Stormwater drainage channel looking north from Van Winkle Drive near Manitou Drive Intersection

Creek Maintenance Summary Report
Sleepy Hollow Creek Homeowners Association
San Anselmo, California
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Prepared for:

SLEEPY HOLLOW HOMEOWNERS ASSOCIATION

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Creek Maintenance Neighborhood Meetings

The December 2012 storms caused creek and drainage ditch overflows at many locations in the Upper Sleepy Hollow Creek watershed (including Van Winkle Creek watershed). The storms also delivered an uncommonly large load of coarse gravel-sized sediment from steep creeks draining the surrounding uplands. More coarse sediment was delivered to the mainstem and tributary creeks than could be transported through the system during the storm. Resulting sedimentation caused the creek bed level to rise 0.5-1.5 vertical feet in deposition-prone creek sections.

County Supervisor Katie Rice convened six (6) field meetings during April and May 2013 attended by Matt Smeltzer, geomorphologist/hydrologist, and affected neighbor groups to assess new and ongoing stormwater drainage problems revealed by the December 2012 storms:

- Dutch Valley Lane residents along Van Winkle Creek downstream from Triple C Ranch uplands and upstream from Mather Road crossing;
- Van Winkle Drive residents along Sleepy Hollow Creek upstream from Van Winkle Drive crossing;
- Tappan Road residents along Van Winkle Creek upstream from Tappan Road crossing;
- Tappan Road and Ichabod Court residents along unnamed Van Winkle Creek tributary creek (i.e., "Tappan Creek") downstream from Tappan Road cul-de-sac crossing;
- Legend Road and Butterfield Road residents along unnamed Sleepy Hollow Creek tributary stormwater drainage channel (i.e., "Legend Ditch") downstream from Legend Road catch basin; and,
- Luzanne Circle and Martling Road residents along unnamed Sleepy Hollow Creek tributary creek (i.e., "Luzanne Creek") downstream from MCOSD uplands and upstream from Butterfield Road.

During the meetings, Mr. Smeltzer reviewed and discussed landowner accounts and descriptions of recent and past historical stormwater flows, and collected basic site measurements where applicable: culvert type and dimensions; depth of culvert sedimentation; culvert inlet and outlet conditions; creek, ditch, and culvert slopes; high water marks; maximum available culvert inlet head depth; culvert overflow flow paths; etc. Mr. Smeltzer then made basic hydrology and hydraulic calculations in the office to assess identified problems and develop recommendations for creek maintenance at the sites: drainage area and estimated peak flows; culvert flow capacities under sedimented and clear conditions; etc. Mr. Smeltzer made follow-up site measurements and developed one-dimensional hydraulic models to assess certain complicated sites where one or more constrictions (i.e., narrow channel conditions caused by encroached creek bank retaining walls) or grade control structures (i.e., grout, retaining wall foundations, or rip-rap bed linings placed on the creek bed) work in combination to limit channel or culvert flow capacity and/or induce chronic creek bed and/or culvert sedimentation.

Mr. Smeltzer then met with County Roads Department Staff at sites where sediment removal near culvert inlets and/or outlets appears would generate a substantial flow capacity improvement and potentially prevent property damages during future storms. Roads Staff reviewed with Mr. Smeltzer past County sediment removal maintenance activities at these and other locations in the Upper Sleepy Hollow Creek watershed. Based on assessments from the neighborhood meetings and feedback from Roads Staff, Mr. Smeltzer prepared a list of sediment removal maintenance activities recommended for near future implementation by Roads.

This report contains: (1) a general description of the watershed and creek geomorphology; (2) summary of peak flow estimates at sites and other key watershed locations; and (3) summary of general findings and recommendations for Homeowners Association (HOA) to share with its members.

Maintenance projects on private property discussed during the neighborhood meetings may be pursued by private parties individually or in cooperation with neighbors. Mr. Smeltzer is available to provide additional feasibility, design, permitting, and implementation advice to project proponents on an hourly time-and-materials basis.

Geomorphic Setting

Upper Sleepy Hollow Creek and primary tributary Van Winkle Creek rise on the eastern and southeastern flanks of Loma Alta underlain by landslide-prone heavily deformed Franciscan mélange bedrock. Upper Sleepy Hollow Creek passes down the shallowly dissected steep landslide body-dominated east flank and then through a narrow valley floor presently occupied by San Domenico School. There was historically a stock pond reservoir at the present location of the school campus. The valley floor widens abruptly about 2,000 ft upstream from the site where the upper Sleepy Hollow Creek valley floor merges with the Van Winkle Creek valley floor. Van Winkle Creek more deeply dissects the foot of the southeastern flank of Loma Alta and flows to the east through a relatively wide valley to join Sleepy Hollow Creek about 600 feet downstream from the Van Winkle Drive crossing. Sleepy Hollow Creek and Van Winkle Creek drain approximately 1.06 and 0.58 square miles, respectively, to their confluence.

The confluence is presently located tight to the valley floor junction – where the west side of the Sleepy Hollow Creek valley floor meets the south side of the Van Winkle Creek valley floor – indicating that the Sleepy Hollow Creek's greater coarse sediment loads have strongly dominated the downstream end of Van Winkle Creek. The Sleepy Hollow Creek valley slope does not change appreciably at the confluence (approximately 1.2-1.3 percent both upstream and downstream). The narrow floodplain between the creeks near the junction is sloped away from Sleepy Hollow Creek toward Van Winkle Creek, indicating that Sleepy Hollow Creek backwaters Van Winkle Creek during recent major floods, not vice-versa.

Valley floor geomorphology suggests that Van Winkle Creek may once have drained a larger watershed area than upper Sleepy Hollow Creek: Van Winkle Creek valley floor is significantly wider than Upper Sleepy Hollow Creek; valley floor topography suggests that relict Sleepy Hollow Creek channels may have occurred on the eastern side of its valley within the valley junction zone. It is a reasonably strong hypothesis that an ancestral Van Winkle Creek drained a great percentage of the southern and eastern flanks of Loma Alta and constructed its relatively wide floodplain -- those upland areas were later captured by upper Fairfax Creek and upper Sleepy Hollow Creek. The rate of upland dissection and resulting pattern of watershed evolution appears to be controlled by faulting and differential massiveness and erodibility of Cretaceous sandstone units exposed within the mélange.

Downstream from the Van Winkle Creek tributary confluence, mainstem Sleepy Hollow Creek cuts against colluvial hillslopes running along the western edge of its valley for half of one mile before adopting an irregular meandering planform through the middle of its valley floor. Sleepy Hollow Creek is tributary to San Anselmo Creek southeast of Drake High School. Like most major San Anselmo Creek tributaries, Sleepy Hollow Creek is relatively incised and generally conveys relatively large floods without flowing overbank. The lower section of Sleepy Hollow Creek within the Town of San Anselmo flooded broadly in 1982 and 2005. In the upper watershed, these floods flowed overbank in places; the 1982 flood produced water surface elevations generally about 0.5 ft higher than the2005 flood.

No bedrock outcrops were observed on the creek beds in the upper watershed, including near the Van Winkle Creek confluence where both creeks are cut in deep colluvium. However, numerous erosion protection structures installed on the creek bed over time at individual properties create grade control and induce upstream deposition of coarse sediment. The overall effect of numerous grade control structures has been to support an artificially high bed elevation through much of the mainstem creeks in the upper watershed. Any bedrock outcrops exposed on the bed by late 19^{th} century and early 20^{th} century channel incision may now be covered by sedimentation induced by these bed and bank stabilization structures. Grade control structures and resulting sedimentation reduce the flood flow capacity in some sections of Sleepy Hollow and Van Winkle Creeks.

The more gradually sloped creeks and stormwater drainage ditches on the valley floor are prone to massive coarse sediment deposition because the steep upland channels often deliver to them more coarse gravel-sized sediment than can be transported during the relatively short duration of the storm. Although the average annual precipitation is substantially lower than that of the larger Corte Madera Creek watershed, the Sleepy Hollow Creek uplands yield more bedload sediment (i.e., coarse sand to coarse gravel-sized sediment) than average for the larger Corte Madera Creek watershed (Stetson Engineers et al. 2000). Higher bedload yields were attributed to the underlying bedrock geology (hummocky terrain, Franciscan mélange appears heavily deformed, surficial geology dominated by higher percentage landslide bodies, faster downslope creep rates apparent, etc.) and lower density vegetation cover (oak woodland, shallow non-native grassland, etc.).

Table 1.
Regional Regression Equation Estimated Peak Flows
Upper Sleepy Hollow Creek Watershed

	Drainage Area (sq mi)	Mean Precip (in/yr)	Altitude Factor (ft/ft)	Peak Discharge Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)
SH Creek at Van Winkle Dr	1.05	36	1	90	138	182	232	280	312
SH Creek at Confluence	1.06	36	1	90	138	183	233	280	313
VW Creek at Triple C P/L	0.17	36	1	17	27	36	47	56	63
VW Creek at Manitou Road	0.18	36	1	18	28	38	49	59	66
Tributary at Manitou Road	0.22	36	1	22	34	46	59	72	80
				40	62	83	108	130	146
VW Creek at Tappan Rd	0.43	36	1	40	62	83	107	128	143
VW Creek Confluence	0.58	36	1	52	81	108	138	166	186
Unnamed Ck at Tappan cul-de-sac	0.047	36	1	5	9	12	16	19	21
Unnamed Creek at Luzanne Circle	0.046	36	1	5	8	12	15	18	20
Unnamed Creek at Martling Rd	0.054	36	1	6	10	13	18	21	24
Relict SH Ck ch at Legend	0.082	36	1	9	14	19	25	30	34
Plus hillside above 971/977	0.024	36	1	3	5	7	9	10	12
				12	19	26	34	41	46

Hydrologic Setting

There are no rainfall gages or stream flow gages in the Sleepy Hollow Creek watershed. Regional regression relations (Waananen and Crippen 1977) were used to estimate the return interval peak flows (Table 1). These estimates are for general evaluation of existing culvert and channel capacity. Culvert design at individual sites should be based on site-specific County of Marin Hydrology and Hydraulics manual calculated return interval peak flows. County method calculations may produce greater estimates than regression equations at some sites.

Landowner accounts throughout the Sleepy Hollow and Van Winkle Creek watershed consistently indicate that the December 2012 storms produced peak water surface elevations only several inches less than the December 31, 2005 flood. The 2005 flood is believed to have produced a peak flow of

1,050 cfs from the entire approximately 3.8 square mile Sleepy Hollow Creek watershed. For that flood, the comparably sized Fairfax Creek watershed is estimated to have produced a 1,645 cfs peak flow (Stetson Engineers et al. 2011).

According to landowner observations, the December 2012 flood water surface elevations may have more closely approached 2005 peaks in the upper Sleepy Hollow Creek watershed than elsewhere in the larger Corte Madera Creek watershed. This is partially corroborated by the massive coarse gravel load transported to the mainstem creeks from the Sleepy Hollow and Van Winkle Creek uplands during the storms.

The only long-term stream flow gage in the Corte Madera Creek watershed is in Ross. Gages were established in San Anselmo and Fairfax after the 2005 flood. Evaluation of December 2012 gage data for all three gages might roughly verify that the December 2012 storm flows were relatively greater in the Sleepy Hollow Creek watershed (e.g., such as by comparison to the pattern of January 24, 2008 storm flows at the gages).

Rough calibration of a Sleepy Hollow Creek HEC-RAS hydraulic model to December 2012 high water marks found near the Van Winkle Drive crossing suggests that the December 2012 floods peaked about midway between the regression relation-estimated 50-year and 100-year peak discharges for that vicinity (i.e., approximately 300 cubic feet per second, cfs, at that site).

General Findings and Recommendations

1. Culvert and channel sedimentation. Landowner accounts consistently indicate that the December 2012 storms caused 12-18 inches of coarse gravel sized sediment deposition in deposition prone sections of creeks, drainage ditches, and affected culverts. This amount of sedimentation may be exceeded only infrequently, but there is nothing to indicate that the December 2012 storms delivered unnaturally high amounts of coarse sediment from the steep upland areas (such as may be caused by poor land use management). Rather, the observed amount and pattern of sediment deposition reflects both:
    - (i) a natural cyclic pattern, beginning with massive channel sedimentation during individual storms, followed by multiple years or decades of incremental downstream transport until lower bed elevations are reestablished;
    - (ii) greater than natural sedimentation depth in certain channel locations caused by restrictive structures installed in the channel.

   That is, the steep uplands will always during certain storms deliver much more coarse gravel sediment than the more gradually-sloped mainstem creeks and ditches can transport. Net bed deposition is natural. The depth of sedimentation is expected to be artificially greater in deposition-prone sections of creeks and ditches influenced by restrictive structures:

    - Immediately upstream from undersized or poorly configured culverts with turbulent and/or deeply ponded inlet conditions;
    - Within tens or hundreds of feet upstream from grade control structures (e.g., concrete or rip-rap bed linings, loose rip-rap from failed structures, etc.) placed on the channel bed,

typically as part of culverts or bank stabilization and erosion protection structures, including inside culverts located within the affected reach; and

- Within excessively gradually-sloped (i.e., less than half of the natural down valley slope) drainage channels and ditches, including inside culverts located within the gradually-sloped channels; etc.

➢ *1. Recommendations:*

(a) One-time sediment removal is recommended after massive sedimentation events like the December 2012 storms at privately and County-maintained sites where restrictive structures cause artificially deep sedimentation and resulting critical flood flow capacity conditions are threatening property damage during the upcoming winter rainy season. Repeat sediment removal will be required so long as the restrictive structures remain in place.

(b) Outreach to Creekside landowners to: (i) Provide basic design standards, including minimum channel width and maximum bed elevations, for creek bank stabilization and erosion protection projects (see also Recommendation 3.a.); (ii) Notice existing County, State, and Federal environmental regulations and permit requirements applying to creeks and ditches; (iii) Prevent installation of additional new restrictive structures; (iv) Encourage removal and appropriate replacement of restrictive structures over time; etc.

(c) Seek agreements with upland landowners to install debris rack or in-channel basin type structures on upland properties immediately upstream from the residential zone in locations where physical conditions are appropriate for safe, maintainable, and effective partial coarse sediment load trapping during storm flows.

2. Blockage of Culvert Inlets by Floated (Woody) Debris. Landowner reports consistently indicate that both County- and privately maintained culvert inlets are prone to partial or near complete blockage by woody debris floated by storm flows. Blockage by woody debris can temporarily reduce channel and culvert flood flow capacity more significantly than coarse sediment deposition. There is nothing to indicate that the amounts of woody debris floated from the steep upland creeks surrounding the watershed are unnaturally high. However, culverts and restricted channels within the residential zone are not large enough to convey larger debris pieces and "rafts" of smaller debris. In addition, there are multiple sources of woody debris originating within the residential zone which can block culvert inlets: (i) landscaping and construction debris discarded by gardeners and contractors over backyard fences into the creekside zones; and (ii) timber planks and partially intact timber structures discharged into the creek by failing/failed retaining walls, footbridges, etc. Attempting to remove woody debris jams from culvert inlets during storm flows is very dangerous, particularly pieces and jams of heavy debris, such as discarded tree limbs and partially intact failed structures.

➢ *2. Recommendations:*

(a) Outreach to creekside landowners to encourage: (i) seasonal removal and replacement of "deer fencing" from within creeks and drainage channels; (ii)

removal of dense and overhanging vegetation from near culvert inlets to reduce excessive and cumulative trapping of floated woody debris near inlets; (iii) appropriate disposal of landscaping debris outside of creekside zones and stormwater drainage channels;

(b) Encourage creekside landowner groups to convene annual pre-rainy season "creek clean-ups" to remove: (i) improperly discarded landscaping and construction debris; (ii) pieces of failed or failing timber retaining walls and other structures; (iii) large failed or nearly failed tree limbs, if applicable; (iv) loose rip-rap pieces on the bed; (v) excessive sedimentation within culverts; etc. Landowner groups can use the meetings to identify general flood flow conveyance problems to be addressed by future projects undertaken by multiple or individual private property owners, such as removal and replacement of restrictive or failing creek bank stabilization and erosion protection projects.

(c) Seek agreements with upland landowners to install debris rack structures on upland properties immediately upstream from the residential zone in locations where physical conditions are appropriate for safe, maintainable, and effective partial trapping of floated woody debris from steep uplands during storm flows.

3. Creek Bank Stabilization and Erosion Protection Structures. As described above, there are numerous poorly configured (restrictive) creek bank stabilization and erosion protection structures which reduce flood flow capacity both by: (i) causing hydraulic backwater effects from constricted sections; and (ii) inducing chronic upstream sedimentation on the bed and within culverts over tens and hundreds of feet upstream from the constricted sections. Over time, on a watershed-wide basis, removal and replacement with non-restrictive structures will significantly increase flood flow capacity, reduce nuisance flooding, reduce property damage, and reduce public and private repeat maintenance and post-flood clean-up effort and costs. Non-restrictive structures are those that: (i) maintain a minimum "equilibrium" channel width; (ii) do not raise the channel bed elevation above the maximum "equilibrium" bed elevation at the site. The "equilibrium" or "natural baseline" bed elevations and widths can be defined from basic hydrologic and geomorphic principles and published in list format for individual creekside parcels throughout the watershed. For example, a single minimum width can be defined for individual tributary creeks, and for individual reaches of the mainstem creeks between successive road crossings. Single maximum bed elevations can be defined for individual parcels by constructing a "natural baseline" longitudinal bed profile, as may be simplified in places by connecting straight lines between the inlet and outlet inverts of successive public road crossing culverts and successive privately owned culverts in non flood-prone reaches, if applicable. The maximum bed elevation for individual parcels can be read from the profile by distance measurement from upstream and downstream public road crossings, such as by Google Earth distance measurement tool.

- *3. Recommendations:*

(a) Develop and provide to creekside landowners bank stabilization and erosion protection project design standards for new and replacement structures,

including minimum channel width and maximum bed elevations lists for individual creekside parcels (See also Recommendation 1.b.i.)

4. Privately Owned Culverts. The majority of culverts inspected during the neighborhood field meetings were sized to match the conveyance capacity of next downstream public road crossing culverts (i.e., typically 25-year flood flow capacity). According to landowner accounts, instances of property damage or near damaging overflows from privately owned culverts were partially or primarily caused by massive culvert barrel sedimentation and/or inlet blockage by floated woody debris during storms at culverts where the site grades promote overflow to bypass the channel on the downstream side of the culvert, thus instead running overflow overland onto neighboring property(ies). Private residential (commonly driveway crossing) culverts farthest upstream and closest to steep upland watershed areas are typically most prone to massive sedimentation and woody debris blockage. As discussed above, massive sedimentation events and excessive floated woody debris can be somewhat reduced by implementing recommendations in this report, but not entirely eliminated.

   In some instances, provisions can be made at chronically blocked and/or overflowing privately owned culverts for safely passing the overflow back to the channel on the downstream side of the culvert by: (i) adding or revising a headwall at the culvert inlet with concrete wall extensions or landscaped earthen berms to contain ponded water to a greater depth before it overflows onto the property and passes uncontrolled onto downstream property(ies); and (ii) revising the grade on landscape and hardscaped areas to channel overflow overland back to the channel on the downstream side of the culvert. In other instances, safely bypassing the overflow is not practically feasible, or the cost of doing so is comparable to culvert replacement. Any project involving elimination of chronic culvert overflow bypassing sections of the downstream channel should include an evaluation of the next downstream culverts to determine if they can also handle the entire creek or channel flow.

- *4. Recommendations:*
  - *(a) County require all new and replacement private residential culverts to: (i) convey the estimated 50-year peak flow without overflowing the top of headwall; (ii) provide for safely controlling the 100-year peak flow overflow to pass back into the channel on the downstream side of the culvert; and (iii) include an analysis to ensure reduction or elimination of bypassed overflow by the project will not cause culvert overflow at next downstream culverts.*
  - *(b) Encourage landowners to individually or jointly implement projects to replace chronically overflowing privately owned culverts to meet the requirements outlined by Recommendation 4a.*
  - *(c) Seek agreements with upland landowners to install debris rack or in-channel basin type structures on upland properties immediately upstream from the residential zone in locations where physical conditions are appropriate for safe, maintainable, and effective partial coarse sediment load and woody debris trapping during storm flows (See Recommendations 1.c and 2.c).*

5. County-Maintained Culverts. County-maintained road crossing culverts inspected during the neighborhood meetings were generally sized to convey up to or about the 25-year peak flow without overflowing onto the street. Municipal stormwater drainage systems are typically sized to convey at a minimum the 10-year peak flow before overflowing onto the street, with provisions for safely handling the temporary street overflow for larger peak flows.

   According to landowner accounts at study sites, street overflow occurred at three county-maintained culverts during the December 2012 storms:

   - Sleepy Hollow Creek at Van Winkle Drive culvert;
   - Van Winkle Creek at Tappan Road culvert; and,
   - "Tappan Creek" at Tappan Road cul-de-sac.

   Coarse gravel sedimentation induced by downstream conditions has substantially reduced the flow capacity of all three culverts. Grade control structures installed for creekbank erosion protection on private properties downstream from the Van Winkle Drive and Tappan Road culverts cause chronic sedimentation within the culvert barrels. Repeat maintenance sediment removal immediately downstream from the culverts would substantially, temporarily increase the culvert flow capacity. Hydraulic calculations indicate that under "clear" conditions, the Tappan Road culvert can convey up to the estimated 25-year peak flow before cresting above the crown of the culvert inlet (i.e., before beginning to backwater upstream from the right-of-way). Hydraulic model calculations indicate that under "clear" conditions, the Van Winkle Drive culvert can convey up to the estimated 10-year peak flow before cresting above the crown of the culvert inlet.

   Landowner accounts indicate that "Tappan Creek" overflows relatively frequently onto Tappan Road from the inlet of the County-maintained culvert at the Tappan Road cul-de-sac. Under ideal conditions, the 18 inch-diameter corrugated metal pipe (CMP) culvert can convey up to about 6 cubic feet per second (cfs) -- between the estimated 2-year and 5-year peak flow at that location – before cresting the crown of the culvert inlet. In recent years the County added an earthen berm around the perimeter of the concrete headwall to reduce the frequency of inlet overflow. Under ideal conditions the headwall-berm begins to overflow at around 12-15 cfs, between the estimated 10-year and 25-year peak flows. However, it is believed that the creek overflows onto Tappan Road much more frequently because the culvert conditions are not ideal:

   - The culvert-headwall abruptly turns the creek flow direction approximately 70 degrees causing turbulent inlet conditions;
   - Chronic coarse gravel sediment deposition in the gradually sloped ditch downstream raises the bed elevation within the culvert barrel 4-5 inches above the invert at the outlet;
   - The resulting sedimentation depth may be greater in the middle of the culvert length where the culvert appears to sag 4-5 vertical inches under the centerline of the cul-de-sac; and,
   - Creek bed sedimentation upstream from the turbulent inletappears may cause overflow onto the street upstream from the right-of-way at lower peak flows than the headwall-berm contain.

There are no stormwater facilities on Tappan Road downstream from the cul-de-sac culvert inlet. Overflows pass down to Van Winkle Creek as sheet flow and enter at least one residential driveway/garage. Landowner accounts indicate that repeated mechanical clearing and sweeping stormwater deposited debris damages the unsealed asphalt concrete road surface.

- *5. Recommendations:*
  - *(a) County remove sediment from the creek bed immediately downstream from Van Winkle Drive culvert, Tappan Road culvert, and Tappan cul-de-sac culvert;*
  - *(b) County put projects for replacement of Van Winkle Drive and Tappan cul-de-sac culverts on long-term capital improvement plans. Design Sleepy Hollow Creek replacement culverts to: (i) at a minimum, convey the estimated 50-year peak flow without overflowing the top of headwall; (ii) provide for safely controlling the 100-year or greater peak flow overflow to pass back into the channel on the downstream side of the culvert; and (iii) if applicable, have "natural bottoms" to provide for unrestricted bed elevation fluctuation and natural fish passage conditions within the crossing.*
  - *(c) Encourage private landowners to remove coarse sediment deposited in the drainage ditch downstream from the Tappan cul-de-sac culvert so as to maintain clear conditions at the culvert outlet.*
  - *(d) Seek agreements with upland landowners to install debris rack or in-channel basin type structures on upland properties immediately upstream from the residential zone in locations where physical conditions are appropriate for safe, maintainable, and effective partial coarse sediment load and woody debris trapping during storm flows (See Recommendations 1.c and 2.c).*

6. Environmental Permitting. Many of the potential projects and activities outlined in these recommendations require temporary disturbances and alterations to the bed and bank of streams and therefore are subject to environmental regulations and permitting requirements of federal and state agencies, as well as the local CEQA-responsible agency, the County of Marin. Project types requiring permits include but are not limited to: (i) one-time and repeat sediment removal from creek beds; (ii) new and replacement bank stabilization and erosion protection projects; (iii) new and replacement culverts; (iv) debris rack and sediment trap installation; and (v) repairs to existing in-creek structures. Projects occurring on human-made stormwater drainage channels may or may not require permitting depending on federal and state agency discretion. The professional planning and administrative cost of obtaining all of the necessary permits for an individual project (not including design) can range from $5,000 to $15,000 depending on project complexity. If environmental agencies cooperate, substantial cost savings could be gained by grouping all of the potential projects into one project or program description, for which a single "general" permit may be obtained.

   There is a sound rationale for general permitting the recommendations in this report. Considered both individually and in their entirety, the projects outlined in these recommendations would have a net beneficial environmental effect. Incremental implementation of the individual projects in virtually any sequence within a prescribed time period (permit duration) consistently trends toward overall increased natural integrity of the creek corridors. For example, restoring the "natural baseline" creek bed elevation profile and providing for appropriate minimum "equilibrium" channel widths would improve fish passage suitability and allow for natural bed level fluctuations and establishment of pool-riffle type bedforms. Over time, elimination of creek constrictions, increasing culvert sizes, replacing culverts with "open bottom" structures, would allow for naturally lower bed elevations to reestablish and reduce need for repeat sediment removal activities. It would also reduce nuisance flooding of developed areas within and adjacent to the creekside zone, as may reduce potential for contamination of stormwater by chemicals stored in garages, etc.

- *6. Recommendations:*
  - *(a) HOA consider obtaining a general permit for projects and activities on private properties;*
  - *(b) County consider obtaining a general permit for projects and activities on public property and rights-of-way, or incorporation in broader general permits already in effect or pending finalization;*
  - *(c) HOA and County confer on potential cost savings to HOA and/or County of obtaining a single general permit for activities on private and public properties, or sharing cost of developing project/program description and analysis documentation referred to in separate general permits.*

References Cited

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