Section 4

Improving Water Quality

Photo Credit: Jessica Casillas

Section 4. Improving Water Quality

The success of solutions recommended by this WPP will be due in large part to how well they are scaled and targeted to address the pollutant sources identified in Section 3. The Partnership conducted a water quality modeling effort[1] to determine the amount of improvement needed for each parameter (*E. coli* and DO). The purpose of this effort was to establish how much *E. coli* needed to be reduced, and how much DO levels needed to be improved to meet their respective SWQSs. **Load duration curves** (LDCs) were used in combination with water quality data to determine these results. Based on these analyses, assessments of land cover and pollution sources, and the locations of points at which future compliance would be measured, different attainment areas were identified within the total watershed. Unique improvement goals were generated specific to the magnitude and composition of pollutant sources estimated for each attainment area.

Load Duration Curves for *E. coli* and Dissolved Oxygen

Pollutants can enter the water body from discrete sources or from nonpoint sources in different flow conditions. The amount of water flowing through a water body can affect concentrations of pollutants. LDCs use observed water quality data (see Section 3) to indicate the difference between observed levels of pollutants in a waterway, and the levels at which the applicable water quality standards would be met. The difference then becomes the basis for improvement goals.

The LDC approach uses flow data from a stream gauge or other source to create a flow duration curve. These curves indicate what percentage of days the flow of water meets certain flow levels (*e.g.*, a certain waterway may meet its base flow 100% of the time, but its highest peak flows only 5% of the time). Based on the numeric criteria for a water quality standard, a maximum allowable load of pollutant is calculated for all flow conditions. Lastly, monitoring data for the pollutant are multiplied by flows to produce a load duration curve, which shows how the actual load of a pollutant in the water changes in different flow situations (an example LDC is shown in **Figure 1**). More importantly, the curve indicates under what flow conditions, and by how much, the observed pollutant levels exceed the allowable load. Areas in which the load duration curve line exceeds the maximum allowable load curve line indicate that the standard is not being met in those flow conditions. If the areas of exceedance are primarily in high flow conditions, it is likely that nonpoint sources are most prominent. If areas of exceedance are instead primarily in the low flow conditions, point sources are more likely suspects. In situations

[1] For greater detail on the modeling efforts for *E. coli* and DO discussed in this section, please refer to the Bacteria Modeling Report on the project website at: https://springcreekpartnership.weebly.com/uploads/1/3/0/7/130710643/10159_4.3_spring_creek_bacteria_modeling_report_032321.pdf

where there is a mix of flow conditions related to exceedances, or in which contaminants exceed the allowable limit in all conditions, a mix of point and nonpoint sources is likely. The amount in which the observed loads exceed the allowable loads is the basis for developing improvement goals.

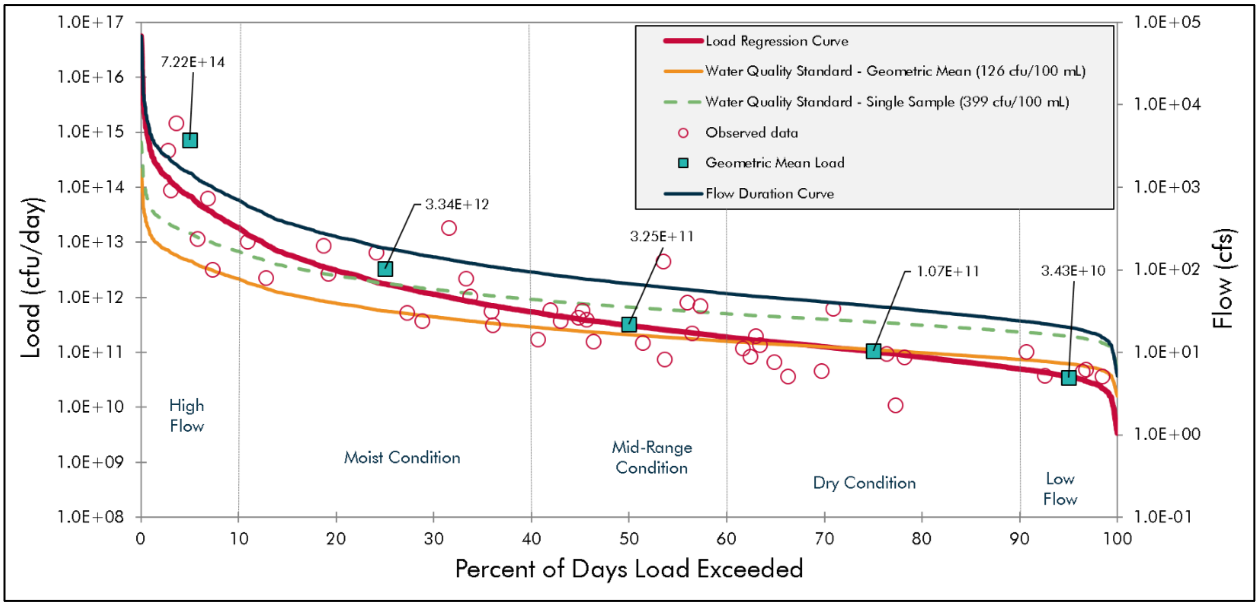

Figure 1. Example of a load duration curve for *E. coli*

Data Development

Project staff developed LDCs for *E. coli* and DO at several monitoring stations throughout the Spring Creek watershed. The purpose of the LDCs was to identify which flow conditions demonstrated exceedances, and to generate goals for *E. coli* reduction and DO improvement.

Site Selection

Site selection for LDCs was based on support for a mix of considerations, including known water quality conditions[2], the need for long-term assessment of progress toward the water quality standard, projected needs for BMP siting decisions, and stakeholder input.

- *Known Water Quality Conditions* — Based on a review of historical ambient water quality trends, wastewater treatment plant discharge monitoring reports, and sanitary sewer overflow information, water quality in the project watershed indicated that conditions in the assessed tributaries and main channel both had a degree of variability and potential for continued exceedance. A single

[2] For more information, see the Water Quality Data Analysis Summary Report on the project website at: https://springcreekpartnership.weebly.com/uploads/1/3/0/7/130710643/10159_3.3_spring_creek_data_analysis_summary_report.pdf

station would not be representative of the variability of conditions based on the water quality review. Therefore, several LDC locations were chosen to represent varying conditions along the waterway. Two stations on Spring Creek were selected to assess water quality in the headwaters as well as the downstream portions of the main stem. Stations on four of the main tributaries (Walnut Creek, Brushy Creek, Willow Creek, and Panther Branch) closest to a confluence with Spring Creek were selected to characterize the influence of the respective subwatershed areas on water quality in the main stem. This design allows for a greater degree of scrutiny of geographic variability of loads in the watershed, and an ability to target reductions more precisely. Evaluating several areas independently ensures area-specific problems would not be lost when diluted by a larger waterway, and that end results reflect variability of conditions throughout the waterway.

- *Long Term Assessment Considerations* — To ensure sufficient periods of record and continued data availability, LDC locations were drawn from existing CRP monitoring stations that have been monitored for at least 10 years and are planned to provide ongoing data. Availability of corresponding long-term streamflow data from USGS gage sites was also considered for site selection. Data from CRP stations and associated USGS gages (**Table 1**, **Figure 2**) selected for LDC analysis include:
    - **Brushy Creek** – Ambient data were collected from Station 20643 (Brushy Creek at Glenmont Estates Boulevard) near Brushy Creek's confluence with Spring Creek. No gaged stream flow data is available on this tributary; however, stream flow was estimated by linear regression. Continuous stream flow values from a nearby USGS gage on Spring Creek (08068275) were plotted against one-time flow recordings logged during sampling events for ambient data. The linear relationship between these values was used to estimate continuous stream flow values.
    - **Walnut Creek** – Ambient data were collected from Station 20642 (Walnut Creek at Decker Prairie Rosehl Road) near Walnut Creek's confluence with Spring Creek. As with Brushy Creek, no gaged stream flow data is available on this tributary, however, stream flow was estimated by linear regression as described in the process used for Brushy Creek.
    - **Spring Creek (Upper)** – Ambient data were collected from Station 11314 (Spring Creek at SH 249) and stream flow data were assessed from USGS gage 08068275.

  - **Willow Creek** – Ambient data were collected from Station 11185 (Willow Creek at Gosling Road) near the confluence with Spring Creek. Stream flow data were collected from USGS gage 08068325. As the USGS gage is located upstream from the location of the station, a drainage area ratio was used to convert continuous stream flow observed at the USGS gage to an estimation of flows further downstream.
  - **Panther Branch** – Ambient data were collected from Station 16627 (Lower Panther Branch at Footbridge 265 M Upstream of Sawdust Road) and stream flow data were assessed from USGS gage 08068450.
  - **Spring Creek (Lower)** – Ambient data were collected from Station 11313 (Spring Creek Bridge at I-45) and stream flow data were assessed from USGS gage 08068500.
- *BMP Siting Requirements* — As discussed previously, LDCs were chosen in part to reflect geographic variability. A greater number of LDC locations is beneficial to compare with modeling results to scale and site solutions (*i.e.*, solution requirements can be refined to the subwatershed level based on the specific reduction needs of the LDC assessment area in which the subwatershed falls).
- *Stakeholder Input* — Project staff built the aforementioned considerations into a set of LDC locations, which were reviewed with stakeholders in the preliminary meetings of the Spring Creek Watershed Partnership.

Table 1. LDC site information

LDC Site	CRP Station	USGS Gage	Assessed Area	Number of *E. coli* Samples	Number of DO Samples
Brushy Creek at Glenmont Estates Boulevard	20463	No Gage	Subwatershed 2	38	37
Walnut Creek at Decker Prairie Rosehl Road	20462	No Gage	Subwatershed 3	39	37
Spring Creek at SH 249	11314	08068275	Subwatershed 4 (and 1 by proxy)	79	83
Willow Creek at Gosling Road	11185	08068325	Subwatershed 5	90	90
Lower Panther Branch at Footbridge 265 M Upstream of Sawdust Road	16627	08068450	Subwatershed 6	33	98
Spring Creek Bridge at I-45	11313	08068500	Subwatershed 7 (and 8 by proxy)	50	66

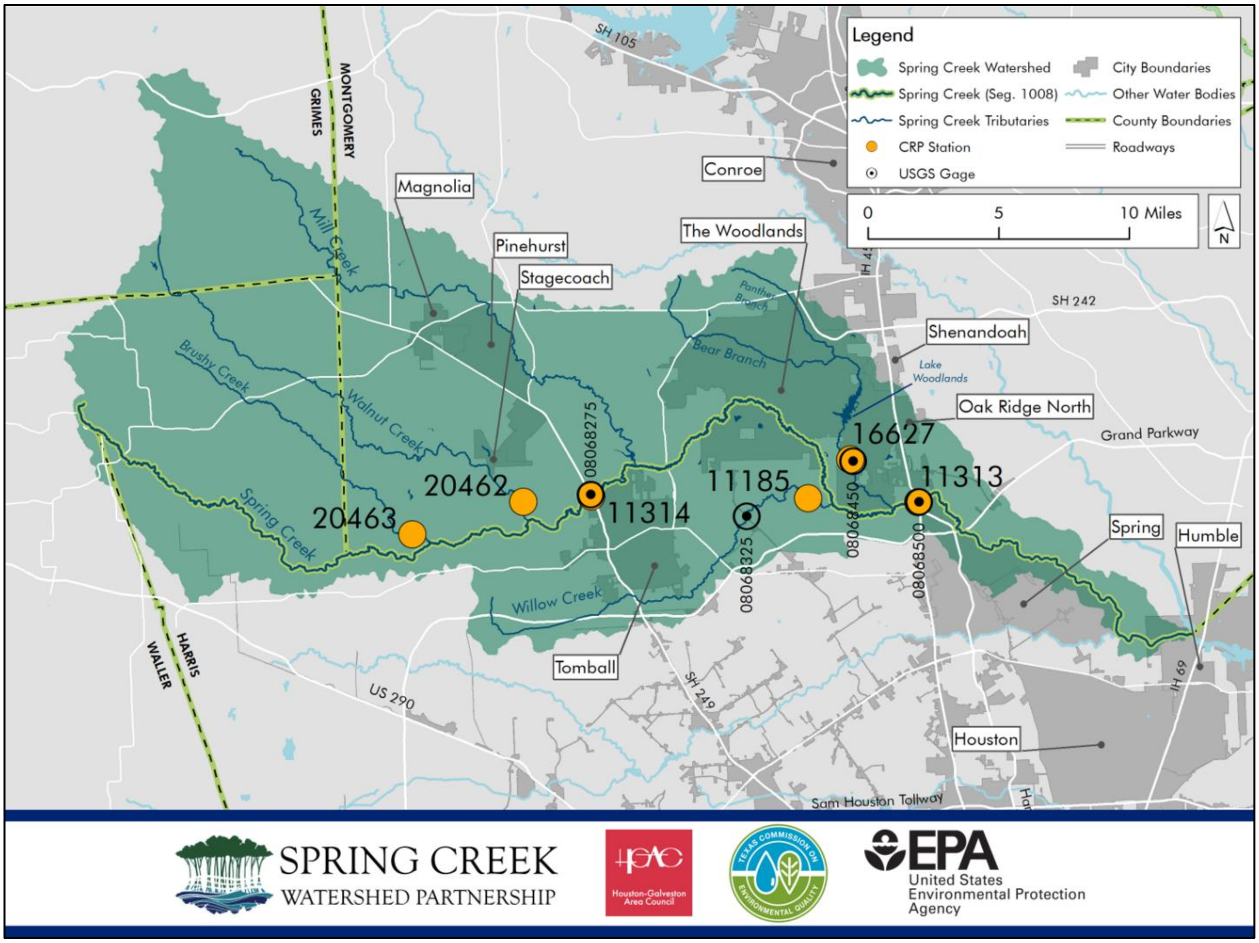

Figure 2. LDC sites

Quality Assurance

Quality-assured ambient water quality results from CRP monitoring were available for all six stations. All stations had at least 10 years of data available (33-90 data points for *E. coli*, and 37-98 data points for DO), which is sufficient to develop the LDCs based on the data quality objectives of the project (**Table 1**). For *E. coli*, both single sample and geomean values were evaluated against their respective criteria, but only geomean values were used in the process of assessing reductions for this modeling effort.

In addition to ambient water quality data, streamflow data is also required (with continuous flow data being preferable) to produce LDCs. Three of the Spring Creek watershed LDC sites (11314, 16627, and 11313) have corresponding USGS gages. On the Willow Creek tributary, Station 11185 occurs downstream of the nearest USGS gage (08068325). To account for this, a drainage area ratio was used to convert continuous stream flow observed at the USGS gage to an estimation of flows further downstream. This process has been used in previous watershed-based plans and meets the quality objectives of the project. No USGS gage data is available for Stations 20642 and 20623 on Walnut Creek and Brushy Creek, respectively. The subwatershed area of these tributaries represents a large portion of the Spring Creek watershed and was therefore critical to characterize with LDC analyses. To accomplish this, a novel approach was used to estimate streamflow. Ambient data recorded at Stations 20462 and 20463 included one-time streamflow measurements from CRP monitoring events. These data were compared to continuous streamflow measured at the closest downstream USGS gage (08068275). The resulting linear relationship between these values was used to estimate continuous stream flow values at the stations on Brushy Creek and Walnut Creek. This process was reviewed internally and with project stakeholders, and found to be sufficient for the quality objectives of the project.

Load Duration Curve Implementation

Both the requisite flow and constituent sample data was sufficient to develop LDCs for all locations and will likely continue to support future revisions and the adaptive management process of evaluating WPP success. Results of the LDC analyses were reviewed internally and with project stakeholders. No issues with the data development and implementation were identified based on quality assurance review and feedback. Full profiles for each LDC site are included in the Bacteria Modeling Report[3].

Load Duration Curve Analysis Summary

Results of LDC analyses for Spring Creek have been reviewed internally and subjected to thorough stakeholder analysis. H-GAC staff discussed these results with stakeholders at partnership meetings and in more focused, one-on-one conversations. Stakeholder support and positive feedback support confidence in the estimated levels of fecal bacteria loadings and reduction targets for the Spring Creek watershed.

Overall, the results indicated that while DO may have some assimilative capacity, *E. coli* loads are greatly in excess of the standard in all locations at high flow and moist flow conditions (**Table 2**). Sites on the western side of the watershed (20463, 20462 and 11314) require more moderate reductions relative to those recommended in more developed areas, however, reductions are recommended for a wider range of flow levels (high flows through dry conditions). On the eastern side of the watershed, sites 16627, 11185 and 11313 bore stronger resemblances to each other in that reductions of greater magnitude are required at the highest flow conditions relative to those

[3] For more information, please refer to the Bacteria Modeling Report on the project website at: https://springcreekpartnership.weebly.com/uploads/1/3/0/7/130710643/10159_4.3_spring_creek_bacteria_modeling_report_032321.pdf

recommended in the west. Dry to low flow conditions are within range of the standard at these sites and only moderate reductions are needed at mid-range conditions for 16627 and 11313.

Table 2. Summary of LDC results

LDC Location	Area Represented	Findings
Brushy Creek (20643)	Segment 1008J; Subwatershed 3	The results of LDC analyses for Station 20463 indicate a need for moderate reductions in fecal bacteria loading at high flow, moist conditions, and mid-range conditions. Brushy Creek demonstrated a greater assimilative capacity DO at higher rates of flow but this ability was limited as flows diminish.
Walnut Creek (20642)	Segment 1008I; Subwatershed 2	Exceedances of the fecal bacteria geomean water quality standard were observed in all flow conditions except low flows. Station 20462 is the only station of the six observed in this analysis that indicated a need for DO improvements. This only occurred at the lowest flow condition (17% improvement needed), with greater assimilative capacities indicated in all other types of stream flow.
Spring Creek, Upstream (11314)	Segment 1008; Subwatershed 4 (& Subwatershed 1 by proxy)	Like Station 20462, fecal bacteria at Station 11314 require reduction in high flows and moist, mid-range, and dry conditions. Comparative to Station 20462, reduction levels at Station 11314 were higher. *E. coli* geomean loads at low flows were within state standard range. DO was compliant with state standards at all levels of flow with higher assimilative capacities observed at higher rates of flow.
Willow Creek (11185)	Segment 1008H; Subwatershed 5	Results at this station are noticeably different from analyses conducted on stations west of this point in that greater geomean loads are observed throughout the curve. Larger reductions in fecal bacteria are recommended at this station compared to previous stations in high flow and moist conditions, but loading became less severe in mid-range conditions, and finally fell within the standard range for dry conditions and low flows. DO was consistently shown to be within the standard range at all flow conditions observed at this station.
Lower Panther Branch (16627)	Segment 1008C; Subwatershed 6	Results indicate that appreciable fecal bacteria load reductions are needed in high flow conditions, and moderate reductions are needed in moist conditions. No exceedances of the *E. coli* geomean water quality standard were observed in any other flow conditions. DO loads were shown to be consistently within the standard range at this station.
Spring Creek, Downstream (11313)	Segment 1008; Subwatershed 7 (& Subwatershed 8 by proxy)	LDC analyses for this station are similar to those observed in other downstream segments—particularly Station 20462. Exceedances of the *E. coli* water quality standard were observed in periods of high flow and in moist and mid-range conditions. Fecal bacteria geomean loads observed in dry and low flows were within the acceptable standard range. DO loads were within range of the standard at all flow conditions with high assimilative capacity observed throughout.

Improvement Goals for *E. coli* and Dissolved Oxygen

The LDCs provided the basis for setting improvement goals for *E. coli* and DO, in the form of percentage reductions of instream loading (for *E. coli*) and percent improvement in DO levels. For DO, no further linkage to sources was calculated due to the lack of an impairment or widespread water quality concerns, the uncertainty of multiple potential precursors to low DO conditions, and the water quality goals set by the stakeholders. Based on the LDC results, where negative values indicate no improvement is needed and additional assimilative capacity may be present, DO conditions at all six LDC sites had additional assimilative capacity with the exception of a 17% improvement needed on Walnut Creek in low-flow conditions only. However, the data represents ambient sampling, and not 24-hour DO, so variation in conditions is likely to happen throughout the daily cycle. Additionally, DO conditions on tributaries with less flow may vary more widely than those in the main stem.

Attainment Areas

In developing improvement goals, the Partnership considered whether a single, watershed-wide goal for *E. coli*, and one for DO, was appropriate. Based on the varied character of the watershed, and to provide for better monitoring of project progress, the Partnership elected to set separate goals for distinct areas in the watershed.

The LDC sites were intended as the focus of long-term attainment; therefore, project staff proposed two attainment areas, each with specific reduction goals (Figure 3). The final selection of attainment areas is designed to reflect the two primary land cover types and associated pollution sources of the watershed, as well as the results of LDC analysis which showed two distinct loading signatures based on site location. For this project, the attainment areas selected represent the headwaters west of SH 249 which are largely surrounded by "natural" land types (subwatersheds 1, 2, 3, and 4), and the downstream waters east of SH 249 which occur in more developed areas (subwatersheds 5, 6, 7, and 8). Data from Station 11314 will represent the headwaters area while data from Station 11313 will represent the downstream. The stakeholders affirmed this approach, with the understanding that through adaptive management, additional targets may be added if needed (*e.g.*, in the Mill Creek subwatershed which does not currently support a monitoring station that meets quality objectives in terms of period-of-record). The monitoring stations and their associated LDCs and improvement goals for these two areas will be the primary focus of measuring water quality achievements under the WPP.

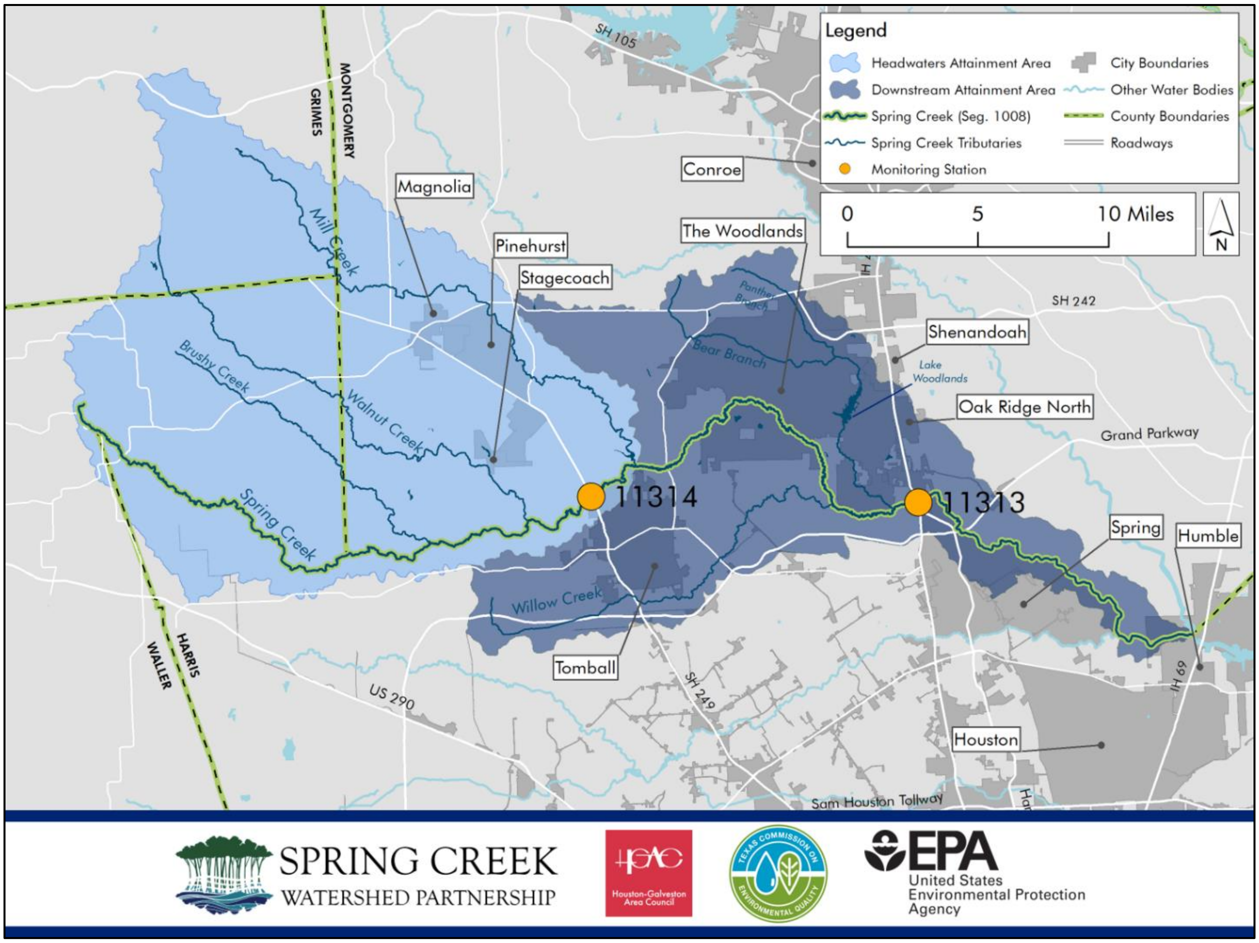

Figure 3. Spring Creek watershed attainment areas

E. coli *Source Load Reduction Goals*

With the establishment of the two primary attainment areas, the Partnership developed specific *E. coli* reduction targets for current and target year (2030) conditions. The first step was to identify a single improvement goal based on the LDCs for each attainment area.

The design for generating single target reductions for each attainment area[4] was based on a compromise between the worst-case scenario (*i.e.*, equating the reduction need to the highest possible reduction need in any flow category) and the least conservative approach (*i.e.*, equating the reduction to the average reduction needed based on all flow conditions). H-GAC proposed, and the stakeholders affirmed, a moderate approach in which reduction targets would be established based on a weighted average of the flow conditions in which reductions were needed, for each attainment area. The equation below demonstrates the calculation used to determine this average, where *W* represents the weighting factor (percent of flows) at high flow (*h*), moist (*m*), mid-range (*mr*), dry (*d*),

[4] As opposed to the modeled reduction values for each flow category.

and low flow (*l*) conditions, and *R* represents the reduction value required at each rate of flow.

$$\text{Weighted Average Reduction} = \frac{WhRh + WmRm + WmrRmr + WdRd + WlRl}{Wh + Wm + Wmr + Wd + Wl}$$

For example, Station 11314 is the farthest downstream station in the attainment area of the headwaters of Spring Creek and was used to represent the area as shown in **Table 3**. At the high flow category which represents the top 10% of flows, an *E. coli* reduction of 81% is recommended. *E. coli* observed in the next 30% of flows (moist conditions) require a reduction of 64% and *E. coli* observed in the following 20% of flows (mid-range conditions) require a 54% reduction. Finally, *E. coli* observed in dry conditions comprising the following 30% of flows only require a 20% reduction. Low flow conditions are not factored into this calculation as no reductions were indicated by the LDC model. The calculation for the weighted average reduction for Station 11314 is shown below:

$$\text{Weighted Average Reduction} = \frac{(10 \times 81) + (30 \times 64) + (20 \times 54) + (30 \times 20)}{10 + 30 + 20 + 30}$$

$$\text{Weighted Average Reduction} = \frac{810 + 1920 + 1080 + 600}{90}$$

$$\text{Weighted Average Reduction} = \frac{4410}{90} = 49$$

This calculation was also used to determine the weighted average fecal bacteria reduction needed at Station 11313 which was selected as the best representative station in the downstream attainment area. While Station 11313 occurs well upstream of the confluence of Spring Creek and the West Fork of the San Jacinto River at the terminal end of the watershed area, it is the furthest downstream station in the attainment area with accompanying stream gage data. Only weighting factors and reduction targets from high, moist and mid-range flows were considered as no reductions were indicated by the LDC model at dry and low flow conditions. The resulting value is shown in **Table 3**.

Table 3. *E. coli* load reduction goals by percentage of load

Attainment Area	LDC Station	Subwatersheds	Weighted Average *E. coli* Reduction Target
Headwaters	11314	1, 2, 3 and 4	49%
Downstream	11313	5, 6, 7 and 8	63%

With the exception of a 17% improvement suggested in low flow conditions on Walnut Creek, LDC results for dissolved oxygen did not indicate the need for improvement. No specific percentage goals were developed for dissolved oxygen in the two attainment areas designated for this watershed. However, the LDCs for dissolved oxygen offer a means to evaluate the relative health of the system in regard to dissolved oxygen levels, which may be used by stakeholders to shape future decisions about implementation measures. It should also be noted that this data may not represent the full variability of dissolved oxygen conditions, so this should not be taken to indicate no improvement of dissolved oxygen is warranted at the attainment area or overall watershed level.

Model Linkage

SELECT was used to generate potential source loads and characterize the source profile. The percent reduction improvement goals developed under the LDCs were applied directly to the source loads to generate the source load reduction targets. This process was developed with H-GAC and TCEQ project staff and reviewed and accepted by the stakeholders. No granular fate and transport modeling was completed for this project. Instead, the linkage relies on the assumption of a linear relationship between source loads and instream conditions. The percent reduction from the LDCs, rather than an absolute number of *E. coli* to reduce, is used for the linkage.

With the model linkage established, calculating *E. coli* reduction targets required that the stakeholders consider two other primary questions: 1) what milestone year would reduction targets be based on; and 2) how would source load reductions be spread out among the fecal waste sources?

Milestone Year

WPPs typically are written to be executed over a 5 to 15-year period. The existing projections developed during the SELECT analyses allowed the stakeholders to target any of the five-year milestone dates between 2018 and 2045. However, the further out the projections went, the greater the uncertainty. In deciding on a target milestone year, the stakeholders balanced the need to set near term, achievable goals within a period of relative certainty, and the need to account for the amount of future growth projected for the watershed. A 5-year plan would not adequately address the appreciable increase in loads through 2045, whereas a more long-term plan would have to rely on less certain predictions[5]. The Partnership and project staff agreed to target the year 2030, allowing a long-term focus to account for watershed change, while focusing on meaningful interim action. For a WPP approved in 2021, this would represent a 10-year plan life.

Allocating Reductions

The mix of sources present in the watershed, and the shift of relative contribution through 2045, posed a challenge for allocating how reduction targets would be met.

[5] This should not be taken to indicate a failure of the modeling methodology, but a reflection of the potential for unaccountable change the further out a model is used to predict conditions.

Stakeholders considered several options, including: 1) targeting all sources proportional to their contribution (e.g., if in 2030, source X made up 30% of the total load, then 30% of the reduction value would be met by addressing that source.); 2) allocating reduction subjectively based on potential solutions; and 3) allocating reduction based on current relative contribution (rather than 2030). Project staff proposed the first option as an initial guide for the calculation of reduction targets, with the understanding that the WPP would stress opportunistic implementation in addition to adaptive management strategies that will be most feasible in the short term. The proportional allocation was modeled for the whole watershed, subwatersheds, and attainment area groupings, with the proposed allocations to focus on the attainment areas. Stakeholders affirmed the proposal.

Based on these decisions, project staff generated reduction targets for each attainment area, subwatershed, and source. Overall reduction targets for each of the attainment areas and the linkage of the reduction target percentages to the source loadings were used to generate the target source load reductions for estimations as of the year 2018, and for the 2030 milestone year (**Table 4**).

Table 4. Current and 2030 source load reduction targets

Attainment Area	Subwatersheds	Weighted Average *E. coli* Reduction Target*	2018 Total Source Load[6]	2018 Source Load Reduction Target[7]	Incremental Load, 2018 to 2030[8]	2030 Total Source Load Reduction Target[9]
Headwaters	1, 2, 3 and 4	49%	3.75E+13	1.84E+13	1.60E+13	3.43E+13
Downstream	5, 6, 7 and 8	63%	5.78E+13	3.64E+13	3.22E+13	6.86E+13

The load reductions needed by source for each of the three attainment areas, were also determined for conditions current as of 2018 and conditions in 2030 (**Table 5**; **Table 6**).

[6] The 2018 total source load is equal to the sum of subwatershed source loads within attainment area.
[7] The 2018 source load reduction target is equal to the 2018 total source load multiplied by the reduction target percentage.
[8] The incremental load is equal to the difference between the 2035 load and the 2018 load.
[9] The 2030 total source load reduction target is equal to the incremental load added to the 2018 source load reduction target.

Table 5. Source reduction loads distributed by source and attainment area, 2018

	Headwaters			Downstream		
Source	SELECT Estimation of Source Load Contribution to Total Daily Load (cfu/day)	SELECT Estimation of Source Percentage of Total Daily Load	Proportionate Source Load Reduction Target Based on SELECT (cfu/day)[10]	SELECT Estimation of Source Load Contribution to Total Daily Load (cfu/day)	SELECT Estimation of Source Percentage of Total Daily Load	Proportionate Source Load Reduction Target Based on SELECT (cfu/day)[11]
WWTFs	4.01E+09	0%	1.96E+09	8.47E+10	0%	5.33E+10
OSSFs	1.22E+12	3%	5.99E+11	1.98E+12	3%	1.25E+12
Dogs	9.74E+12	26%	4.77E+12	4.40E+13	76%	2.77E+13
Cattle	1.00E+13	27%	4.91E+12	1.91E+12	3%	1.20E+12
Horses	7.18E+10	0%	3.52E+10	1.37E+10	0%	8.64E+09
Sheep/Goats	4.58E+12	12%	2.24E+12	8.74E+11	2%	5.51E+11
Deer	2.29E+11	1%	1.12E+11	1.06E+11	0%	6.69E+10
Feral Hogs	7.87E+12	21%	3.85E+12	3.04E+12	5%	1.91E+12
Safety Margin	3.75E+12	10%	1.84E+12	5.78E+12	10%	3.64E+12
TOTAL	**3.75E+13**	**100%**	**1.84E+13**	**5.78E+13**	**100%**	**3.64E+13**

Table 6. Source reduction loads distributed by source and attainment area, 2030

	Headwaters			Downstream		
Source	SELECT Estimation of Source Load Contribution to Total Daily Load (cfu/day)	SELECT Estimation of Source Percentage of Total Daily Load	Proportionate Source Load Reduction Target Based on SELECT (cfu/day)[12]	SELECT Estimation of Source Load Contribution to Total Daily Load (cfu/day)	SELECT Estimation of Source Percentage of Total Daily Load	Proportionate Source Load Reduction Target Based on SELECT (cfu/day)[13]
WWTFs	8.49E+09	0%	5.46E+09	1.18E+11	0%	8.97E+10
OSSFs	3.15E+12	6%	2.02E+12	4.45E+12	5%	3.40E+12
Dogs	2.46E+13	46%	1.58E+13	7.12E+13	79%	5.43E+13
Cattle	8.09E+12	15%	5.20E+12	1.49E+12	2%	1.14E+12
Horses	5.80E+10	0%	3.73E+10	1.07E+10	0%	8.15E+09
Sheep/Goats	3.70E+12	7%	2.38E+12	6.81E+11	1%	5.19E+11
Deer	2.13E+11	0%	1.37E+11	1.01E+11	0%	7.70E+10
Feral Hogs	8.24E+12	15%	5.30E+12	2.93E+12	3%	2.24E+12
Safety Margin	5.35E+12	10%	3.43E+12	9.00E+12	10%	6.86E+12
TOTAL	**5.35E+13**	**100%**	**3.43E+13**	**9.00E+13**	**100%**	**6.86E+13**

[10] This is equal to the SELECT model estimated % contribution multiplied by the 2030 load reduction target.
[11] See note above.
[12] This is equal to the SELECT model estimated % contribution multiplied by the 2030 load reduction target.
[13] See note above.

Representative Units and Scaling Implementation

To determine what the source load reduction targets meant in terms of the scaling of solutions, representative units were used. Representative units are an average, quantifiable component of each fecal waste source. For example, solutions targeting waste reduction for pet dogs would be scaled based on a representative unit of a single dog (*i.e.*, if one had to reduce 10 hypothetical units of fecal waste, and each dog represented one hypothetical unit, then one would need to address 10 dogs). The total number of units that would need to be addressed in each attainment area in 2030 was calculated by dividing the target load reductions by the per unit *E. coli* source load of the representative unit (**Table 7**). The representative unit load is the full SELECT loading rate (*i.e.*, not reduced for being outside the buffer area). In cases where a specific solution is sited in an area outside the riparian buffer, the number of representative units will be less than the actual number of units to address. Likewise, for any solution with a reduction efficiency of less than 100%, the number of actual units to address will be more than the representative units. All units are rounded up to the nearest whole unit.

Table 7. Representative units to address by 2030, by attainment area

Source	Representative Unit	Representative Unit Daily Load (cfu/day)	Units to Address by 2030, Headwaters	Units to Address by 2030, Downstream
WWTFs	1 million gallons of effluent[14]	4.77E+09	1	19
OSSFs	1 failing OSSF[15]	3.71E+09	545	2,786 (915)
Dogs	(waste of) 1 dog	2.50E+09	7,049 (6,335)	21,718
Cattle	(waste of) 1 cow	2.70E+09	1,926	421
Horses	(waste of) 1 horse	2.10E+08	177	39
Sheep/ Goats	(waste of) 1 sheep/goat	9.00E+09	264	58
Deer[16]	(waste of) 1 deer	1.75E+08	NA (781)	NA (440)
Feral Hogs	1 feral hog	4.45E+09	1,592 (1,190)	502

[14] This representative unit assumes effluent discharged at a typical permit concentration standard of 126 cfu/100mL of *E. coli*.

[15] Dog and Feral Hog numbers are increased to cover Deer and Safety Margin reduction loads in the headwaters, whereas OSSF numbers are increased to cover the Deer and Safety Margin reduction loads in the downstream per stakeholder preference. Because there is no representative unit for the Safety Margin, that reduction value is not shown, but an equivalent reduction values for Dogs and Feral Hogs in the headwaters and OSSFs in the downstream are added to the total representative units. The number in parentheses represents the number of Dogs, Feral Hogs, and OSSFs that would have had to have been addressed if Deer and Safety Margin loads were not converted into equivalent OSSFs.

[16] Deer units to address are shown as NA as the Partnership elected to over convert reductions in other sources given a lack of viable solutions for deer. The numbers in parentheses represent the number of units that would have needed to be reduced if the Partnership had not chosen this course.

Because the Safety Margin as a category does not have a representative unit, it is not included in this table. Deer and Safety Margin reduction targets were converted into equivalent OSSFs in the downstream, and Dog and Feral Hog waste in the headwaters to account for stakeholder preference in not selecting specific solutions to target deer and wildlife.

The solutions for livestock are based on the implementation of Water Quality Management Plans (WQMPs) and similar conservation plans through TSSWCB and USDA Natural Resources Conservation Service (NRCS). Section 5 provides details on these solutions. To translate the number of livestock units to address into number of plans, project staff worked with TSSWCB and the local Soil and Water Conservation Districts (SWCDs) in this and previous projects to develop an assumed average number of livestock units (50) to be served by each plan. The number of plans is then derived by dividing the number of livestock units by the average units per plan and rounding up to the nearest whole representative plan (**Table 8**). The actual load reduction value for each plan will differ depending on the mix of livestock involved (given their different representative unit loading values).

Table 8. Agricultural plans needed to address livestock loads by 2030

Attainment Area	Total Livestock Units to Address	Total Plans
Headwaters	2,367	48
Downstream	518	11

Source Load Reduction Summary

The findings of the *E. coli* modeling efforts for Spring Creek reinforce the image of a watershed in transition. Driven by the general growth of the Houston area, and pushing outward from transportation corridors, the project area has seen significant growth in recent decades and will continue to do so in coming years. Developmental changes will reduce legacy agricultural sources in many areas, especially the Headwaters attainment area. The loss of load from agricultural activities will be outweighed by the increases of sources derived from developed areas.

The increasing loads highlight the need for intervention through the WPP and other means. Current water quality issues will be compounded by future loads, leading to degrading water quality through the planning period absent any effort to the contrary.

Uncertainty is present throughout the assumptions and methodologies of this modeling approach, as noted throughout this document. Project staff used the best available data and stakeholder feedback to minimize uncertainty wherever possible, but the results should be taken in the context of their use in characterizing fecal waste pollution on a broad scale, and for scaling and siting BMPs. For these purposes, the level of uncertainty and precision of the results was deemed to be acceptable by the stakeholders. Further refinement of results may be needed in the future in light of changing conditions. While *E. coli* source tracking or other DNA source tracking analyses were not a function of this project, it may be a consideration in the future to further characterize sources, identify location-specific challenges, and refine the linkage between source loads and instream conditions.

Figure 4. Sunset in the Spring Creek watershed