This report provides a review of the Pine Canyon Water & Sanitation District Pine Canyon Water Reclamation Facility Site Application, prepared by Aqua Engineering, dated July 2020. This review was completed by Vista Engineering LLC, on behalf of Castle Rock Water. The site application was reviewed based on design criteria from Colorado Department of Public Health & Environment (CDPHE) "Design Criteria for Domestic Wastewater Treatment Works", dated Sept 2012, and Town of Castle Rock "Wastewater Collection Design, 2018 Criteria Manual". The abbreviation used for a domestic wastewater treatment works, also referred to as a water reclamation facility, will be DWWTW.

Definitions

The following discussion provides definitions for wastewater treatment facilities to provide a context of terms used in the Site Application Report and CDPHE design criteria. The site application refers to a water reclamation facility. ***Water reclamation*** is defined as a process by which wastewater from homes and businesses are cleaned using biological and chemical treatment so that water can be returned to the environment safely to augment the natural systems from which it came. ***Wastewater treatment*** is defined as a process used to convert wastewater into an effluent (outflowing of water to a receiving body of water) that can be returned to the water cycle with minimal impact on the environment or directly reused. CDPHE wastewater treatment works design criteria uses the term "domestic wastewater treatment works" (DWWTW). All of these terms refer to sewer treatment.

General

Operation of a small-community DWWTW was a difficult undertaking. Problems were related to stringent discharge requirements, high per-capita costs, limited finances, and limited operation and maintenance budgets.[1] These problems will likely be experienced at the Pine Canyon development. Another problem with the proposed formation of a special district is the method and effort to educate potential home owners that might purchase lots. Pine Canyon is a unique community surrounded by Castle Rock. The homes within Pine Canyon would likely be similar to the homes in the surrounding developments – size, construction quality, lot size. The difference would be how water and wastewater services were offered. Pine Canyon is proposing to form a special district, construct wastewater collection infrastructure within the community, then construct and operate its own treatment plant (DWWTW). The site application report appears to have underestimated the required DWWTW capacity, its associated construction costs, and proposes to offer part-time staff for operation and maintenance. Home owners in the Pine Canyon development could have wastewater service that costs more than their Castle Rock neighbors.

Preliminary Effluent Limits

The site application report was based on preliminary effluent limits (PELs) provided by CDPHE, but based on information provided by Pine Canyon. The information omitted the fact that the proposed DWWTW outfall is just upstream of the Town of Castle Rock surface-water-

[1] Tchobanoglous, G., Burton, F.L.: *Wastewater Eng 3th Ed.*, Metcalf & Eddy, New York, 1991.

influenced groundwater wells. Therefore, the PELs require revision and the technological aspects of the site application report require revision.

Nutrient Removal

The small plant proposed for Pine Canyon would have similar discharge limits required for Plum Creek Water Reclamation Authority's (PCWRA) DWWTW, including total inorganic nitrogen, total phosphorus, and arsenic. The Pine Canyon DWWTW proposed an advanced biological treatment, dual-train process with pre-anoxic basin, aeration basin, post-anoxic basin, and membrane bioreactor (MBR) basin. The Pine Canyon treatment train was designed to remove nitrogen through primarily biological processes (although chemical addition including methanol and alkalinity were required to meet the stringent limits), but did not discuss biological phosphorus removal. Chemical phosphorus removal was proposed by adding ferric chloride to the MBR basin. Chemical sludge has resulted in a sludge yield of over 1 lb sludge/lb BOD removed.

Plum Creek's plant has optimized nutrient removal through its biological processes, reducing the amount of chemicals required to meet discharge limits. Plum Creek has demonstrated their anaerobic selector basins remove BOD, and maintain a population of phosphorus-accumulating organisms (PAOs). The phosphorus is removed in the sludge. Reducing nutrient concentrations in the biological processes reduces the amount of chemical required to meet nutrient limits, and reduces the volume of chemical sludge generated per mass of nutrient removed.

Regulation 31 is expected to bring lower nutrient limits for phosphorus, nitrogen, ammonia, and selenium. Limits are expected in 2027. Section 4.1.2 of the site application report states the total nitrogen (TN) concentration would be lower than most economically viable treatment technologies are capable of achieving. The site application report notes that the proposed DWWTW could soon require additional processes, including a dissolved organic nitrogen (DON) treatment process. Section 5.2.2 of the site application report states sampling for DON would be conducted after the facility was operational. Treatment processes could include ultraviolet advanced oxidation process (UV AOP), granular activated carbon (GAC), chemical coagulation, or electrocoagulation. Costs for the capital improvements were not included in the OPC.

High Per-capita Costs

The Pine Canyon District has not been formed. Section 8.1.2 of the site application report stated the district will pursue bonds or other financing available to Colorado Special Districts to pay for the DWWTW. The discussion did not address how the complete infrastructure for the community would be financed and ultimately purchased. The report's Table 17 listed the DWWTW cost at $12,004,000. The report's Table 18 listed the impact fees at $17,665,086, and noted that the number included bond interest. It is unclear what amount was budgeted for the wastewater collection system, or how it would be purchased. Section 8.1.2 stated, "the revenue projections demonstrate that PCWSD has the financial capacity to construct, operate and manage the facility. The cash flow projection demonstrates that PCWSD will be able to meet its increased debt obligation, have a debt service reserve of at least 1.10, pay the projected utility

costs, and maintain all other aspects of operation of the PCWRF, through implementation of the projected user rates and impact fees, and successful acquisition of bonds or other capital funding." The discussion seems to be short on detail, other than the indication of financing the project with new debt.

Pine Canyon would be a Title 32, Article 1 special district, and would have various financial powers. The district would have the power to tax and/or assess fees for services, and to issue municipal bonds to pay for water and wastewater infrastructure. Issuing bonds is a method of borrowing money, which places the district in legal indebtedness. The debt can generally only be issued as the result of an election. But, a newly formed district can hold an election with its early customers (who can be associated with the district's forming members). The bonds are sold to investors who must be repaid over time with interest. Terms including interest rate and repayment period on these bonds vary but is often 20 years. The investors' money is used by the district to pay for infrastructure including water treatment plants and lines, sewer treatment plants and lines, and reuse irrigation holding ponds, pump stations, and lines.

The special district has legal authority to establish and collect property tax on the properties within its boundaries to redeem the bonds. The district could use other revenues available to retire the debt. An example would be user fees. The Colorado Department of Local Affairs (DOLA) recommends prospective property owners looking to purchase homes within a special district consider the following to determine future tax liability:[2]

- How much outstanding general obligation debt does the district have?
- Are the principal and interest payments on the general obligation bonds insured?
- Are the bonds rated, if so, what is the rating?
- If the bonds are Limited Tax Obligations, what is the mill levy cap associated with the bonds?
- Does the developer hold the bonds, or, have they been issued to the public?
- What is the amount of the yearly debt service payment?
- What revenue is being used to pay the debt service?
- What is the ratio of debt outstanding to the assessed valuation of the district?

Colorado legislature has passed a number of laws requiring certain disclosures to buyers of residential property, so that they would be aware that they were buying property that might be within a special district that can levy taxes and may have outstanding debt.

Operation & Maintenance (Annual) Costs

The site application report proposed a constant annual operating cost of $780,000. The report did not address price increases over time, staff cost increases, contingency for unexpected equipment failure, and other factors that would drive increases in operating costs. The example DWWTWs listed for reference served small communities that are located in relatively rural areas. Town of Bennett, Spring Valley Ranch Metropolitan District, and Town of Johnstown

[2] "Special Districts: A Brief Review for Prospective Homeowners", Colorado Department of Local Affairs (DOLA), June 2019.

were not located within the service district of a large regional DWWTW, and were forced to try to operate a stand-alone plant. The site application report did not provide a discussion about the success these example DWWTWs were having to prevent gradual decline that would require significant capital improvements.

Section 7.2.1 of the site application report stated the planned operation time was 20 hours/wk for 1 person. It is unclear how 1 person for an average of 4 hours/day for 5 days/week will complete: 1 hour process control/day, 7 days/week; conduct discharge permit monitoring including sampling and transporting samples to a certified lab; operate the screw press to dewater biosolids (sludge) and transport thickened solids to a permitted land application site; and conduct maintenance on membrane cartridges, pumps, blowers, chemical feed equipment, chemical storage tanks, and, lastly, respond to alarms and deal with failure conditions.

SERVICE AREA

The design loading to a DWWTW is determined by defining the service area, considering historical data, engineering flow and loading (e.g., organic, solids, nutrient) assumptions, area population, land use, unique customers (industrial, retail, restaurants), and population and employment projections and/or land use projections as noted in the Service Area Definition of the Regulation 22 Guidance Document §22.4(1)(b)(i). Potential changes in land use, flow and concentration trends are required to be considered in the development of hydraulic and loading forecasts. Treatment processes are typically designed for maximum month conditions. Maximum Month Flow (MMF) and Maximum Month Load (MML) represent the highest 30-day average flow or load expected to be received at the DWWTW.

The Pine Canyon service area will be sited on a 540-acre parcel, located in Sections 34-36, Township 7 S, Range 67 W, of the 6th Principal Meridian. The parcel has been broken off from the original 1,800-arce Scott Ranch, and is currently unincorporated Douglas County. The parcel is divided into two portions by Interstate 25 and surrounded by Castle Rock's residential communities. Pine Canyon's east portion is surrounded by the Woodlands community to the North, the Terrain community to the East of Founders Parkway, the Bluffs at Castle Rock community to the South, and I-25 to the West. The West portion is bordered by offices and industrial development to the North and South, I-25 to the East, and adjacent to a golf-course and Red Hawk community to the West.

The Pine Canyon development was divided into 20 planning areas (PA). Single family density was proposed to be 1.7 dwelling units (DU)/acre to 4.2 DU/acre. Multi-family density was proposed to be 14.2 DU/acre. Mixed use density was proposed to be 15.8 DU/acre to 20.4 DU/acre. A school is proposed for the 12.7-acre PA-14. A high-quality, destination Spa Resort was proposed for the 21.4-acre PA-6. Dwelling Units and commercial development square footage are listed on Figure 2 of the site application report.

DESIGN FLOWS

The site application report proposed austere, conservation-based, average daily wastewater flows for residential SFEs. The approach assumed 50 gpd/person, and estimated average household size to be 3 residents per single family equivalent (SFE) for both single family and multi-family housing units. The household count was derived from the United States Census Bureau. The site application report established the annual average daily flow to be 150 gpd/SFE. This value was adjusted by a peaking factor of 1.2 to establish the maximum month average daily flow to be 180 gpd/SFE. The site application report outlined their approach and provided references for the data, as listed in the following table:

Table 1 Site Application Estimated Average Daily Wastewater Flow

DOCUMENT	INDOOR WATER USE gpd/SFE	OUTDOOR WATER USE gpd/SFE
Denver Water Efficiency Plan		
Water Research Foundations "Residential End Uses of Water, Version 2	138 gpd/SFE	
Colorado Water Plan	60 gpd/person (180 gpd/SFE)	
EPA Water Sense New Home Specification Ver 1.0	110 gpd/SFE	
Site Application	150 gpd/SFE	

Conservation studies use average daily flows over a relatively large community. The studies do not identify the portion of homes that are empty, second homes as an example. The studies do not identify the number of residents that choose to shower at a club, or have laundry done at the dry cleaners. The studies do not identify the number of residents that travel throughout the week. This year, 2020, has resulted in more people staying home. People are working from home and children are learning on-line. Water usage would be expected to increase. Another change in home use has been vacation rentals, as AirBnB. Homes have been filled to capacity for several days each month.

Annual average flow does not account for daily fluctuations. Using annual average typically under-sizes a treatment facility. CDPHE requires that treatment facilities be sized for maximum 30-day average flows. Peaking factors have been established by comparing the different flow categories. The following table lists typical fluctuations in water use in community systems:

Table 2 Peaking Factors

	Percentage of Average for Year[3]	
	Range	Typical
Daily average in maximum month	110 - 140	120
Daily average in maximum week	120 - 170	140
Maximum day	160 - 220	180
Maximum hour	225 - 320	270

This review used design criteria from the Town of Castle Rock's "Wastewater Collection Design, 2018 Criteria Manual". SFE are listed in the following table:

[3] Tchobanoglous, G. and Schroeder, E.D.: *Water Quality*, Addis14.9on-Wesley, Reading, MA 1985.

Table 3 Wastewater Flowrates from Residential Sources

SOURCE	Typical ADF/UNIT	TYPICAL SFEs/unit
Single Family Residential & Duplexes	200 gpd/dwelling unit (DU)	1/DU
Multi-family Residential	130 gpd/DU	0.65/DU
Retail/Offices	0.1 gpd/ft^2	0.0005/ft^2
Hotels/Motels	75 gpd/room	0.375/room
Restaurants	1.5 gpd/ft^2	0.0075/ft^2
Industrial/Other Commercial	600 gpd/acre	3.0/acre
School, Middle (25 ac, 850 students)	8,500 gpd/school	42.50/school

Single Family Equivalent

Pine Canyon plans on 800 single-family DUs, 225 multi-family DUs, and 600 multi-family DUs associated with mixed use development.

Commercial/Business Water Usage

Section 3.1.2.2 of the site application report states commercial and business space will consist of offices and retail stores. The site application report estimated 550,000 ft^2 of office space at 60 gpd/1,000 ft^2. Plumbing code estimates office wastewater flows at 20 gpd/employee. The proposed 60 gpd/1,000 ft^2 would correspond to 3 employees/1,000 ft^2, or 1,650 employees. The site application report estimated 50,000 ft^2 of retail space at 20 gpd/1,000 ft^2. Plumbing code estimates retail wastewater flows at 20 gpd/employee and restrooms at 1 gpd/10 ft^2.

Using Town of Castle Rock design criteria, the estimated flows from the 50,000 ft^2 of retail space would be 5,000 gpd. The estimated flows from the 11.4 acres of commercial space would be 6,840 gpd.

The site application report did not include food service business in any of the non-residential uses. That would be different than surrounding commercial development. Food service was included in the revised flow estimate at 5,000 ft^2 x 1.5 gpd/ft^2, for 7,500 gpd.

Hotel

Section 3.1.2.3 states a 220-room hotel is planned. The estimated flow from the hotel was 60 gpd/room, or 13,200 gpd. Using the Town of Castle Rock design criteria, the flow estimated was 75 gpd/room x 220 rooms, or 16,500 gpd. There was no discussion about restaurants associated with the hotel or resort, so actual flows could be higher.

School

Section 3.1.2.4 estimated an 800-person school, and a unit flow of 25 gpd/person. The school flows of 20,000 gpd will be included in the flow estimate. That unit flow would include gym's showers or cafeteria. Staff should be estimated at 20 gpd/person. At 1 teacher per 20 students, the school(s) would have 40 teachers. Additional staff would include office administration and teaching aids, estimated as 15 staff.

This review will use the Town of Castle Rock design criteria. School flows will be estimated at 10 gpd/student, or 8,000 gpd.

Infiltration & Inflow (I&I)

Section 3.1.4 of the site application report stated the infiltration and inflow (I&I) was not expected to have a significant impact on the expected flows to the DWWTW due to specified construction practices requiring waterproofing and leak testing. Inflow occurs in new collection systems. Service stub-outs temporary plugs can leak. Collection main end plugs can leak. Service lines are not leak tested during installation. Although I&I might not be significant, it will be measurable. I&I will be included in the flow estimate as recommended in the Town of Castle Rock design criteria, and was included in the following table.

Revised Max 30-day Average Flow

Design average daily flows are listed in the following table. Figure 2 of the site application report did not break-out the retail and office space. Using the approach outlined in the Town of Castle Rock design criteria, the average daily flows will be adjusted by a peaking factor to estimate the maximum 30-day average flow. Infiltration & inflow (I&I) will be estimated as 10% of the average daily flow.

Table 4 Pine Canyon DWWTW Design Flow

DEVELOPMENT AREAS	USE	DWELLING UNITS (DU)	FLOW (gpd)
PA-1	Single Family	75	15,000
PA-2	Single Family	50	10,000
PA-3	Single Family	95	19,000
PA-4	Single Family	90	18,000
PA-6	Hotel/Resort	225 rooms	16,500
PA-8	Single Family	105	21,000
PA-9	Single Family	135	27,000
PA-10	Single Family	35	7,000
PA-11	Single Family	40	8,000
PA-12	Single Family	90	18,000
PA-13	Single Family	85	17,000
PA-14	School	800 students	8,000
PA-16	Multi-family	225	29,250
PA-17	Mixed Use	200	26,000
PA-18	Mixed Use	400	52,000
PA-19	Business/Light Industrial	11.4 acres	6,840
TOTAL			363,990 gpd
Max 30-day Average Flow (x1.2)			0.4368
I&I			0.0364
Design Flow			0.4732

Section 3.1.3 of the site application report states the proposed DWWTW design capacity would be 0.405 MGD. Evaluating the proposed loading using the Town of Castle Rock design criteria increases the design capacity to 0.4732 MGD. It is recommended additional capacity be included in the design for slipstream return to the treatment basins. As an example, activated sludge will be wasted from the process and held in a waste basin. The sludge will be approximately 98% water. The sludge will be dewatered using a rotary screw sludge thickener. The thickened sludge will be conveyed to a sludge truck. Process water will be returned to the

treatment basins. The membrane cartridges require cleaning with large volumes of water and cleaning chemicals, as citric acid. The "dirty water" from the cleaning process is returned to the process basins. At a minimum, it is recommended the DWWTW be sized for 0.500 MGD (an increase of approximately 25%).

EFFLUENT LIMITS

Preliminary effluent limits were received from CDPHE – WQCD Permits Section. Discharge was proposed to be to East Plum Creek, stream segment COSPUS10A and reclaimed water PELs for Regulation 84 Category 3. Regulation 85-related effluent limits were listed in the following table:

PARAMETER	ANNUAL MEDIAN LIMIT	95TH PERCENTILE LIMIT
Total Phosphorus	0.7 mg/L	1.75 mg/L
Total Inorganic Nitrogen as N	7 mg/L	14 mg/L

IRRIGATION

Irrigation water would be applied per the Notice of Authorization (NOA) and Land Application Management Plan (LAMP) approved by CDPHE. The water application rate, and corresponding nitrogen and phosphorus effluent loading would be limited by the agronomic rates of the irrigated vegetation species.

PROPOSED WWTP LOCATION

The proposed site of the DWWTW is West of Interstate 25, adjacent to the Rio Grande railroad track. The plant site is proposed to be 2 acres located in Walter J. Scott Riparian Park. Open-space trails pass by the plant. The plant would be approximately 1700 feet from the edge of the Red Hawk community. It is recommended the plant be fully enclosed in buildings of architectural design to disguise the true purpose of the plant. The plant examples shown in the site application report, Wolf Creek, Utah and Richmond, Utah, were metal buildings designed to look like barns. This architecture would not blend with the surrounding communities. Figure 3 of the site application report shows exterior concrete basins for anoxic and aeration processes, and standby generator are outside. Noise, odor, and aerosols could provide public nuisance complaints. The membrane bioreactor (MBR) (clarifier-type basin) and sludge dewatering equipment were proposed to be located in a building. Placing the stand-by generator outside would provide unacceptable noise, as the generator is run each week and would run continuously in event of power failure. The barbed-wire-topped-chain-link fence would have an impoundment yard look, and be unacceptable for the open-space park location. The plant did not include a dilute waste activated sludge tank (DWAS) and a thickened waste activated sludge tank (TWAS). If the proposed operational approach was to fill a sludge truck from the screw dewatering equipment, the volume of sludge truck traffic through the open space would likely be unacceptable.

Section 6.1.7 of the site application states "the facility is located on a segregated site and is not immediately adjacent to residences." Report states design will consider both odor control and

facility architecture/aesthetics, although no costs for odor control was included in the OPC. Sewer plant smells wafting across the open space would not be acceptable.

WASTE LOAD ALLOCATION

The site application report includes a section on waste load allocation, including trading the non-point loading of phosphorus from cattle and horses to the point loading from the DWWTW outfall into East Plum Creek.

The following excerpt is from the site application report's drainage report: "East Plum Creek is located along the West side of the Pine Canyon property. Two minor drainageways convey stormwater flows through the parcel. Walker Tributary #1 conveys stormwater flows from the east portion underneath I-25, Liggett Road, and the Union Pacific Railroad, to discharge into East Plum Creek. Walker Tributary #2 conveys stormwater flows from the East parcel to the southern edge of the site where stormwater is conveyed through The Woodlands filing #9 and Scott II filing #3 existing developments. There are no other major drainageways, existing irrigation ditches, or canals located on the site." It appears these two minor drainageways are dry except during significant storm events. The site application report did not include stream and soil sampling along the drainageways to better quantify the amount of phosphorus making its way off the pasture and into the waterways.

The Pine Canyon parcel is divided into 2 portions: approximately 424 acres in the eastern portion and approximately 116 acres in the western portion. Cattle are grazed over the entire parcel. No information was provided on cross fencing and rotational grazing practices. Section 3.2 of the "Trade Application Engineering Report" stated 65 cows, 40 calves, and 7 horses are typically grazed on the property for 6 months per year. The grazing density is approximately 4.8 acres per animal.

Section 1.1 of the "Trade Application Engineering Report" quoted a Journal of Animal Science article that "watersheds with concentrated livestock populations have been shown to discharge as much as 5 to 10 times more nutrients than watersheds in cropland or forestry." That section also quoted R.K. Hubbard, about the potential of pathogens traveling from grazing land to surface water bodies. This lead-off in the phosphorus trade application report seems to provide extraneous information, as the ranch property has been carefully managed to control grazing pressure to prevent forage damage. Concentrated livestock feed is not currently practiced on the property. Pathogens monitoring has not been related to phosphorus monitoring.

The proposed phosphorus loading of 1,528 lb/yr was based on the wet weight of manure being carried into East Plum Creek. R.K. Hubbard, "Water Quality and the Grazing Animal"[4] stated grazing animals and pasture production can affect water quality both positively and negatively. When livestock are produced on pasture and the land is not overgrazed, the likelihood of nutrient contamination of water may be much lower than that of heavily fertilized conventionally produced crops. When land has a thick cover of perennial forages, there is little runoff and therefore less chance for fertilizers to be washed away. Most forage crops, especially perennial

[4] R.K. Hubbard, "Water Quality and the Grazing Animal", *American Society of Animal Science*, 2004.

grasses, form dense root systems that effectively serve as filters to remove contaminants before they can seep into the groundwater. Organic components of manure and urine from grazing animals can build soil organic matter reserves, resulting in soils having increased water-holding capacity, increased water-infiltration rates, and improved structural stability. These changes can decrease soil loss by wind and water erosion. Manures stimulate the growth of beneficial soil microbial populations, increase microbial activity within the soil, and increase the population of beneficial mesofauna, such as earthworms. A study by Chichester et al (1979)[5] showed that concentrations of phosphorus were not increased by summer grazing of pasture in Ohio. Forage systems protect the soil surface from erosion, and when animal waste inputs are low to moderate, both surface and ground water quality under grazed areas may be better than that under cropper areas.

The Pine Canyon parcel has been carefully managed since 1909. The land has not been overgrazed during the summer months, and animals were removed during the winter months. The grazing has helped improve the pasture grass (forage). The animals have contributed nutrients, including nitrogen and phosphorus, at a level that has provided a benefit to pasture improvement. The site application report did not provide data that indicated phosphorus in excess of the soil's uptake rate had been applied to the pasture. Therefore, the amount requested does not appear to be available to be removed from East Plum Creek.

CONCLUSION

The proposed DWWTW is undersized based on flow and process. The hydraulic capacity is approximately 25% undersized. Processes omitted from the design include biological phosphorus removal, dissolved organic nitrogen (could be ultraviolet advanced oxidation process (UV AOP), granular activated carbon (GAC), chemical coagulation, or electrocoagulation), diluted waste activated sludge holding tank/basin (DWAS), thickened wastewater activated sludge holding tank/basin (TWAS), and a process building to enclose the activated sludge process basins. The proposed design did not include architectural enhancements to make the buildings blend with surrounding development.

The proposed treatment processes are incomplete, in part, because the preliminary effluent limits did not consider the proposed outfall location be upstream of the Town of Castle Rock's drinking water wells. The phosphorus waste load allocation proposed a trade between animal manure and the DWWTW's effluent. The proposal was to remove the livestock from the parcel, and the lack of manure would remove 1,528 lb of phosphorus per year from the watershed. There was no sampling and analysis of the land and East Plum Creek included in the parcel to determine the existing phosphorus loading. The land has been well managed since the formation of the Scott Ranch in 1909. The land is not overgrazed. It is likely the phosphorus deposited on the parcel has helped maintain the healthy pasture land.

[5] Chichester, F.W., R.W. Van Keuren, and J.L. McGuinness, "Hydrology and chemical quality of flow from small pastured watersheds: II. Chemical quality." *Journal of Environmental Quality*, 8:167-171.