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DRAFT TECHNICAL MEMORANDUM

Date:	18 November 2009
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From:	Ken Susilo, PE, D.WRE, CPSWQ and Julie Stephenson, Geosyntec Consultants
Subject:	Public Benefits Related to Water Quality – Cucamonga Creek Watershed Water Quality Project

INTRODUCTION

The Cucamonga Creek Watershed Water Quality Project (Project) proposes to treat stormwater runoff from the Cucamonga Creek watershed while creating recreational and habitat opportunities. The intent of the Project is to create a regional stormwater treatment facility which treats dry- and wet-weather flows within the Cucamonga Creek watershed.

The Project is proposed for locations on both public and private floodplain parcels owned by the United States Army Corps of Engineers (USACE), Chino Holding Company, LLC, and Steuve brothers. Of the 45 acre proposed project footprint, approximately 85% is located on public (USACE) land. Public land is proposed for use for stormwater treatment to enable realization of additional water quality benefits associated with regional treatment system siting. The purpose of this memorandum is to quantify the public benefits realized from siting the Project regionally.

WATER QUALITY BENEFIT ANALYSIS APPROACH

General Approach

Criteria for sizing stormwater treatment facilities is typically based on a design storm approach which requires the treatment of either the volume or peak flow that would run off from a tributary drainage area during the design storm event. If placed within the subject tributary area, a treatment facility would fill to capacity only under design storm conditions. Based on design storm criteria from a variety of municipalities in Southern California, the treatment facility would fill to capacity during the 85th percentile storm event. In contrast, a treatment facility of the same size, located further downstream, or regionally, would have a larger tributary area, receiving greater amounts of total runoff possibly for longer durations and would fill to capacity more frequently.

While on-site or localized treatment might be more straight-forward to implement due to siting and land availability, regional treatment can provide additional water quality benefits related to increased long-term volume capture and treatment. For purposes of this memorandum, the public benefit is defined as the incremental increase (additional benefits) in volume of water treated that results from the use of public lands and a regional treatment approach for the Project. Volume of water treated is used as the metric for comparison because the primary treatment mechanism proposed in the Project, extended detention, is limited in performance by storage volume. Additionally, treatment volumes can be quantified cumulatively over a long period of time and more easily compared to watershed totals to estimate the portion of the total watershed treated.

Additional benefits are quantified based on a comparison of average annual wet- and dry-weather volume treated by the proposed treatment facility under two different siting scenarios. The siting scenarios include:

Scenario A: the proposed treatment facility regionally located on property owned by USACE, Chino Holding Company, LLC, and Steuve brothers (as proposed in the Project), and

Scenario B: the proposed treatment facility located immediately downstream of a tributary area draining a hypothetical catchment that would require a Best Management Practice (BMP) of the same volume capacity as proposed for the Project (based on the San Bernardino County Model Water Quality Management Plan BMP sizing requirements [SBCMWQMP]).

Proposed Treatment Facility

The proposed treatment facility is comprised of constructed wetland and extended detention treatment components. The constructed wetland is effectively set in the bottom of the extended detention basin, extending to 4 feet of depth below the extended detention basin invert. The slopes of the extended detention basin walls are set back from but surround the constructed wetland treatment component. The combined system has a shared outlet structure which is designed to maintain a 6 day residence time in the constructed wetland and a 48 hour graduated drawdown of the extended detention basin.

The treatment facility is proposed to treat both dry- and wet-weather runoff. Dry-weather flow treatment would occur in the constructed wetland which would be designed either a) to treat a specific portion of dry-weather flow based on capacity (Scenario A), or b) to treat typical anticipated dry-weather flows (Scenario B). Wet-weather flow treatment would occur in the extended detention basin, which is designed to have a 150 acre-foot storage capacity.

Analysis Scenarios

Average annual dry- and wet- weather flow were estimated for Scenarios A and B. Average annual dry-weather treatment volumes were estimated both through hydrologic and hydraulic modeling using EPA's Stormwater Management Model (SWMM) and through the application of typical runoff volumes per acre of development due to differences in the availability of dry-weather flow data for each scenario. Average annual wet-weather treatment volumes were estimated through hydrologic and hydraulic modeling using SWMM. The methods used in estimating treatment volumes for Scenarios A and B differ primarily in how runoff is generated for the contributing watershed and in how dry-weather treatment volumes are estimated. Both scenarios are described below in more detail to outline methods and assumptions specific to each.

Scenario A: Regional Treatment

This scenario simulates the proposed treatment facility as a regional treatment system located on the USACE/Chino Holding Company, LLC/Steuve brothers property site adjacent to Cucamonga Creek at its terminus and transition to Mill Creek (see Figure 1). The regional nature of the treatment facility at this location requires that flows be diverted from Cucamonga Creek into the treatment system. The treatment system is therefore capturing a portion of runoff from the entire Cucamonga Creek watershed tributary to the diversion point (76.7 mi^2).

Model Set-up

Because of the availability of high frequency flow data for Cucamonga Creek in the vicinity of the diversion, the operation of the proposed treatment facility for this scenario could be simulated in SWMM for both wet- and dry-weather flow conditions. Ten years (1996-2006) of measured flows from USGS stream gauge #11073495 were used as input to Cucamonga Creek at the gauge location and were routed through the creek and treatment facility system to downstream of the proposed regional treatment system outlet. The treatment facility diversions and pond system were modeled based on the proposed design discussed in the Conceptual Hydrologic and Hydraulic Project Design and Function, Mill Creek Recreation and Restoration Demonstration Project (Geosyntec Consultants, 2008).

Based on the proposed design, dry-weather flows would be diverted at approximately 5 cfs, determined as the capacity of the dry-weather treatment system (constructed wetlands) assuming a 6-day residence time, and allowing for adequate downstream environmental flows. Wet-weather flows would be diverted separately at rates dependent on the flow and water levels in Cucamonga Creek. The maximum wet-weather flow diverted for treatment is between 249 and 269 cfs, although larger flows can be diverted under extreme circumstances (maximum diverted flow is equal to 384-404 cfs). Diverted flowrates exceeding rates of discharge from the system cause the basins to fill. Once full, continued diversion of flowrates greater than rates of discharge from the system would bypass.

Treatment Volume Estimation

Because measured flows were input to the model, dry- and wet-weather operational conditions were not modeled separately for this scenario. Flows in Cucamonga Creek at the proposed regional site are perennial, supplied during dry weather periods by discharges from two wastewater treatment plants operated by the Inland Empire Utilities Agency (IEUA). Dry-weather baseflows rise and fall with fluctuations in IEUA discharges and also vary by season and are therefore difficult to separate out from wet-weather flows.

For the purposes of this study, a threshold dry-weather flow of 40 cfs (the typical dry weather flow rate over the period of record for the hydrologic data) was assumed. This was an approximation of the typical dry-weather flow considering seasonal and annual variations for the modeled duration. Diversion structure representation was then adjusted commensurate to this threshold such that larger diversions to the Project do not occur until the threshold is exceeded. Given this threshold flow, annual dry-weather treatment volumes were estimated as the cumulative volume of flows less than 40 cfs in Cucamonga Creek diverted and treated by the treatment facility over the course of one year. Annual wet-weather treatment volumes were estimated as the cumulative volume of flows greater than 40 cfs diverted and treated by the treatment facility over the course of one year. Annual average dry- and wet-weather treatment volumes were then calculated from the 10 years of dry- and wet-weather treatment volumes for comparison to Scenario B (as reflected in the results tables).

Scenario B: On-Site Treatment

This scenario simulates the performance of the proposed treatment facility located immediately downstream of a hypothetical watershed requiring a stormwater treatment system of the same storage capacity as the wet-weather treatment system proposed in the Project (based on sizing criteria in the SBCMWQMP). Because of the local nature of this scenario, the treatment system was modeled in-line with all runoff generated by the hypothetical catchment. The treatment system therefore captures all runoff from the hypothetical catchment up to storage capacity, under which conditions flows bypass.

Model Set-up

Due to the hypothetical nature of this model scenario, historical hydrographs synthetically generated from precipitation records and watershed characteristics were used as input to the treatment system. Because precipitation records only provide input for wet-weather flow generation, dry-weather operational conditions for this scenario were not modeled using SWMM. Therefore, the treatment facility modeled in SWMM represented only the extended detention basin treatment component to maintain consistency in wet-weather storage capacity between Scenario A and B.

The intent in modeling the hypothetical catchment is to simulate the capture performance of the proposed treatment system sited locally, or immediately downstream of a catchment containing the watershed characteristics that would require a treatment BMP of the same size. Because the proposed treatment facility consists of an extended detention basin for water quality treatment, the volume-based BMP sizing method described in the SBCMWQMP was used to back calculate watershed characteristics for the hypothetical catchment in the model. The volume-based BMP sizing method described in the SBCMWQMP is based on site-specific drainage area, precipitation, imperviousness and drawdown time. An area averaged 2-year 1-hour precipitation depth of 0.51 inches (based on the NOAA Atlas 14 precipitation depth) was assumed for Lower Mill Creek Watershed. Imperviousness was assumed to be 60%, which was derived using land-use based assumptions for a typical mixture of land uses for the Lower Mill Creek Watershed. A graduated drawdown time of 48 hours was assumed to optimize treatment and minimize potential vector issues per drawdown design for the Project and recommendations made in the SBCMWQMP. Based on these assumptions and a known volume-based BMP size, the watershed drainage area was calculated to be 3,000 acres.

Precipitation data for the period 1996 to 2006 from the Prado Dam gauge (1948-2009; NCDC gauge # 047123) was used as input to the model. Soil infiltration parameters were selected based on the San Bernardino County Hydrology Manual soil maps, which show the area to be mainly B soils, with some A and C soils (Natural Resources Conservation Service [NRCS]). The saturated hydraulic conductivity thus assumed to be 0.225, which is average for B soils (Musgrave, 1955).

Tables 1 and 2 include values of key parameters used in the model.

Table 1: SWMM Runoff Module Parameters

SWMM Runoff Parameters	Units	Values
Wet time step	seconds	900
Wet/dry time step	seconds	900
Dry time step	seconds	14,400
Impervious Manning's n		0.012
Pervious Manning's n		0.25
Shape		Rectangular, 200 ft flow path length (represents typical overland flow path lengths in urban/suburban development, not a very sensitive parameter)
Slopes	ft/ft	0.03 (represents average of relatively flat landscaping, streets, and roofs)
Evaporation	in/ month	75% of reference ET values contained in Table 2 (CIMIS Zone 9)
Hydraulic Conductivity	in/hr	0.225 (average B soils)
Suction Head	inches	8, based on Table 5-11 in SWMM manual for Sandy Loam (James and James, 2000)
Initial Moisture Deficit	fraction	0.33, based on Table 5-10 in SWMM manual for Sandy Loam (James and James, 2000)
Depression storage, impervious	inches	0.02, based on Table 5-14 in SWMM manual (James and James, 2000)
Depression storage, pervious	inches	0.1, based on Table 5-14 in SWMM manual (James and James, 2000)

Table 2: Evaporation Parameters for Hydrology Model (from CA ETo map)

Month	Evapotranspiration Rates (Zone 9)			75%
	in / day	days / month	in / Month	in / Month
January	0.07	31	2.17	1.63
February	0.1	28	2.8	2.10
March	0.13	31	4.03	3.02
April	0.17	30	5.1	3.83
May	0.19	31	5.89	4.42
June	0.22	30	6.6	4.95
July	0.24	31	7.44	5.58

Month	Evapotranspiration Rates (Zone 9)			75%
August	0.22	31	6.82	5.12
September	0.19	30	5.7	4.28
October	0.13	31	4.03	3.02
November	0.09	30	2.7	2.03
December	0.06	31	1.86	1.40
	Total	365	55.14	41.36

Treatment Volume Estimation

Because precipitation was used as input to the SWMM model, only wet-weather operational conditions were modeled and the separation of dry- and wet-weather treatment volumes based on a threshold flow was not necessary for this scenario. Modeled wet-weather treatment volumes were summed for each year of the ten years simulated. The ten years of annual wet –weather treatment volumes were then averaged to get average annual wet-weather treatment volume for comparison with Scenario A.

Dry-weather flows were approximated based on previous regional estimates of dry-weather runoff per acre made by Irvine Ranch Water District (IRWD). The Irvine Residential Runoff Reduction (R3) study performed by IRWD provides estimated flows of approximately 200 gallons per day per acre or approximately 0.0003 cfs/acre. While dry weather runoff is expected to vary with time of day, day of week, and time of year, this value provides an order of magnitude estimate of dry-weather flows that could be expected from the hypothetical catchment. On this basis, the total dry-weather runoff is estimated to be approximately 700 acre-feet per year. For this scenario, it is assumed that all dry-weather runoff would be treated by the proposed treatment facility.

WATER QUALITY BENEFIT SUMMARY AND DISCUSSION

Results

The average annual wet-weather flow volume and dry-weather flow volume treated by the proposed treatment facility for Scenarios A and B were estimated from annual volumes treated over the modeled period. The treatment facility performance results are summarized in Table 3 and 4 below.

Table 3: Wet-Weather Treatment Performance Comparison

Scenario	Wet-Weather Volume Tributary to Project (ac-ft/yr)	Wet Weather Volume Treated (ac-ft/yr)	Percent of Total Watershed Wet-Weather Volume Treated Annually
A	22,600	4,200	19 %
B	1,977	1,520	7 %

Table 4: Dry-Weather Treatment Performance Comparison[1]

Scenario	Dry-Weather Volume Tributary to Project (ac-ft/yr)	Dry-Weather Volume Treated (ac-ft/yr)	Percent of Total Watershed Dry-Weather Volume Treated Annually
A	26,800	2,700	10 %
B	700	700	3 %

Discussion

Based on the analyses presented above, the implementation of the proposed treatment facility at the proposed regional location (on USACE, Chino Holding Company, LLC and Steuve brothers properties) treats on an average annual basis approximately 4,200 acre-feet of wet-weather runoff (about 19% of total watershed wet-weather runoff volume), whereas if the same treatment facility were to be implemented locally, it would treat on an average annual basis approximately 1,520 acre-feet of wet-weather runoff (about 7% of total watershed wet-weather runoff volume). This represents an **increased efficiency of about 270%** for wet-weather runoff treatment and the treatment of an **additional 2,625 acre-feet** of potentially polluted stormwater runoff each year.

Similarly, implementation of the proposed treatment facility on a regional scale would result in the treatment of approximately 2,700 acre-feet of dry-weather runoff on an average annual basis (approximately 10% of total watershed dry-weather runoff volume) whereas implementation on a local scale would result in the treatment of approximately 700 acre-feet of runoff (3% of total watershed dry-weather runoff volume). This represents an **increased efficiency for dry-weather**

[1] Estimates of dry-weather volume treated for Scenario A is represented as a minimum determined by the capacity of the constructed wetland system as currently designed. Simple design modifications could increase average annual dry-weather flow treated by the system (up to 15 cfs) without consequence to in-stream habitat downstream of the diversion.

runoff treatment of 333% which is equal to the treatment of an **additional 2,000 acre-feet** of potentially polluted dry-weather runoff each year.

REFERENCES

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