# HYDROMODIFICATION SCREENING

# FOR

# LAKE JENNINGS MARKETPLACE

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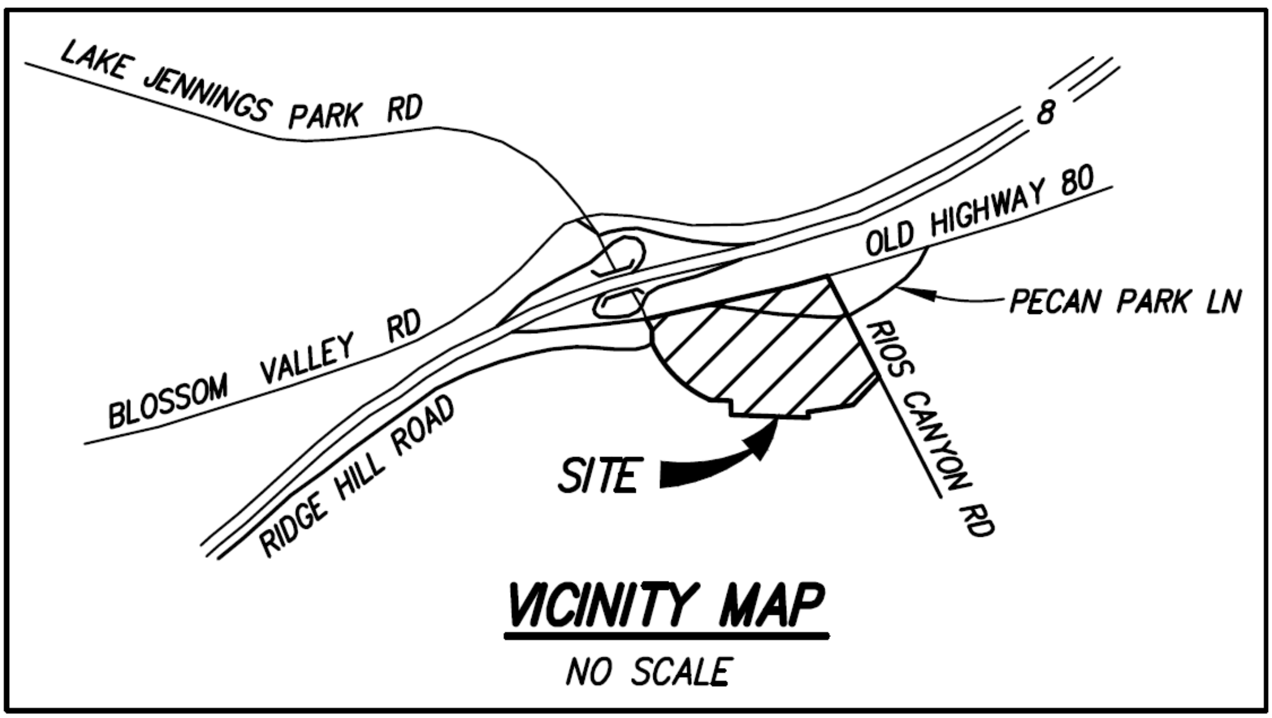
## INTRODUCTION

The County of San Diego's March 2011, *Final Hydromodification Management Plan*, and January 8, 2011, *Standard Urban Stormwater Mitigation Plan* (SUSMP) outline low flow thresholds for hydromodification analyses. The thresholds are based on a percentage of the pre-project 2-year flow ($Q_2$), i.e., $0.1Q_2$ (low flow threshold and high susceptibility to erosion), $0.3Q_2$ (medium flow threshold and medium susceptibility to erosion), or $0.5Q_2$ (high flow threshold and low susceptibility to erosion). A flow threshold of $0.1Q_2$ represents a natural downstream receiving conveyance system with a high susceptibility to bed and/or bank erosion. This is the default value used for hydromodification analyses and will result in the most conservative (largest) on-site facility sizing. A flow threshold of $0.3Q_2$ or $0.5Q_2$ represents downstream receiving conveyance systems with a medium or low susceptibility to erosion, respectively. In order to qualify for a medium or low erosion susceptibility rating, a project must perform a channel screening analysis based on the March 2010, *Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility*, developed by the Southern California Coastal Water Research Project (SCCWRP). The SCCWRP results are compared with the critical shear stress calculator results from the County of San Diego's BMP Sizing Calculator to establish the appropriate erosion susceptibility threshold of low, medium, or high.




This report provides hydromodification screening analyses for the Lake Jennings Marketplace project being designed by Stuart Engineering. The site is located southeast of the intersection of Lake Jennings Park Road and Olde Highway 80 in the Lakeside community of the county of San Diego. The project proposes mixed-use development consisting of retail stores, restaurants, a gas station, business offices, a grocery store as well as associated parking, landscaped areas, and walkways. The total disturbed area will be approximately 10.4 acres.

Under pre-project conditions, the site primarily contains sparse vegetation with a few scattered buildings along the north, east, and west sides of the property. Surface runoff from the project area generally sheet flows in a southwesterly direction into Los Coches Creek without a defined drainage course. Under post-project conditions, the site runoff will be collected by the proposed storm drain system. The system will convey the runoff to a single discharge point into an existing unnamed natural channel immediately west of the site. Consequently, there is one point of compliance (labeled POC A on the Study Area Exhibit contained after this report text) for the project. Runoff below POC A flows southerly in the unnamed natural channel about 102 feet, is conveyed approximately 120 feet in an existing culvert under Ridge Hill Road, and then continues in the natural channel about 135 feet before it confluences into Los Coches Creek near the southwest corner of the site.

The SCCWRP screening tool requires both office and field work to establish the vertical and lateral susceptibility of a downstream receiving channel to erosion. The vertical and lateral assessments are performed independently of each other although the lateral results can be affected by the vertical rating. A screening analysis was performed to assess the low flow threshold for each POC.

The initial step in performing the SCCWRP screening analysis is to establish the domain of analysis and the study reaches within the domain. This is followed by office and field components of the screening tool along with the associated analyses and results. The following sections cover these procedures in sequence.

## DOMAIN OF ANALYSIS

SCCWRP defines an upstream and downstream domain of analysis, which establish the study limits. The County of San Diego's HMP specifies the downstream domain of analysis based on the SCCWRP criteria. The HMP indicates that the downstream domain is the first point where one of these is reached:

- at least one reach downstream of the first grade control point
- tidal backwater/lentic waterbody
- equal order tributary
- accumulation of 50 percent drainage area for stream systems or 100 percent drainage area for urban conveyance systems (storm drains, hardened channels, etc.)

The upstream limit is defined as:

- proceed upstream for 20 channel top widths or to the first grade control point, whichever comes first. Identify hard points that can check headward migration and evidence of active headcutting.

SCCWRP defines the maximum spatial unit, or reach (a reach is circa 20 channel widths), for assigning a susceptibility rating within the domain of analysis to be 200 meters (656 feet). If the domain of analysis is greater than 200 meters, the study area should be subdivided into smaller reaches of less than 200 meters for analysis. Most of the units in the HMP's SCCWRP analysis are metric. Metric units are used in this report only where given so in the HMP. Otherwise English units are used.

*Downstream Domain of Analysis*

The downstream domain of analysis location for the study area has been determined by assessing and comparing the four bullet items above. As discussed in the Introduction, the project runoff will be collected by a proposed on-site storm drain system that outlets at a single location west of the site (see the Study Area Exhibit). The downstream domain of analysis is selected below this point of compliance identified as POC A.

Per the first bullet item, the first permanent grade control below POC A was located. A site inspection revealed that a permanent grade control exists at the entrance of the existing culvert under Ridge Hill Road (see Figure 4). The culvert is a corrugated metal pipe with a concrete apron so it will maintain the upstream channel bed elevations. Since the culvert is under a public roadway, it is considered to be a permanent facility.

The second bullet item is the tidal backwater or lentic (standing or still water such as ponds, pools, marshes, lakes, etc.) waterbody location. Based on review of Google Earth, there is no tidal backwater or lentic waterbody near the site. The nearest such waterbody is an in-stream pond within the San Diego River over 4 miles northwest of the site. Therefore, the second bullet item criteria will not govern over the first bullet item criteria in establishing the downstream domain of analysis location.

The final two bullet items are related to the tributary drainage area. As mentioned in the Introduction, the unnamed natural channel confluences with Los Coches Creek near the southwesterly corner of the site. The area tributary to the unnamed natural channel covers 125.28 acres at the confluence (see discussion in the Initial Desktop Analysis Section below). On the other hand, the Los Coches Creek watershed tributary to the confluence extends approximately 4 miles upstream (see the Comparison of Receiving Channel vs. Los Coches Creek exhibit in Appendix A). Therefore, the Los Coches Creek watershed is significantly larger than the unnamed natural channel's watershed, and the tributary drainage area criterion is met at the confluence of the two streams.

From the above assessment, the downstream domain of analysis location for POC A was based on the equal order tributary criteria. This is the closest location to POC A. The permanent grade control requires the downstream location to be one reach below the grade control, which would be further downstream than the confluence (the confluence is only 135 feet below the grade control). Therefore, the downstream domain of analysis location for POC A was selected as the confluence of the unnamed natural channel with Los Coches Creek.

*Upstream Domain of Analysis*

The unnamed natural channel extends a short distance upstream of POC A (approximately 33 feet) before it reaches an existing culvert under Olde Highway 80. The culvert functions as a permanent grade control similar to the culvert under Ridge Hill Road. Therefore, the culvert outlet is the upstream domain of analysis location.

*Study Reaches within Domain of Analysis*

The entire domain of analysis contains three study reaches (see Study Area Exhibit contained after this report text) with a total length of 270 feet. This total length does not include the culvert under Ridge Hill Road, which is estimated at 120 feet long from the project's topographic mapping. The maximum study reach length within the domain of analysis must be the lesser of 200 meters (656 feet) or 20 channel top widths. Each of the three study reaches is less than 656 feet in length. Reach 1 (upstream-most reach) begins at the outlet of the existing culvert under Olde Highway 80 and extends downstream for 33 feet to POC A. Reach 2 continues 102 feet below POC A to the entrance of the culvert under Ridge Hill Road. Reach 3 extends over 135 feet from the exit of the culvert under Ridge Hill Road to the confluence with Los Coches Creek. The length of each of these three reaches was selected so that they generally cover a portion of the unnamed natural drainage course with similar characteristics (channel width, slope, vegetative cover, etc.). The channel top width of Reaches 1, 2, and 3 is 9, 9, and 12 feet, respectively. This was determined from a site visit and well as review of aerial photographs and topographic mapping.

## INITIAL DESKTOP ANALYSIS

After the domain of analysis is established, SCCWRP requires an "initial desktop analysis" that involves office work. The initial desktop analysis establishes the watershed area, mean annual precipitation, valley slope, and valley width. These terms are defined in Form 1, which is included in Appendix A. SCCWRP recommends the use of National Elevation Data (NED) to determine the watershed areas, valley slopes, and valley widths.

NED data is similar to USGS quadrangle mapping. Stuart Engineering delineated the off-site watershed using USGS-based GIS mapping. Their off-site watershed is included in Appendix A and covers 112.40 acres. In addition, Stuart Engineering's on-site watershed is included in Appendix A from their drainage study and covers 12.88 acres. The total tributary area to Reach 1 and 2 is the sum of the off- and on-site areas or 125.28 acres. Reach 1 and 2 are so short that the minor variation in tributary area for each reach will be insignificant for the channel assessment results, so the same area was used for both reaches. For Reach 3, the additional drainage area was delineated using the 1-foot contour interval topographic mapping prepared for the project. The additional drainage area is included on the Study Area Exhibit and covers 1.81 acres. Therefore, the total area tributary to Reach 3 is 127.09 acres.

The mean annual precipitation was obtained from the rain gage closest to the site. This is the Western Regional Climate Center's Lakeside gage (see Appendix A). The average annual rainfall measured at this gage for the period of record from 1967 to 2013 is 15.58 inches.

The valley slope and valley width were determined for each study reach from the 1-foot contour interval flown topographic mapping prepared for the project. NED data was not used because it is not very accurate for these parameters. The valley slope is the longitudinal slope of the channel bed along the flow line, so it is determined by dividing the elevation difference within a study reach by the length of the flow line. The valley width is the valley bottom width dictated by breaks in the hillslope. The tributary area, valley slope, and valley width for each reach is included in Table 1. The valley widths are identified on the Study Area Exhibit.

These values were input to a spreadsheet to calculate the simulated peak flow, screening index, and valley width index outlined in Form 1. The input data and results are tabulated in Appendix A. This completes the initial desktop analysis.

| Reach | Tributary Drainage Area, sq. mi. | Valley Slope, m/m | Valley Width, m |
|---|---|---|---|
| 1 | 0.1958 | 0.0059 | 2.74 |
| 2 | 0.1958 | 0.0059 | 3.35 |
| 3 | 0.1986 | 0.0115 | 4.88 |

**Table 1. Summary of Drainage Area, Valley Slope, and Valley Width**

## FIELD SCREENING

After the initial desktop analysis is complete, a field assessment must be performed. The field assessment is used to establish a natural channel's vertical and lateral susceptibility to erosion. SCCWRP states that although they are admittedly linked, vertical and lateral susceptibility are assessed separately for several reasons. First, vertical and lateral responses are primarily controlled by different types of resistance, which, when assessed separately, may improve ease of use and lead to increased repeatability compared to an integrated, cross-dimensional assessment. Second, the mechanistic differences between vertical and lateral responses point to different modeling tools and potentially different management strategies. Having separate screening ratings may better direct users and managers to the most appropriate tools for subsequent analyses.

The field screening tool uses combinations of decision trees and checklists. Decision trees are typically used when a question can be answered fairly definitively and/or quantitatively (e.g., $d_{50}$ < 16 mm). Checklists are used where answers are relatively qualitative (e.g., the condition of a grade control). Low, medium, high, and very high ratings are applied separately to the vertical and lateral analyses. When the vertical and lateral analyses return divergent values, the most conservative value shall be selected as the flow threshold for the hydromodification analyses.

*Vertical Stability*

The purpose of the vertical stability decision tree (Figure 6-4 in the County of San Diego HMP) is to assess the state of the channel bed with a particular focus on the risk of incision (i.e., down cutting). The decision tree is included in Figure 12. The first step is to assess the channel bed resistance. There are three categories defined as follows:

1. Labile Bed – sand-dominated bed, little resistant substrate.

2. Transitional/Intermediate Bed – bed typically characterized by gravel/small cobble, Intermediate level of resistance of the substrate and uncertain potential for armoring.

3. Threshold Bed (Coarse/Armored Bed) – armored with large cobbles or larger bed material or highly-resistant bed substrate (i.e., bedrock).

Figures 9 through 11 contain photographs of the bed material within the each of the three study reaches. A gravelometer is included in the photographs for reference. Each square on the gravelometer indicates grain size in millimeters (the squares range from 2 mm to 180 mm). Based on the photographs and site investigation, the bed material and resistance is within the transitional/intermediate bed category in all reaches. There was no evidence of a threshold bed condition. However, some bed areas contained smaller grain sizes found in a labile bed. A pebble count was performed that determined the median ($d_{50}$) bed material sizes for Reaches 1 through 3 varies from 16 to 32 millimeters (see Appendix B). Figure 6-4 in the County HMP indicates that a $d_{50}$ of 16 mm or greater is within the transitional/intermediate bed category. Dr. Eric Stein from SCCWRP, who co-authored the *Hydromodification Screening Tools: Field Manual* in the *Final Hydromodification Management Plan* (HMP), indicated that it would be appropriate to analyze channels with multiple factors that impact erodibility using the transitional/intermediate bed procedure. This requires the most rigorous steps and will generate the appropriate results for the size range.

Transitional/intermediate beds cover a wide susceptibility/potential response range and need to be assessed in greater detail to develop a weight of evidence for the appropriate screening rating. The three primary risk factors used to assess vertical susceptibility for channels with transitional/intermediate bed materials are:

1. Armoring potential – three states (Checklist 1)

2. Grade control – three states (Checklist 2)

3. Proximity to regionally-calibrated incision/braiding threshold (Mobility Index Threshold – Probability Diagram)

These three risk factors are assessed using checklists and a diagram (see Appendix B), and the results of each are combined to provide a final vertical susceptibility rating for the intermediate/transitional bed-material group. Each checklist and diagram contains a Category A, B, or C rating. Category A is the most resistant to vertical changes while Category C is the most susceptible.

Checklist 1 determines armoring potential of the channel bed. The channel bed along each of the four study reaches is within Category B, which represents intermediate bed material of unknown resistance or unknown armoring potential due to a surface veneer such as vegetation. Figures 1 through 8 show that the entire unnamed natural channel course contains a dense cover of mature vegetation including grasses, large brush, and large trees. Figures 9 through 11 show that the channel material contains gravel-sized particles and larger. The soil was probed and penetration was relatively difficult through the underlying layer.

Checklist 2 determines grade control characteristics of the channel bed. The downstream end of Reach 1 and 2 contain a permanent grade control formed by the existing culvert under Ridge Hill Road. The culvert is 102 feet (31.1 meters) below Reach 1 and immediately below Reach 2. The downstream end of Reach 3 contains a grade control formed by the backwater associated with the much larger Los Coches Creek flows. Each of the grade controls is less than 50 meters below the upstream reach. Consequently, Reaches 1, 2, and 3 are within Category A on Checklist 2.

The Screening Index Threshold is a probability diagram that depicts the risk of incising or braiding based on the potential stream power of the valley relative to the median particle diameter. The threshold is based on regional data from Dr. Howard Chang of Chang Consultants and others. The probability diagram is based on $d_{50}$ as well as the Screening Index determined in the initial desktop analysis (see Appendix A). $d_{50}$ is derived from a pebble count in which a minimum of 100 particles is obtained along transects at the site. A pebble count was performed for each of the three reaches within the unnamed natural drainage course. The spacing of each sample location within a reach was determined by dividing the total length of a representative cross-section (see Study Area Exhibit for location) within the reach by 100. This distance was paced off in the field and a sample taken. The extents of each reach was estimated in the field by reviewing an aerial photograph and topographic mapping. SCCRWP states that if fines less than ½-inch thick are at a sample point, it is appropriate to sample the coarser buried substrate.

The $d_{50}$ value is the particle size in which 50 percent of the particles are smaller and 50 percent are larger. The pebble count results for each study reach is included in Appendix B and summarized in Table 2. The screening index values (INDEX) for the reaches are tabulated on Form 1 in Appendix A and also included in Table 2. The Screening Index Threshold diagram in Appendix B provides 50% Risk values for various $d_{50}$ values. These values are included in the second to last column of Table 2. If the INDEX value is less than the 50% Risk value, the reach has less than 50 percent probability of incising and falls within Category A. Table 2 shows that this is the case for all three study reaches.

| Reach | $D_{50}$, mm | INDEX | 50% Risk | Difference[1] |
|---|---|---|---|---|
| 1 | 32 | 0.0060 | 0.0700 | 0.0640 |
| 2 | 32 | 0.0060 | 0.0700 | 0.0640 |
| 3 | 16 | 0.0117 | 0.0490 | 0.0373 |

[1]Positive Value Reflects Less Than 50% Probability of Incision

**Table 2. Summary of Pebble Count, Screening Index, Risk of Incision**

The overall vertical rating is determined from the Checklist 1, Checklist 2, and Mobility Index Threshold results. The scoring is based on the following values:

Category A = 3, Category B = 6, Category C = 9

The vertical rating score is based on these values and the equation:

$$\text{Vertical Rating} = [(\text{armoring} \times \text{grade control})^{1/2} \times \text{screening index score}]^{1/2}$$

Table 3 summarizes the checklist 1, 2, and 3 values for each reach as well as their vertical rating score.

| Reach | Checklist 1 | Checklist 2 | Checklist 3 | Vertical Rating |
|---|---|---|---|---|
| 1 | 6 | 3 | 3 | 3.6 |
| 2 | 6 | 3 | 3 | 3.6 |
| 3 | 6 | 3 | 3 | 3.6 |

**Table 3. Overall Vertical Rating**

The vertical rating for Reaches 1 through 3 is less than 4.5, so these reaches have a low threshold for vertical susceptibility.

*Lateral Stability*

The purpose of the lateral decision tree (Figure 6-5 from County of San Diego HMP is included in Figure 13) is to assess the state of the channel banks with a focus on the risk of widening. Channels can widen from either bank failure or through fluvial processes such as chute cutoffs, avulsions, and braiding. Widening through fluvial avulsions/active braiding is a relatively straightforward observation. If braiding is not already occurring, the next logical step is to assess the condition of the banks. Banks fail through a variety of mechanisms; however, one of the most important distinctions is whether they fail in mass (as many particles) or by fluvial detachment of individual particles. Although much research is dedicated to the combined effects of weakening, fluvial erosion, and mass failure, SCCWRP found it valuable to segregate bank types based on the inference of the dominant failure mechanism (as the management approach may vary based on the dominant failure mechanism). A decision tree (Form 4 in Appendix B) is used in conducting the lateral susceptibility assessment. Definitions and photographic examples are also provided below for terms used in the lateral susceptibility assessment.

The first step in the decision tree is to determine if lateral adjustments are occurring. The adjustments can take the form of extensive mass wasting (greater than 50 percent of the banks are exhibiting planar, slab, or rotational failures and/or scalloping, undermining, and/or tension cracks). The adjustments can also involve extensive fluvial erosion (significant and frequent bank cuts on over 50 percent of the banks). Neither mass wasting nor extensive fluvial erosion was evident within any of the reaches during a field investigation. As seen in the figures, many of the banks are moderately to densely vegetated confirming that mass wasting and extensive fluvial erosion has not occurred.

The next step in the Form 4 decision tree is to assess the consolidation of the bank material. The banks were moderate to well-consolidated. This determination was made because the ground surface was difficult to penetrate with a probe and/or the banks were densely vegetated as seen in the figures. In addition, the banks showed no evidence of crumbling and were composed of relatively well-packed particles. This is logical because development exists on either side of the channel banks.

Form 6 (see Appendix B) is used to assess the probability of mass wasting. Form 6 identifies a 10, 50, and 90 percent probability based on the bank angle and bank height. From the topographic mapping and site investigation, the average bank angles in all three reaches are equal to or flatter than 2:1 (26.6 degrees). Form 6 shows that the probably of mass wasting and bank failure has less than 10 percent risk for a 30 degree bank angle or less regardless of the bank height.

The final two steps in the Form 4 decision tree are based on the braiding risk determined from the vertical rating as well as the Valley Width Index (VWI) calculated in Appendix A. If the vertical rating is high, the braiding risk is considered to be greater than 50 percent. Excessive braiding can lead to lateral bank failure. For the three study reaches the vertical rating is low, so the braiding risk is less than 50 percent. Furthermore, a VWI greater than 2 represents channels unconfined by bedrock or hillslope and, hence, subject to lateral migration. The VWI calculations in the spreadsheet in Appendix A show that the VWI for all three reaches is much less than 2.

From the above steps, the lateral susceptibility rating is low for Reaches 1 through 3 (colored circles are included on the Form 4: Lateral Susceptibility Field Sheet decision tree in Appendix B showing the decision path).

## CONCLUSION

The SCCWRP channel screening tools were used to assess the downstream channel susceptibility for the Lake Jennings Marketplace mixed-use project by Stuart Engineering. The project’s storm runoff will be collected by a proposed on-site drainage system and conveyed to a single outfall (POC A) into an unnamed natural drainage channel to the west. A downstream channel assessment for POC A was performed based on office analyses and field work. The results indicate a low threshold for vertical and lateral susceptibility for Reaches 1 through 3.

The HMP requires that these results be compared with the critical stress calculator results incorporated in the County of San Diego’s BMP Sizing Calculator. The BMP Sizing Calculator critical stress results are included in Appendix B for each of the three study reaches. The channel dimensions were estimated from the topographic mapping. Based on these values, the critical stress results returned a low threshold consistent with the SCCWRP channel screening results. Therefore, the SCCWRP analyses and critical stress calculator demonstrate that a low overall threshold is applicable to Reaches 1 through 3 (i.e., $0.5Q_2$).

**Figure 1. Looking Downstream towards Reach 1 from Upper End**

**Figure 2. Downstream End of Reach 1 and Upstream End of Reach 2**

**Figure 3. Looking Downstream towards Reach 2 from Upstream End**

**Figure 4. Existing Culvert under Ridge Hill Road at Downstream End of Reach 2**

**Figure 5. Looking Upstream at Reach 2 from Lower End**

**Figure 6. Looking Southeast at Reach 3 from Upper End**

**Figure 7. Looking Upstream at Reach 3 from Middle**

**Figure 8. Looking Upstream at Reach 3 from Lower End**


**Figure 9. Gravelometer within Reach 1**


**Figure 10. Gravelometer within Reach 2**

**Figure 11. Gravelometer within Reach 3**

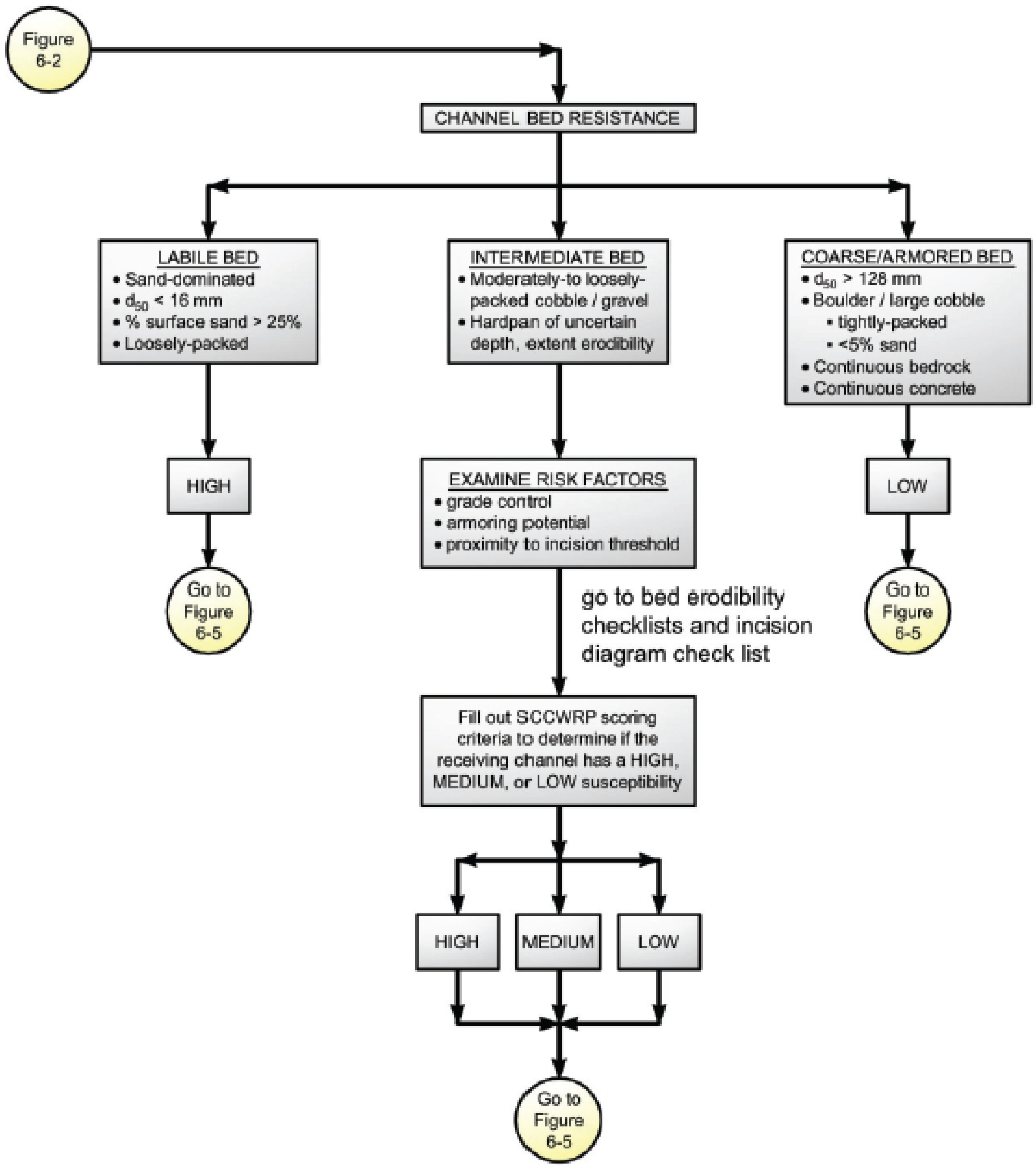



*Figure 6-4. SCCWRP Vertical Susceptibility*

**Figure 12. SCCWRP Vertical Channel Susceptibility Matrix**

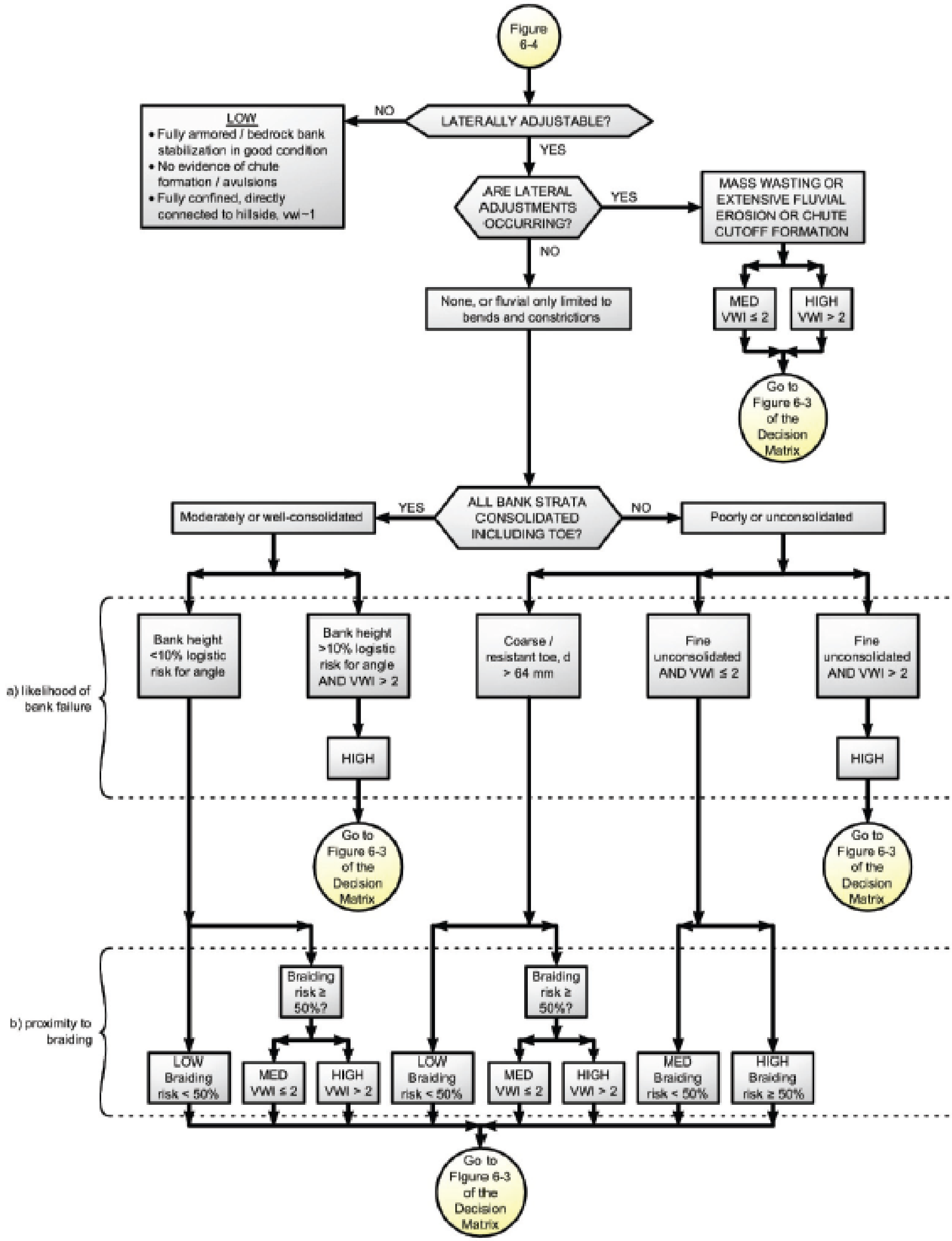



*Figure 6-5. Lateral Channel Susceptibility*

**Figure 13. SCCWRP Lateral Channel Susceptibility Matrix**