CDM

Memorandum

To: *Middle Santa Ana River Bacteria TMDL Task Force*

From: *CDM*

Date: *September 30, 2010*

Subject: *Final Technical Memorandum - Dry Weather Runoff Controllability Assessment for Lower Deer Creek Subwatershed (Chris Basin)*

Introduction

Lower Deer Creek drains an approximately 10 mi^2 subwatershed entirely within the City of Ontario MS4 system (Figure 1). San Bernardino County Flood Control District (SBCFCD) owns and operates Chris Basin at the downstream end of Lower Deer Creek prior to the confluence with Cucamonga Creek (Figure 2). Dry weather runoff of approximately 1 cfs (based on data collected under the Urban Source Evaluation Plan (USEP) Monitoring Program) is not retained within Chris Basin due to poor infiltration rates in the underlying soils and facility characteristics that facilitate water movement through the Basin during dry weather conditions. USEP Monitoring Program samples collected at this outfall in 2007-2008 identified frequent exceedance of water quality objectives for bacterial indicator concentrations, and the presence of human and dog sources of bacteria (Table 1). Based on these findings, the Middle Santa Ana River (MSAR) Pathogen TMDL Task Force (Task Force) gave a high priority to source evaluation activities within the Lower Deer Creek subwatershed. This controllability assessment was prepared as the first source evaluation task for this subwatershed.

This assessment evaluates two options for control of dry weather runoff from Chris Basin:

- Construction of a horizontal subsurface flow (HSSF) wetland within Chris Basin
- Conceptual project to divert urban runoff from Lower Deer Creek to an existing recharge facility

This technical memorandum also includes recommendations for additional monitoring to assess specific sources of bacteria to determine if there are any alternatives to downstream runoff capture and treatment.

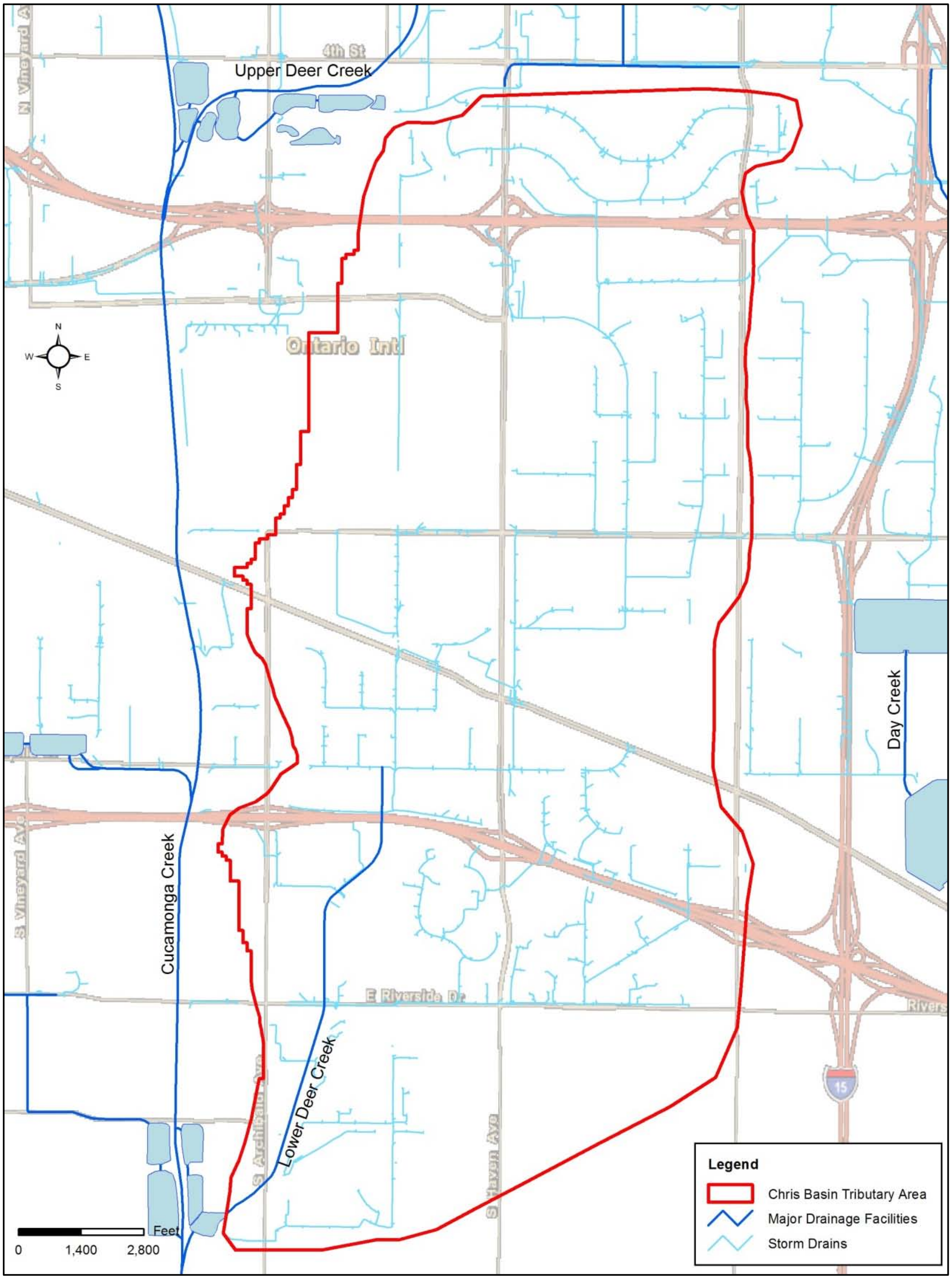

Figure 1
Lower Deer Creek Subwatershed

Figure 2
Aerial Photo of Lower Deer Creek Channel, Chris Basin, and Cucamonga Creek Flood Control Facilities

Table 1
Fecal Indicator Bacteria Concentration and *Bacteroides* Detections at the Chris Basin USEP Monitoring Site (Lower Deer Creek subwatershed)

Sample Date	*E. coli* (cfu/100 mL)	Fecal coliform (cfu/100 mL)	*Bacteroides* Source Detections
7/12/07	190	350	Human, Dog, Bovine
7/19/07	4,600	26,000	Dog
7/24/07	2,400	4,800	Dog
7/31/07	2,000	11,000	Dog
8/7/07	4,000	4,800	Dog
8/28/07	400	850	None
9/4/07	140	1,000	Bovine
9/11/07	410	2,200	Dog
9/18/07	300	760	Dog
9/25/07	2,100	5,700	Dog
12/9/07	4,600	4,800	Dog
12/10/07	900	940	Dog
12/11/07	480	410	None
1/15/08	2,900	2,400	Human, Dog
1/22/08	4,500	6,700	Human, Dog
2/12/08	540	710	Dog
2/19/08	2,200	780	Dog

Dry Weather Runoff Control Options

Constructed wetland

Aside from infiltration, which is not generally feasible at this location due to low permeability of underlying soils, HSSF wetlands are the only natural treatment system shown to be effective at reducing bacterial indicator concentrations to levels needed for protection of downstream water contact recreational use. From a large database of 130 HSSF wetland applications with varying operating conditions, the median global removal of fecal coliform was 1.82 $\log_{10}$ (Kadlec and Wallace 2009[1]). In the case of Lower Deer Creek, a removal of 1.82 $\log_{10}$ would reduce bacteria concentration from current levels of ~2,000 mpn/100 mL to 30 mpn/100 mL (a 2-log removal would reduce concentrations by two orders of magnitude to 20 mpn/100 mL). Therefore, a HSSF wetland system will likely provide bacteria reduction needed to meet water quality objectives. A site-specific evaluation was conducted to assess the technical feasibility and cost of constructing a HSSF wetland system within Chris Basin to treat dry weather runoff from the Lower Deer Creek subwatershed.

[1] Kadlec, Robert H. and Scott Wallace. *Treatment Wetlands; 2nd Edition*, CRC Press, 2009.

HSSF wetlands consist of gravel or soil beds planted with wetland vegetation. The water, kept below the surface of the bed, flows horizontally from the inlet to the outlet (Figure 3). HSSF wetlands are typically comprised of inlet piping, a clay or synthetic liner, filter media, emergent vegetation, berms, and outlet piping with water level control. A key operational consideration is the propensity for clogging of the media. A slope to the water surface (not the bottom bed slope) is required for flow to occur across the HSSF wetland cell. Figure 3 shows an inverted siphon at the outlet, which facilitates a sloping energy grade line while keeping the wetland cell saturated.

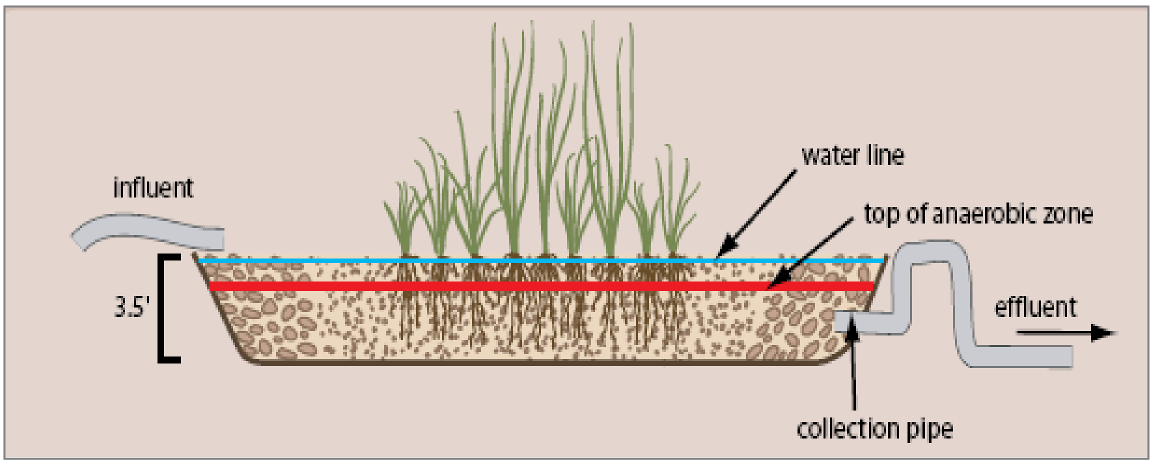

Figure 3
Schematic of a Horizontal Subsurface Flow Wetland (from Lyon, Stephen. Subsurface-Flow Wetlands for Water Treatment, Southwest Hydrology, v5(1), 2006

Generally, fecal coliform removal in HSSF wetlands is enhanced with longer hydraulic residence time (HRT) or lower hydraulic loading, finer bed materials (sand, but only to the extent that the fine bed material does not impair hydraulic performance), warmer water temperatures, and shallower bed depths. The presence of plants in HSSF wetlands has a beneficial effect on pathogen reduction. Evaluation of the effect of the depth of the gravel bed (30 vs. 60 cm) indicates that the deeper gravel beds performed much more poorly. Bed clogging that occurs in HSSF wetlands as a result of TSS accumulation has often led to hydraulic failure.

A diversion structure is needed that can ensure only dry weather runoff is routed directly into the HSSF wetland. Wet weather runoff is a significant concern because of its high sediment concentration and scouring potential. The diversion structure would include a low berm or weir to retain and divert dry weather runoff from the channel to a single manhole equipped with a trash screen (use of a vortex solids separation device is an alternative to a simple trash screen). A series of water level sensors powered by an on-site DC solar panel would operate a gate to prevent inflow to the HSSF (Figure 4). Wet weather flows would bypass the manhole and enter Chris Basin through the existing outfall. The design of the diversion must ensure that backwater conditions do not create flooding problems upstream in Lower Deer Creek.

Inundation of the entire Chris Basin bottom during storm events will result in some settling of sediments onto the top of the HSSF wetland. Geotextile fabrics overlying the gravel substrate will minimize the potential for this sediment to migrate downward into the gravel bed and impact the hydraulics within the HSSF wetland.

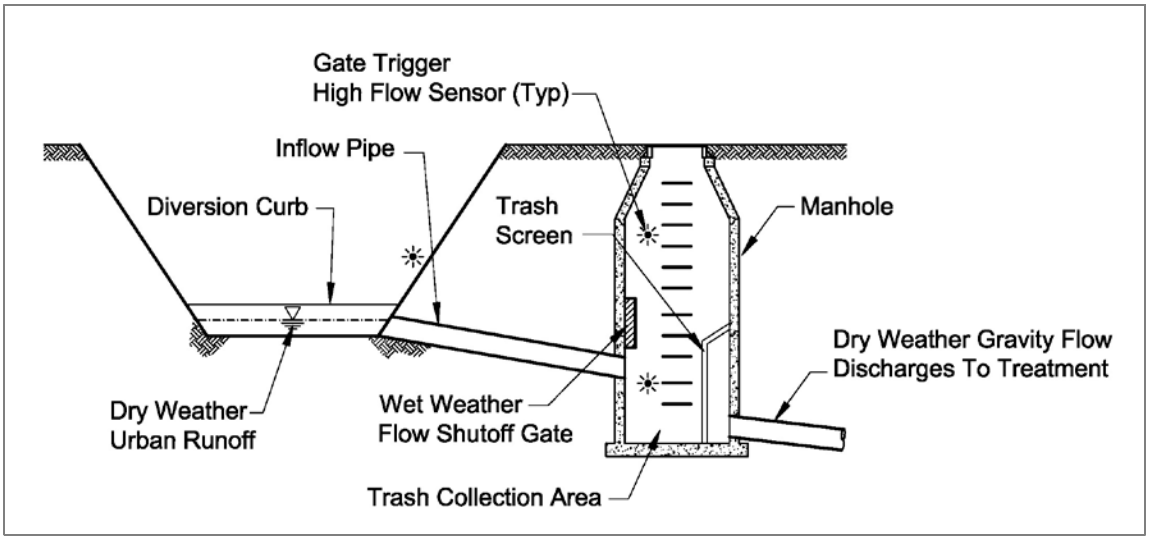

Figure 4
Schematic of Potential Dry Weather Runoff Diversion from Lower Deer Creek to HSSF wetland in Chris Basin (not to scale)

HSSF wetlands are commonly sized with a performance-based approach using the first-order k-C* model (Kadlec and Knight, 2009[2]). This model estimates the acreage of wetland necessary to reduce the wetland influent concentration of fecal coliform ($C_{influent}$) to a target effluent concentration ($C_{effluent}$) for a given flowrate (Q_{cfs}):

$$A_{wetland} = \frac{179Q_{cfs}}{k} \times \ln\frac{(C_{influent})}{(C_{effluent})}$$

The data from a number of HSSF wetlands has been analyzed to calculate first-order areal removal rate constants for use in the k-C* model. For fecal coliform, the median k value is 103 yr^{-1}, corresponding to a 1.82 $\log_{10}$ reduction. This model, applied to dry weather runoff in Lower Deer Creek, approximates the space needed within Chris Basin for a potential HSSF. The geometric mean of fecal coliform in Chris Basin outflow during dry weather conditions is 1,900 cfu/100 mL, based on 18 dry weather samples collected in 2007-2008 (see Table 1). Flow measurements taken at the time of sampling averaged 0.78 cfs. Thus, for a target effluent concentration of 200 cfu/100 mL, the model estimates that the project footprint should be at least 3.1 acres.

[2] Kadlec, R. H. and R. L. Knight. *Treatment Wetlands*, Lewis Publishers, 1996.

Chris Basin is approximately five acres in size. Therefore, a HSSF wetland would need to span across more than half of the entire basin bottom. While technically feasible, the operation and maintenance (O&M) requirements for an HSSF wetland of this size will need to address potential challenges. For example, managing sediment and vegetation over this large of a project footprint will require the facility to be separated into numerous cells, each requiring a controlled supply of water. Routine monitoring of water distribution between the different cells would require more frequent site visits than for a smaller facility. SBCFCD staff would need to manage both solids and vegetation when maintaining HSSF wetland cells.

Diversion to Recharge Location

One concept for addressing the water quality issues in Chris Basin is to divert dry weather runoff from Chris Basin to a location where it could be recharged into the Chino groundwater basin. This would generally eliminate dry weather bacterial loading to Cucamonga Creek from Chris Basin as the runoff would be infiltrated. However, several issues would need to be addressed, including concerns about the water quality impacts on the groundwater basin at the recharge site. In addition, in order for this concept to be cost-effective, it would have to tie into some existing recharge project, but there are no nearby recharge facilities due to the poor infiltration rates in the area.

The Chino Basin Watermaster has considered, as part of its 2010 Recharge Master Plan Update (CBRMP – 2010 Update[3]), the concept of conveying stormwater from areas with limited recharge potential to basins where underlying soils are more favorable to support groundwater recharge. The purpose of the CBRMP is to maximize the capture of stormwater for recharging groundwater to reduce reliance on imported sources of water and improve groundwater quality. An interim report was recently completed for the CBRMP -2010 Update which looked at various options. One of several concepts recommended for further consideration is to construct a large in-line detention facility on lower Cucamonga Channel to capture wet weather flow and pump to a recharge facility in the upper part of the basin. This is a very preliminary concept and it has not been fully evaluated for cost, technical feasibility, environmental concerns and other issues (including which recharge facility would receive the captured water). However, if there were such a detention facility on lower Cucamonga Channel, it would be technically feasible to divert water from Chris Basin into it. The tie in would involve construction of a diversion structure (see Figure 4) and approximately 2,000 feet of gravity pipeline. The diversion structure for this option would be the same as for a HSSF wetland (see Figure 4), except a wet weather trigger and shut off gate is not necessary. The channel bottom elevation of Lower Deer Creek between Archibald Avenue and the inflow to Chris Basin ranges from 725 to 735 feet and the hypothetical bottom elevation of a Cucamonga detention facility is 710 feet. Agricultural fields and a Southern California Edison right of way are between a potential diversion and the proposed detention facility, thus several alignment options should be feasible.

---

[3] see http://rmp.wildermuthenvironmental.com/final-rmpu.html)

Potential Costs

Cost estimates for these options use published literature values or are extrapolated from similar projects and are therefore considered as planning level, intended to compare options and provide order of magnitude estimates.

Constructed wetland

The costs for treatment wetlands consist of both capital and operating costs. Cost components of a HSSF wetland include material, construction labor, engineering, and other administrative costs (Table 2). These costs are average values based on median unit costs provided by Kadlec and Wallace (2009) for 12 HSSF wetland applications in Minnesota and therefore do not reflect local economics. Operating costs for HSSF wetlands are typically low and primarily involve vegetation management, e.g., at IEUA's Chino Creek Wetlands Education Park (personal communication, Eric Lesser, IEUA). Scaling up from this facility, the estimated cost for a potential 3.1-acre HSSF wetland would be approximately $26,000 per year.

Table 2
Planning Level Cost Estimate for Horizontal Sub-surface Flow Wetland at Chris Basin

Equipment/Services	Estimated Cost
Materials and Construction [1]	$770,000
Contingency [2]	$230,000
Engineering & Administration [3]	$250,000
Total Capital Cost	***$1,250,000***
Operation & Maintenance	
Annual O&M ($/yr) [4]	***$26,000***

1) Includes diversion structure, gravel media, plants, liners, earthwork, and construction labor
2) Contingency is 30 percent of construction costs
3) Includes permitting, engineering, mobilization, and construction management; assumed 25 percent of constructed cost
4) Based on estimated cost for maintenance of subsurface flow wetlands at IEUA's Chino Creek Wetlands Education Park (personal communication Eric Lesser)

Diversion to Recharge Location

New facilities required to divert runoff from Lower Deer Creek to a conceptual detention facility within Cucamonga Creek include a diversion structure and approximately 2,000 feet of small diameter (8 inches) gravity pipeline. Costs of these options are summarized in Table 3. These costs do not include the cost of constructing a detention and pumping facility on Cucamonga Creek.

Table 3
Planning Level Cost Estimate for Diversion to Conceptual Project in the CBRMP 2010 Update

Equipment/Services	Estimated Cost
Materials and Construction [1]	$310,000
Contingency [2]	$90,000
Engineering & Administration [3]	$100,000
Total Capital Cost	***$500,000***
Operation & Maintenance	
Annual O&M ($/yr) [4]	***$6,400***

1) Includes diversion structure and ~2,000' of 8" diameter pipeline at $15 per diameter inch per linear foot; does not include costs associated with the project concept under evaluation in the CBRMP
2) Contingency is 30 percent of construction costs
3) Includes permitting, engineering, mobilization, and construction management; assumed 25 percent of constructed cost
4) Assumes four maintenance visits for solar panel battery replacement and cleaning of manhole per year at $1600 each

Recommendations

The following recommendations were developed to be consistent with the BMP Control Strategy and Prioritization Plan (CSPP) prepared for the Task Force[4]. The CSPP provides specific recommendations for reducing bacterial indicator concentrations in each of the major subwatersheds of the MSAR watershed so that the TMDL targets are met at the watershed-wide compliance sites during dry weather. This CSPP is evolving into a Comprehensive Bacteria Reduction Plan for dry weather runoff, a requirement in the recently adopted MS4 permits for San Bernardino and Riverside Counties.

One alternative to implementation of one of the structural BMP options presented in this assessment would be to conduct additional monitoring to further evaluate human sources of bacteria in the study area. Specifically, in the near-term additional monitoring could attempt to identify the source(s) of bacteria in the Lower Deer Creek subwatershed that may be responsible for high bacteria concentrations and presence of human-sourced bacteria. Source evaluations recommended for implementation include:

- Assess degree to which Lower Deer Creek contributes bacteria to Cucamonga Creek. It is currently assumed to be an important contributor, but this should be verified through monitoring of Cucamonga Creek above and below Lower Deer Creek confluence. At the same time, it is currently presumed that bacteria concentrations above Chris Basin are as high as observed at the Basin outlet. Additional monitoring should be conducted above Chris Basin to verify this assumption.

---

[4] SAWPA. 2010. *BMP Control Strategy and Prioritization Plan*. Prepared by CDM on behalf of SAWPA and the Middle Santa Ana River Watershed TMDL Task Force. February 2010.

- Verify human sources continue to be present (as was identified in 2007 - 2008). These samples were collected at the Chris Basin outfall to Cucamonga Creek. This location should be evaluated for human sources to verify that they are still present. In addition, human source analyses should be conducted on samples collected from flows entering Chris Basin. If human sources are still consistently present, implement a source control study extending upstream from Chris Basin, to identify potential source(s).

In addition to these source evaluation activities, the CSPP recommends that a Use Attainability Analysis (UAA) be prepared for the open channel portion of Lower Deer Creek upstream from Chris Basin to Highway 60. Completion of this UAA may eliminate the need for outfall specific controls upstream of the basin and allow for implementation of a regional treatment solution in the area of Chris Basin such as one of the two options presented above.

If control of runoff from Lower Deer Creek subwatershed prior to outflow to Cucamonga Creek is determined to be the best course of action toward TMDL compliance, then this controllability assessment provides a comparison of two alternatives at this location. This information can provide the foundation for any future discussions among stakeholders if implementation becomes necessary.