developer, it is assumed City costs will be $5,000 to operate and maintain the truck.

6.4.1.2.7 Equipment Repair and Replacement Costs

R/R costs are included at an assumed cost and schedule based upon manufacturer recommendations and engineering experience. Per the STEP pump replacement BCE (see Section 3.5.2.1), it is assumed that only 25 percent of the pumps are replaced at the 20-year interval at a cost of $600, while the remainder of the pumps are repaired/refurbished at a cost of $200. The average R/R cost for the STEP pumps is $300. Collection system piping is assumed not to require repair or replacement within the design period evaluated. The R/R costs and schedule for the collection system alternatives are summarized below:

- ***STEP alternative:***
  - Pump R/R ($300) at 20-year interval
  - Float replacement ($100) at 10-year interval
  - Misc. component replacement ($100) at 10-year interval
- ***Grinder pump alternative:***
  - Pump repair ($800) at 10, 30, and 50 years
  - Pump replacement ($1,500) at 20 and 40 years
  - Float replacement ($100) at 10-year interval
  - Misc. component replacement ($100) at 10-year interval
- ***Gravity alternative*** (regional pump station R/R costs are divided over 540 connections):
  - Pump repair ($1,500 total for two pumps) at 5-year interval (repair pump every 5 years and replace at 20 years)
  - Pump replacement ($15,000 total two pumps) at 20-year interval
  - Pump station structure rehab ($50,000) at 25-year interval

6.4.1.2.8 Benefit Costs

The gravity collection system alternative provides the opportunity for future water rights mitigation through increased groundwater infiltration (due to higher flows). The benefit was quantified using the methodology developed in Section 5.6. for the reclaimed water BCE, including an assumed benefit of $1,550 per ac-ft per year and a 50 percent offset. Increased flows were estimated using an assumed gravity system I/I of 350 gpd per acre[4] and a total development area of 1,250 acres. The benefit was spread over 4,320 connections and the 30-year development of Thurston Highlands.

6.4.1.2.9 Risk Costs

Risk costs associated with an equipment learning curve and the need for additional spare equipment for the gravity and grinder pump alternatives were quantified (consistent with Section 3) by assuming $25,000 for training and additional spare equipment spread out over the first 3 years of operation. Costs were divided among 4,320 new connections to develop per connections costs consistent with the rest of this section. However, in practice, this cost is more appropriately applied to the first connections made during initial development of the MPC. Risk costs associated with power outages are as follows for grinder pump and STEP alternatives:

- Grinder pump alternative: Although costly, and likely not feasible for a collection system serving an area the size of the Thurston Highlands MPC, it was assumed that one portable generator (capital cost borne by the developer) would be on hand for each 20 connections. An O&M cost of $500 for labor and diesel fuel costs per 20 connections for an extended power outage was assumed every 5 years.
- The risk of an extended power outage for a STEP collection system is smaller, and was quantified assuming the actual City response to a recent 3–4-day power outage. Four pumping crews operated for 2 days (9 hours per day) at $120 per hour per crew. The total risk of approximately $10,000 is divided over 2,125 existing connections and applied once every 5 years.

6.4.1.3 Summary of BCE Inputs

Table 6-6 summarizes the inputs for each alternative.

Table 6-6. Summary of Thurston Highlands Wastewater Collection System BCE

BCE input	Alternative 1: STEP collection system	Alternative 2: Grinder pump collection system	Alternative 3: Gravity collection system
Capital costs	• Capital costs borne by the developer	• Capital costs borne by the developer	• Capital costs borne by the developer
	• Total capital cost: None	• Total capital cost: None	• Total capital cost: None
O&M costs	• Annual proactive maintenance: $52 per connection • Annual reactive maintenance: $5 per connection • Annual septage hauling fees: $41.66 per connection • Annual WAS disposal fees through 2030: $35.30 per connection • Annual WAS disposal fees after 2030: $23.65 • Electrical utility costs are borne by the homeowner ($0)	• Annual proactive maintenance: $52 per connection • Annual reactive maintenance: $6.25 per connection • Annual grease O&M: $3.50 per connection • Annual WAS disposal fees through 2030: $66.30 per connection • Annual WAS disposal fees after 2030: $33.15 per connection • Increased WRF capacity (solids): $5.80 per connection in 2050 • Electrical utility costs are borne by the homeowner ($0)	• Annual proactive/reactive maintenance: $57 per connection for first 1,000 connections and decreases incrementally for each subsequent 1,000 connections • Annual WAS disposal fees through 2030: $66.30 per connection • Annual WAS disposal fees after 2030: $33.15 per connection • Annual pump station O&M: $13.90 per connection in 2050 • Increased WRF capacity (flow): $10.40 per connection in 2050 • Increased WRF capacity (solids): $5.80 per connection in 2050 • Headworks O&M: $4.05 per connection

[4] The 2007 Parametrix Wastewater Technical Report used peak day and maximum month I/I values of 1,000 and 500 gpd per acre, respectively, to project gravity sewer flows.

Table 6-6. Summary of Thurston Highlands Wastewater Collection System BCE			
BCE input	Alternative 1: STEP collection system	Alternative 2: Grinder pump collection system	Alternative 3: Gravity collection system
			• Vactor truck O&M: $1.20 per connection
	• Total annual O&M: $122.30 per connection in 2050	• Total annual O&M: $100.70 per connection in 2050	• Total annual O&M: $102.70 per connection in 2050
Benefits	• None	• None	• Water right offset: $2.90 per connection
	• Total benefit: None	• Total benefit: None	• Total benefit (annual): $2.90 per connection
Equipment R/R costs	• Pump R/R ($300) at 20-year interval • Float replacement ($100) at 10-year interval • Misc. equipment replacement ($100) at 10-year interval	• Pump replacement ($1,500) at 20-year interval • Pump repair ($800) at 20-year interval (repair at 10 yrs and replace at 20 yrs) • Float replacement ($100) at 10-year interval • Misc. equipment replacement ($100) at 10-year interval	• Pump replacement ($15,000) at 20-year interval • Pump repair ($1,500) at 5-year interval (repair at 5 yrs and replace at 20 yrs) • Pump station structure rehab ($50,000) at 25-year interval
	• Total 30-year R/R: $900 per connection	• Total 30-year R/R: $3,700 per connection	• Total 30-year R/R: $134 per connection
Risks	• Emergency power: $10,000 per 2,000 connections every 5 years to account for extended power outage	• Equipment learning curve and additional spares: $25,000 for first 3 years (divide among 415 connections) • Emergency power: $500 for labor/fuel for each 20 connections every 5 years to account for extended power outage	• Equipment learning curve and additional spares: $25,000 for first 3 years (divide among 415 connections)
	• Total 30-year risk: $30 per connection	• Total 30-year risk: $156 per connection	• Total 30-year risk: $6 per connection

6.4.1.4 BCE Results and Selected Alternative

Results of the BCE analysis are summarized in Table 6-7 based upon per connection costs for the 30-year period between 2020 and 2050. As shown in this table, the alternative with the most favorable NPV is Alternative 3, a gravity collection system. Gravity collection system costs are approximately 20 percent lower than the STEP alternative when evaluating the entire 30-year period. Evaluating the NPV for individual years, the STEP collection system is equal to or more favorable through 2040, after which the gravity alternative is increasingly more cost-effective. This result agrees with analyses presented by Parametrix (2007) and KPFF (2008), which suggested that the gravity alternative may be preferred in a long-term evaluation.

Table 6-7. Results of Thurston Highlands Wastewater Collection System BCE (per connection cost for the 30-year period between 2020 and 2050)						
	Capital cost	O&M cost	Benefit	R/R cost	Risk cost	NPV
Alternative 1: STEP	$ 0	$ 3,920	$ 0	$ 900	$ 30	($ 3,880)
Alternative 2: Grinder pump	$ 0	$ 3,561	$ 0	$ 3,700	$ 156	($ 5,863)
Alternative 3: Gravity	$ 0	$ 4,212	$ 90	$ 134	$ 6	($ 3,076)

The total 30-year O&M costs are very similar for all three alternatives, with the gravity collection system being slightly higher due to the O&M required for the WRF with increased capacity for higher influent flow and load characteristics. Despite having higher O&M costs, the gravity collection system has much lower risk and R/R costs than the other alternatives, and also has the added benefit of providing a greater reclaimed water resource for a potential water right offset. Furthermore, it is likely that the power outage risks for a STEP collection system have been underestimated for an area as large as the planned Thurston Highlands MPC. Therefore, the City will require that Thurston Highlands be developed using gravity collection system technology.

Because previous flow and load projections developed for this GSP are based upon the assumption that STEP collection system technology would be used, Section 6.5 presents new projections for a gravity collection system serving the Thurston Highlands MPC.

6.4.2 Thurston Highlands Wastewater Treatment

Alternatives for treatment of wastewater generated within the Thurston Highlands MPC include treatment of MPC wastewater at the existing City WRF, at a satellite treatment facility within Thurston Highlands, or a combination of both locations where initial wastewater flows from Thurston Highlands would be conveyed to the existing WRF until there is enough flow/load to justify a satellite facility. As discussed previously in this section, any alternative that includes wastewater treatment using existing facilities is fatally flawed when evaluated with respect to City goals and current system limitations. Therefore, the only remaining wastewater treatment alternative is construction of a satellite wastewater treatment facility within Thurston Highlands. The satellite facility would be developer-financed, but owned and operated by the City and its staff.

Based upon current City goals and the lack of a disposal option other than groundwater recharge in RIBs or some other means, Class A reclaimed water production is the only viable treatment alternative. The technology to be used to achieve Class A standards will be evaluated and identified as part of a Facilities Plan to be paid for by the MPC developer as part of the MPC planning process. The City will require the developer to develop life-cycle costs similar to the BCEs in this GSP that demonstrate that the technology selected has the lowest operating costs while meeting applicable state and City requirements for reliability.

For reference, Table 6-8 provides order-of-magnitude costs for recently constructed treatment facilities with the approximate treatment capacity of the required MPC satellite facility and having the capability to produce Class A reclaimed water. The data in this table suggest that capital costs for a new Class A reclaimed water facility of the size required for the initial phases of the MPC development will be on the order of at least $12 million to $15 million (2012 dollars).

Table 6-8. Order of Magnitude Costs for Recent Class A Reclaimed Water Facilities

Plant	Capacity	Reported cost
Belfair: MBR, Class A reclaimed water	0.5 mgd	$12.6M
Tenino: MBR, Class A reclaimed water	0.25 mgd	$6.2M (treatment plant only)
Shelton Satellite Plant: MBR, Class A reclaimed water	0.4 mgd	$11.4M
Winlock: MBR	0.3 mgd	$12M

6.4.3 Thurston Highlands Reclaimed Water Production

As described in Section 6.4.2, wastewater treatment in the Thurston Highlands will be provided by a satellite treatment plant that will discharge Class A reclaimed water to new RIBs. The satellite treatment plant will not discharge reclaimed water to the existing WRF, the Centralia Power Canal, or Nisqually River. The Parametrix Wastewater Technical Report provides an evaluation of areas suitable for recharge within the MPC, and identifies several potentially favorable areas based on proposed land use, soil conditions, and available hydrogeologic data. The Wastewater Technical Report states that, for a continuous infiltration flow of 1.5 mgd, a basin size of 3.5 acres appears feasible. The total area for the facility, including facilities such as monitoring wells and access roads, would be approximately 5 acres. The estimated cost of the infiltration basin facility in 2007 was $2.4 million, which included the cost of land, engineering/administrative costs, and a contingency of 20 percent. Selection of the final recharge sites will require further evaluation of hydrogeologic conditions and should take into account the final location determined for the satellite treatment plant. The water used for groundwater recharge within the Highlands may provide mitigation benefits for future City water rights.

In addition to groundwater recharge, reclaimed water should be used to irrigate rights-of-way, public spaces, and parks planned in the Highlands. Specifically, the Thurston Highlands EIS describes a large regional sports complex planned for the northeast corner of the MPC. Providing Class A reclaimed water to irrigate the sports complex will reduce demand on the City's potable water system and potentially extend the life of water rights that serve the entire city. Additional opportunities for potable water offset should be evaluated on a case-by-case basis as planning and development within the Highlands progresses.

Reclaimed water conveyance infrastructure should be constructed with an intertie to the City's existing reclaimed water system. This will allow for the Highlands to supply other areas of the city with reclaimed water in the event the existing WRF is not able to meet reclaimed water demands in these areas.

6.5 Flow and Load Projections for Gravity Collection System Serving the Thurston Highlands MPC

The flow and loading projections for the Thurston Highlands MPC developed in Section 2 and summarized in Section 6.3.2 (see Table 6-2) were based upon the assumption of the continued use of STEP collection system technology currently utilized by the City of Yelm. However, the collection system BCE performed for Thurston Highlands (see Section 6.4.1) recommended a gravity sewer collection system as the preferred alternative. This section provides revised flow and load projections for Thurston Highlands based upon Ecology design recommendations provided in the Criteria for Sewage Works Design (Ecology, 2008).

Table G2-2 of the Criteria for Sewage Works Design presents the Ecology "Design Basis" for new sewer systems. Table 6-9 summarizes the per capita and per square foot flow, BOD, and TSS design basis values for average annual conditions that will be used in this section to project flows and loads for Thurston Highlands.

Table 6-9. Flow and Loading Design Basis for New Sewer Systems per Ecology [a]

	Units	Average annual flow (gpd) [b]	Average annual BOD (lb/day)	Average annual TSS (lb/day)
Residential	per person	100	0.2	0.2
School [c]	per person	10	0.025	0.025
Commercial [d]	per 1,000 ft^2	250	0.01	0.01

a. *Criteria for Sewage Works Design (Ecology, 2008).*

b. *Includes normal infiltration.*

c. *Schools with cafeteria, but without showers.*

d. *Shopping center development. Average was selected from the range (200 to 300) provided by Ecology.*

Table 6-10 presents flow and load projections for Thurston Highlands using the Ecology average annual design basis values and based on the schedule of Thurston Highlands development, starting in 2020 and reaching buildout in 2050, assumed in Sections 2 and 6. Peak hour and maximum month flow and loading values, calculated using peaking factors applied to the average annual projections, will be used to define treatment and hydraulic capacity of the necessary treatment facilities. Peaking factors were developed in Section 2 based upon the existing STEP collection system. The Section 2 peaking factors for flow are not applicable to a gravity collection system, but BOD and TSS loading peaking factors are applicable as they are not impacted by I/I into the collection system.

Estimated peak hour and maximum month flow/load projections are presented in Table 6-11 and were estimated as follows:

- Peak hour flow: Figure C1-1 from the *Criteria for Sewage Works Design* provides a peaking factor for the ratio of peak hourly flow to average annual flow. For a population of approximately 13,000 people, the recommended peaking factor is 2.9.
- Maximum month flow: A peaking factor of 2.0 was selected based upon engineering experience.
- Maximum month BOD/TSS loading: Maximum month peaking factors for BOD (1.12) and TSS (1.20) were developed in Section 2.7. The gravity sewer flow and load projections for Thurston Highlands presented in Table 6-9 generally agree with the projections developed previously by Parametrix (2007) and KPFF (2008). Flow projections presented in this section are slightly higher because they assume some infiltration (included in the Ecology design basis) and are based upon a slightly higher buildout population (12,963 vs. 12,548). BOD projections presented in the section are nearly identical to the Parametrix projections, while TSS projections presented in this section are slightly lower because Parametrix used a higher per capita loading value of 0.26 lb/day (as compared to the Ecology value of 0.2 lb/day). KPFF did not develop BOD and TSS loading projections. Flow and load projections presented in this section are compared to the Parametrix and KPFF projections for buildout conditions in Table 6-12.

Table 6-10. Thurston Highlands Average Annual Flow and Load Projections for Gravity Sewer Alternative

				Residential			School			Commercial			Total		
Year	Residential population	School population	Commercial development	Flow (gpd)	BOD (lb/day)	TSS (lb/day)	Flow (gpd)	BOD (lb/day)	TSS (lb/day)	Flow (gpd)	BOD (lb/day)	TSS (lb/day)	**Average annual flow (gpd)**	**Average annual BOD (lb/day)**	**Average annual TSS (lb/day)**
2020	1,244	99	32,000	124,400	249	249	990	2.5	2.5	8,000	0.3	0.3	**133,400**	**252**	**252**
2030	5,195	1,004	352,000	519,500	1,039	1,039	10,040	25	25	88,000	3.5	3.5	**617,500**	**1,070**	**1,070**
2040	9,079	1,833	656,000	907,900	1,816	1,816	18,325	46	46	164,000	6.6	6.6	**1,090,200**	**1,870**	**1,870**
2050	12,963	2,661	960,000	1,296,300	2,593	2,593	26,610	67	67	240,000	9.6	9.6	**1,562,900**	**2,670**	**2,670**

Table 6-11. Thurston Highlands Peak Hour and Maximum Flow and Load Projections for Gravity Sewer Alternative

Year	Average annual flow [a] (mgd)	Peak hour flow [b] (mgd)	Maximum month flow [c] (mgd)	Average annual BOD [a] (lb/day)	Maximum month BOD [d] (lb/day)	Average annual TSS [a] (lb/day)	Maximum month TSS [e] (lb/day)
2020	0.13	0.39	0.27	252	282	252	302
2030	0.62	1.79	1.24	1,070	1,200	1,070	1,300
2040	1.09	3.16	2.18	1,870	2,100	1,870	2,250
2050	1.56	3.13	4.53	2,670	3,000	2,670	3,200

a. *As calculated per Ecology recommendations in Table G2-2 of the Criteria for Sewage Works Design and presented in Table 6-10.*

b. *Assuming a peaking factor of 2.9 per Figure C1-1 of the Criteria for Sewage Works Design.*

c. *Assuming a peaking factor of 2.0.*

d. *Assuming a peaking factor of 1.12.*

e. *Assuming a peaking factor of 1.20.*

Table 6-12. Flow and Load Projection Comparison: Thurston Highlands Gravity Sewer at Buildout			
	Average annual flow (mgd)	Average annual BOD load (lb/day)	Average annual TSS load (lb/day
Parametrix	1.30	2,760	3,260
KPFF	1.16	n/a	n/a
Current analysis based upon Ecology design basis	1.56	2,670	2,670

6.6 Policy Recommendations

The City's policy will be for the wastewater system infrastructure serving the Thurston Highlands MPC to be developed as a satellite wastewater system. While physically separate from the existing Yelm wastewater system, this satellite system will be owned and operated by the City as part of its wastewater utility.

The service area policies discussed in Section 1.7 are applicable to the wastewater system within the Thurston Highlands MPC. In addition to the previously identified service area policies, the City will also apply the following policies when considering service area growth with respect to Thurston Highlands:

- Capital costs of wastewater collection, treatment, and reclaimed water infrastructure will be paid by the developer, including permitting, planning, design, and construction. The City will be responsible for permitting, planning, design, and construction of wastewater infrastructure, including gravity pipelines 8 inches in diameter and larger, unless otherwise agreed with the developer. A Developer Agreement will be prepared that defines how all developer and City costs, to be borne by the developer in total, will be paid by the developer.
- The City planning process will incorporate evaluation of alternatives for wastewater collection, treatment, and reclaimed water infrastructure via a BCE to select the preferred alternative based upon lowest life-cycle costs while taking into account risks and benefits. Alternatives to be evaluated will be consistent with the recommendations and analyses presented within this GSP.
- Reclaimed water is a resource to be managed by the City, not by the developer.
- Reclaimed water transmission and distribution pipelines will be installed in all phases of the development of Thurston Highlands.
- The Thurston Highlands MPC will utilize a gravity collection system to be designed consistent with development guidelines prepared by the City specific for Thurston Highlands.
- The treatment facility for the Thurston Highlands MPC will be designed and constructed to produce 100 percent Class A reclaimed water.
- O&M costs for the collection, treatment, and reclaimed systems will be paid by the City through collection of rates and connection charges.
- The City recognizes that during the initial stages of development of the MPC sufficient wastewater may not be generated to effectively operate a Class A reclaimed water treatment facility. The City will consider approval of a community septic system to serve the earliest stages of development, contingent on the necessary state and local government approvals.

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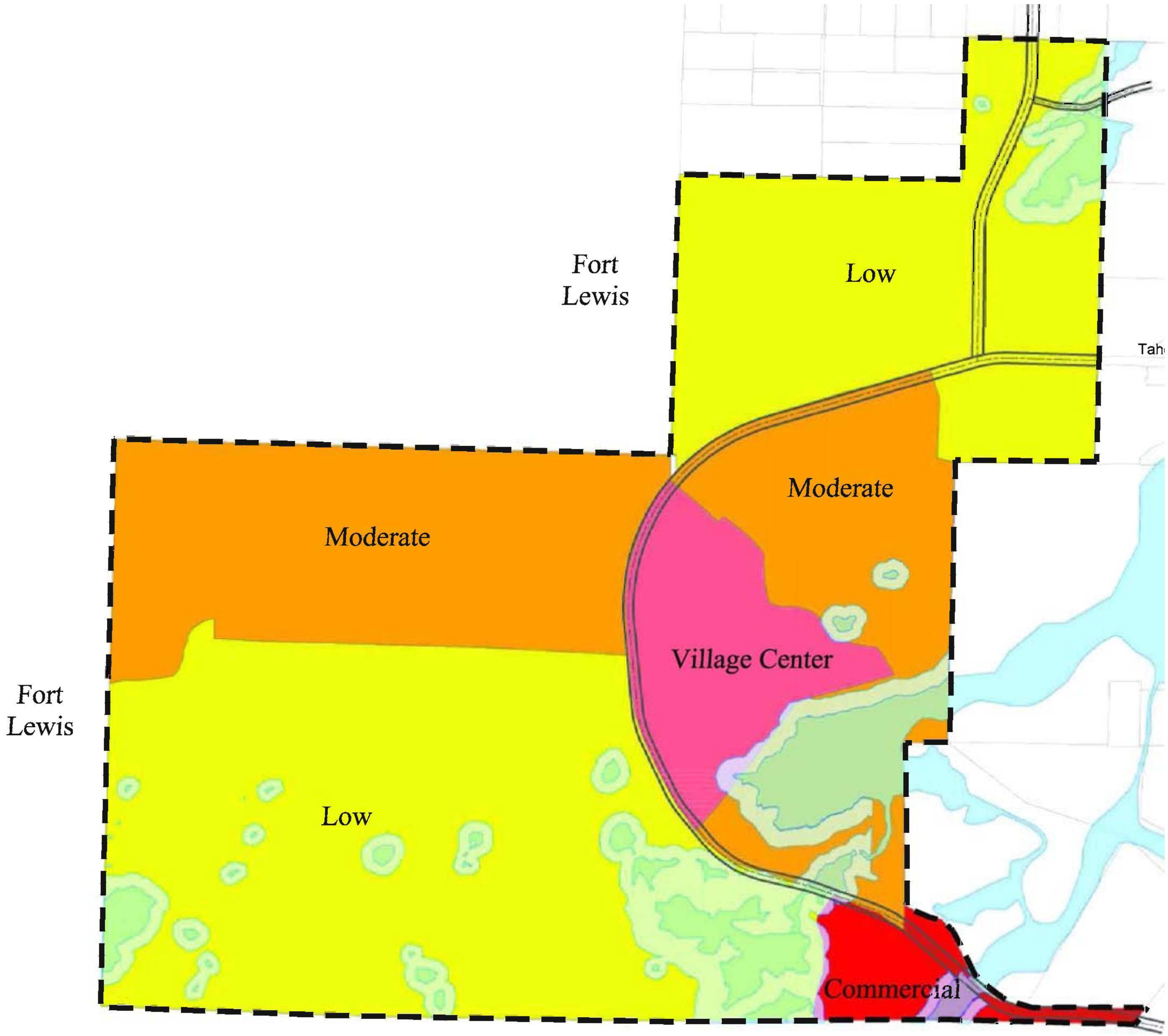

Legend

Wetlands
- Wetland
- Buffer

Land Use Designation
- Commercial
- Village Center
- Moderate Density
- Low Density
- Property Boundary

Source: Thurston Highlands Environmental Impact Statement, Figure 1.3-2, 2007.

N

0 1,500 Feet

1 inch = 1,500 feet

Figure 6-1. Thurston Highlands Preferred Alternative Conceptual Land Use Plan

Brown AND Caldwell

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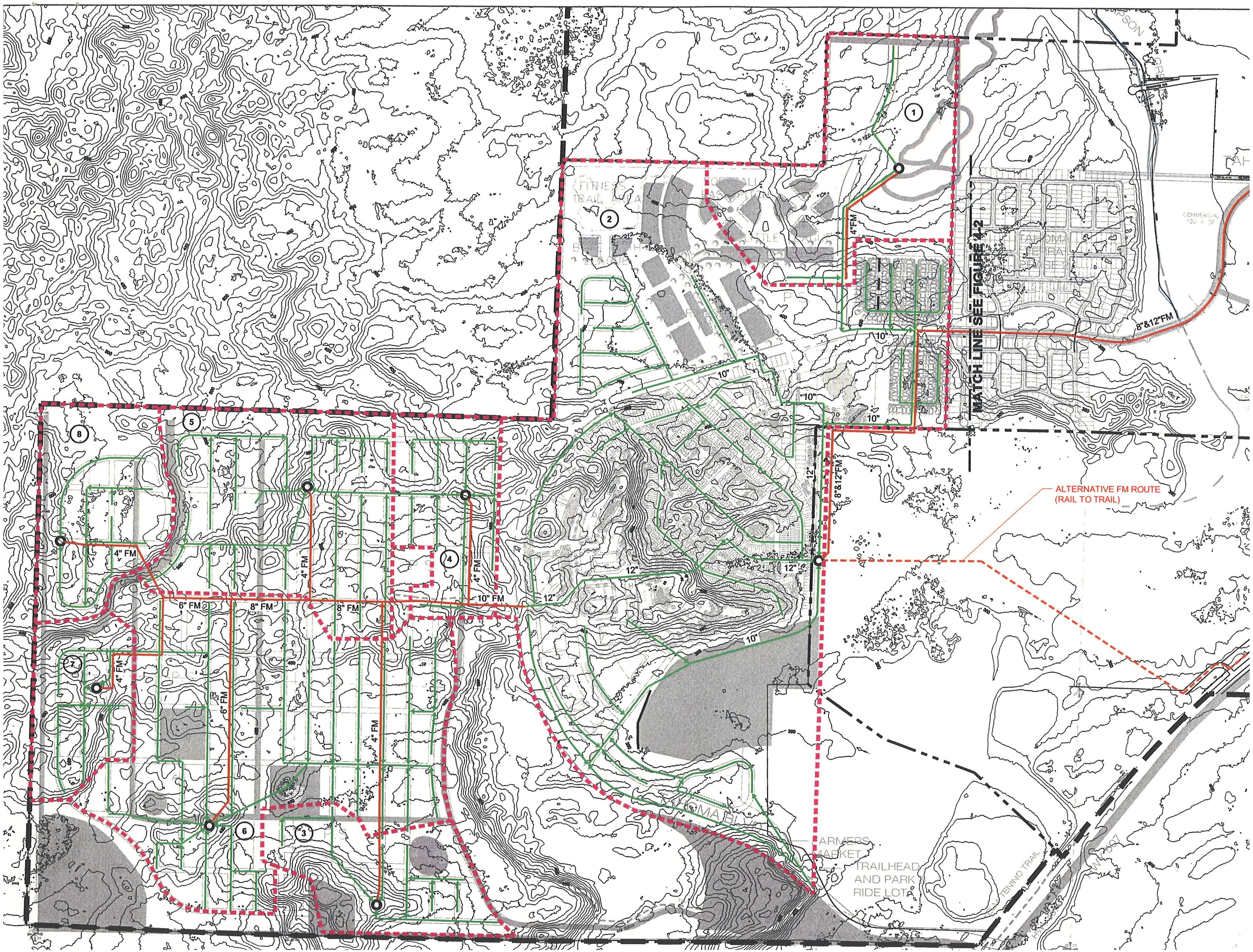


Legend

- 4" FM — Forcemain/Size
- Forcemain (Alt)
- Pump Station
- 12" — Gravity Sewer/Size
- Pump Station Service Area
- 1 — Pump Station Service Area Designator

*All gravity sewers 8" diameter unless size shown

Source: Parametrix Wastewater Technical Report, Figure 4-1, 2007.

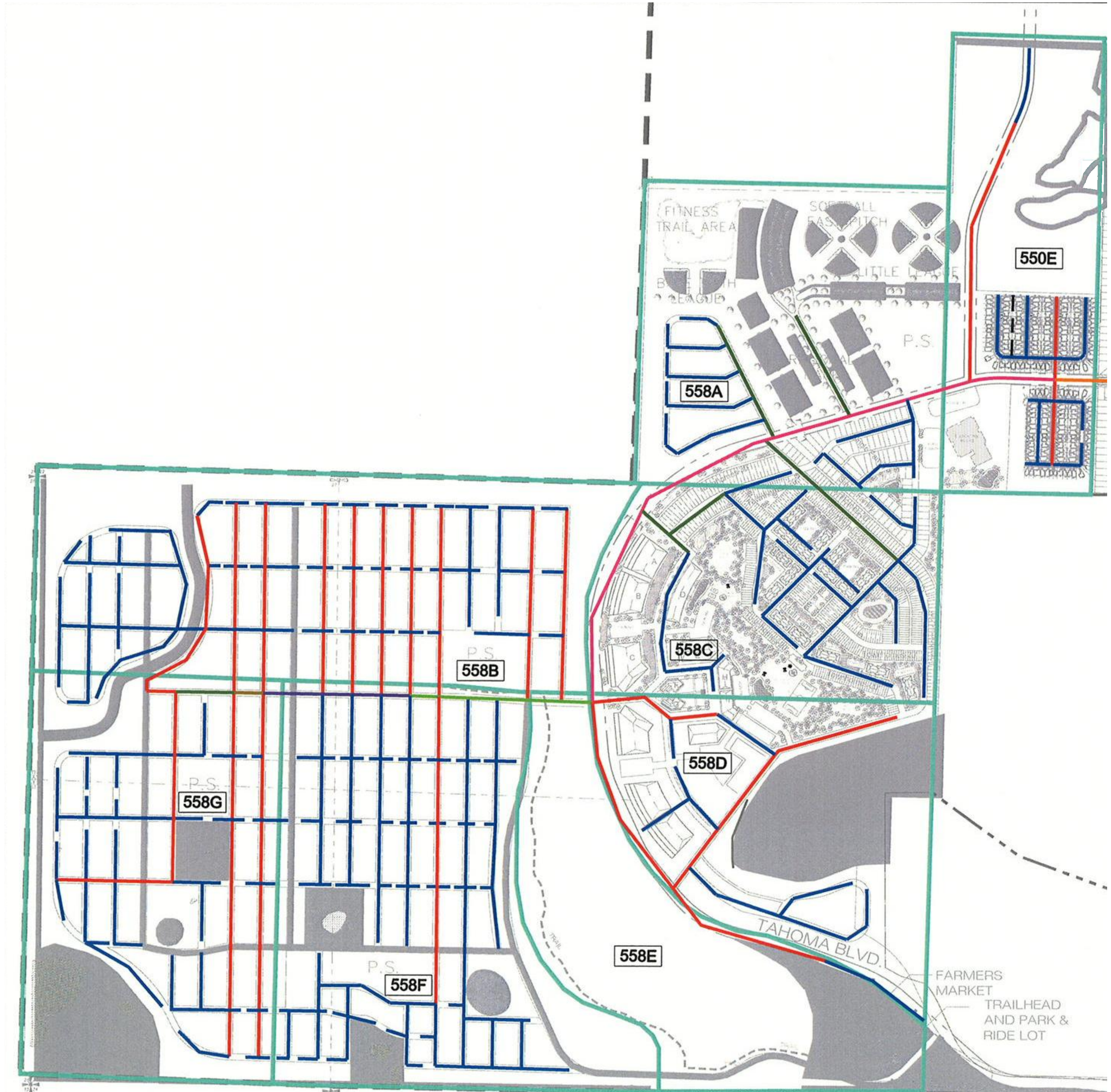
N

0 1,000 Feet

1 inch = 1,000 feet

Figure 6-2. Thurston Highlands Gravity System Layout

Brown AND Caldwell



Legend

- 2 INCH LINE
- 3 INCH LINE
- 4 INCH LINE
- 6 INCH LINE
- 8 INCH LINE
- 10 INCH LINE
- 12 INCH LINE
- 14 INCH LINE
- TAZ BOUNDARY
- 558B TAZ NUMBER

Source: Parametrix Wastewater Technical Report, Figure 4-3, 2007.

N

0 1,000 Feet

1 inch = 1,000 feet

Figure 6-3.
Thurston Highlands
STEP System Layout

Brown AND Caldwell