**2) Rock Slope Collapse**

As an example, the DIS results for Cebu-Balamban Transcentral Highway (27 km 970m- 28 km 28m) for Rock Slope Collapse are shown in Figure 5.23 to 5.28.

Considering field conditions, the countermeasure alternatives were planned as summarized in Table 5.11.

Based on the outputs from Sheets 1 to 4, an indicative feasibility assessment was undertaken, as shown in Figure 5.28.

**Table 5.11 Example of Countermeasure Alternative Planning for Rock Slope Collapse**

| Alternative | Effectiveness | Risk Reduction Ratio |
|---|---|---|
| Alternative-I | High Effectiveness: Permanent countermeasures to prevent disasters<br><br>- Shotcrete<br>- Pre-splitting/Cutting | 0.9 |
| Alternative-II | Moderate Effectiveness: Mitigating the disasters to some extent<br><br>- Rock net | 0.7 |
| Alternative-III | Low Effectiveness: Limited treatment<br><br>-Cleaning of existing debris on road and drainage | 0.3 |

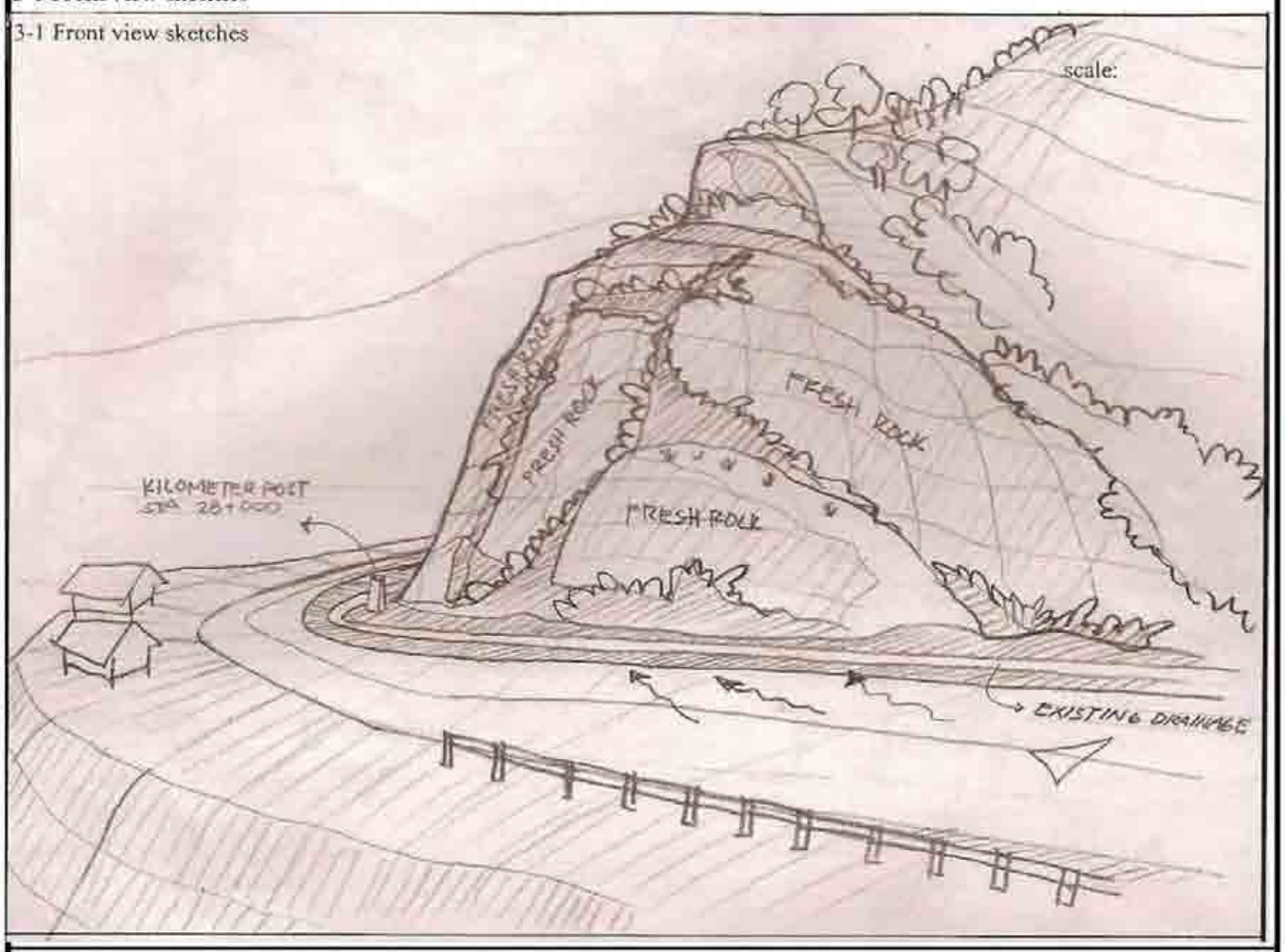
**Figure 5.23 General View of Example DIS Slope for Rock Slope Collapse**

**Inventory Sheet 3 Sketches**

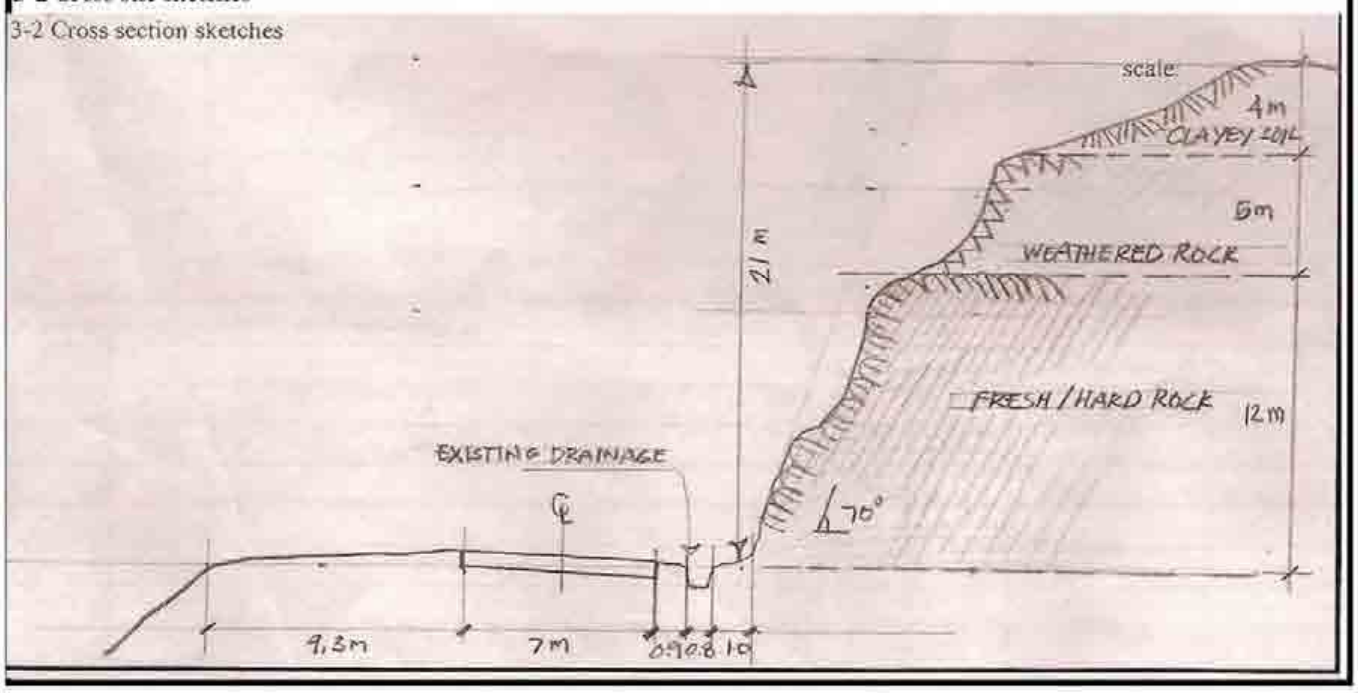
| | | | | |
|---|---|---|---|---|
| Road Name | Cebu-Balamban Transcentral Highway | | | |
| Station from | km 27 | m 970 | Side of survey | Right side of road |

| | | | | |
|---|---|---|---|---|
| Name of Inspector/ Coordinator for detailed inventory survey; sheet 3, 4, 5 | | Survey date (d/m/y) | Date | Month | Year |
| Name of surveyor | Judefer Castano | | 27 | Nov. | 2006 |

3-1 Front view sketches




3-2 Cross site sketches



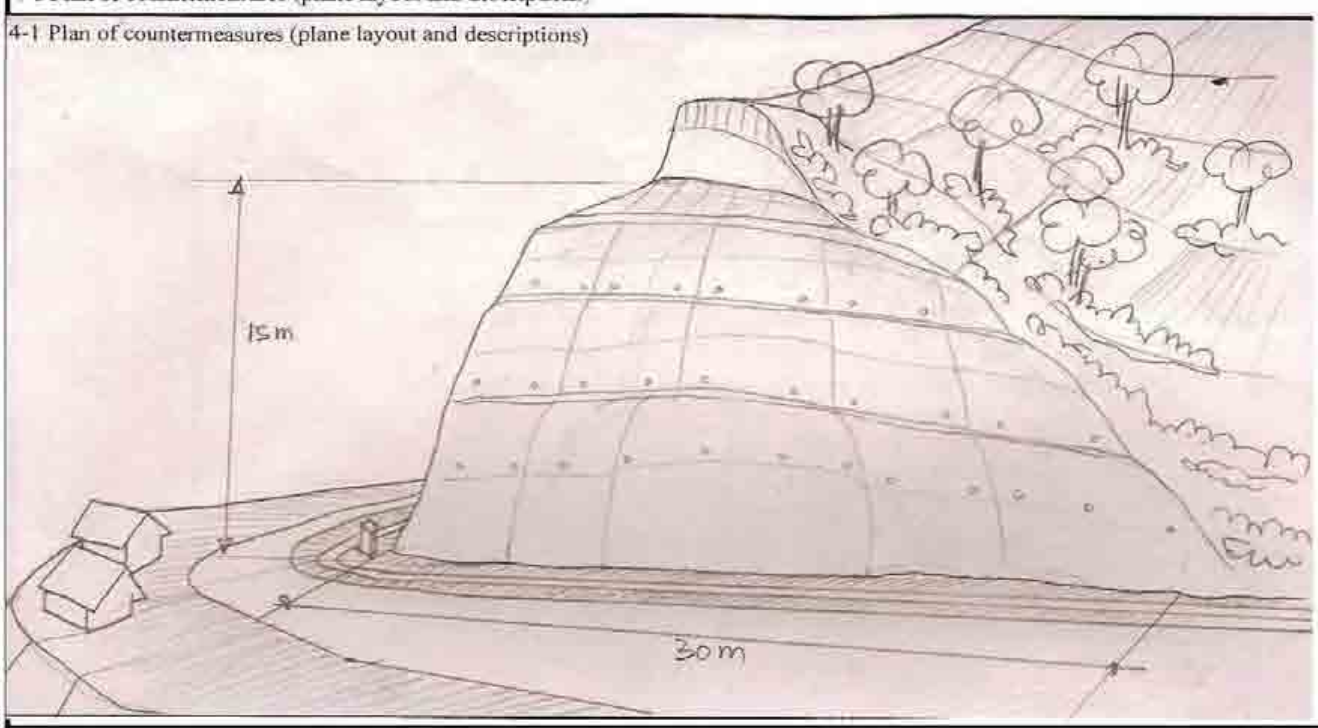

Note
- Numerical value or terms should be inputted.
- Numerical value is automatically inputted.

**Figure 5.24 Example of Inventory Sheet 3: Sketches for Rock Slope Collapse**

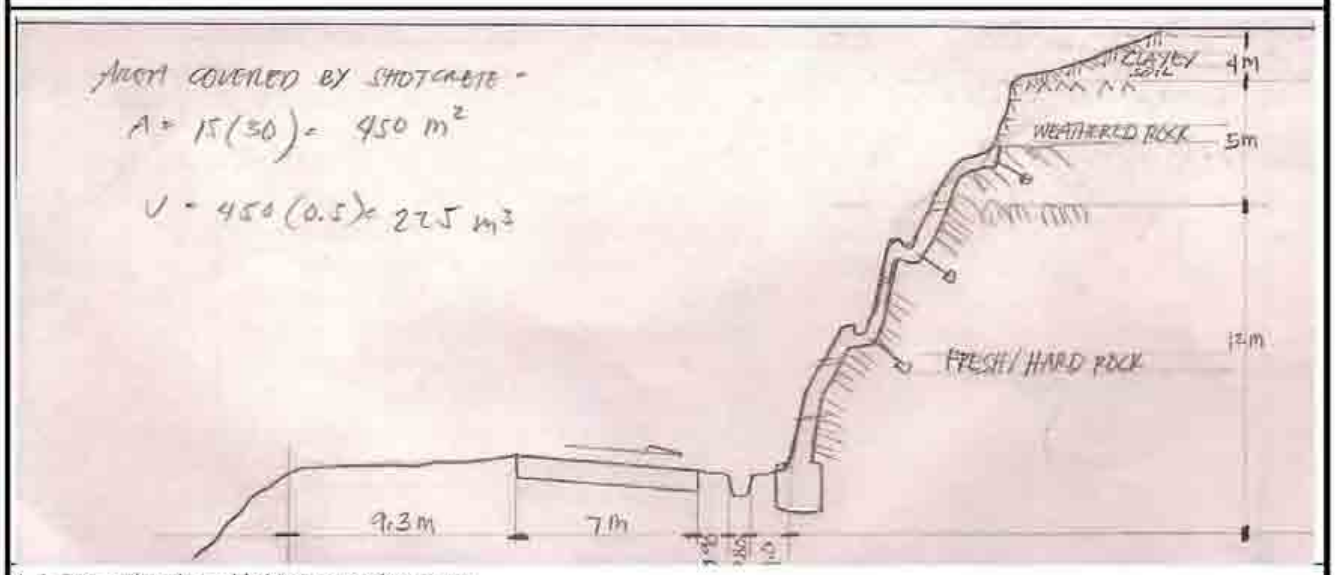
**Inventory Sheet 4-1 Planning of Countermeasures** Alternative I

| Road Name | Cebu-Balamban Transcentral Highway | | | | |
|---|---|---|---|---|---|
| Station from | km | 27 | m 970 | Side of survey | Right side of road |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4-3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Shotcrete (0.10m thick with reinforcements) | $m^2$ | 450 | 2,484.00 | 1,117,800.00 |
| 2 | Pre-splitting / Cutting | $m^3$ | 225 | 1,884.00 | 423,900.00 |
| 3 | Maintenance +30% | LS | 1 | 462,510.00 | 462,510.00 |
| 4 | | | | | 0 |
| 5 | | | | | 0 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 2,004,210 |

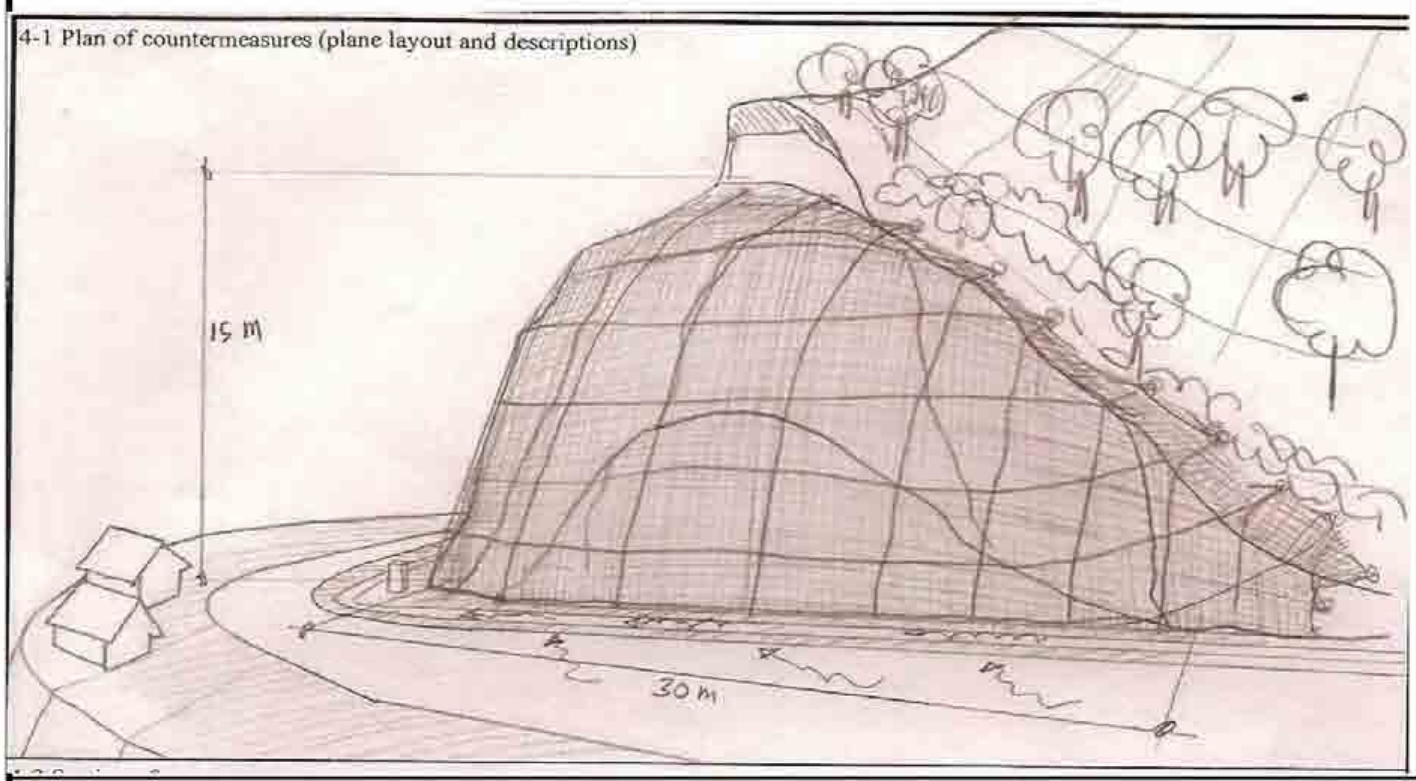
Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.25 Example of Inventory Sheet 4-1: Planning of Countermeasure Alternative I for Rock Slope Collapse**

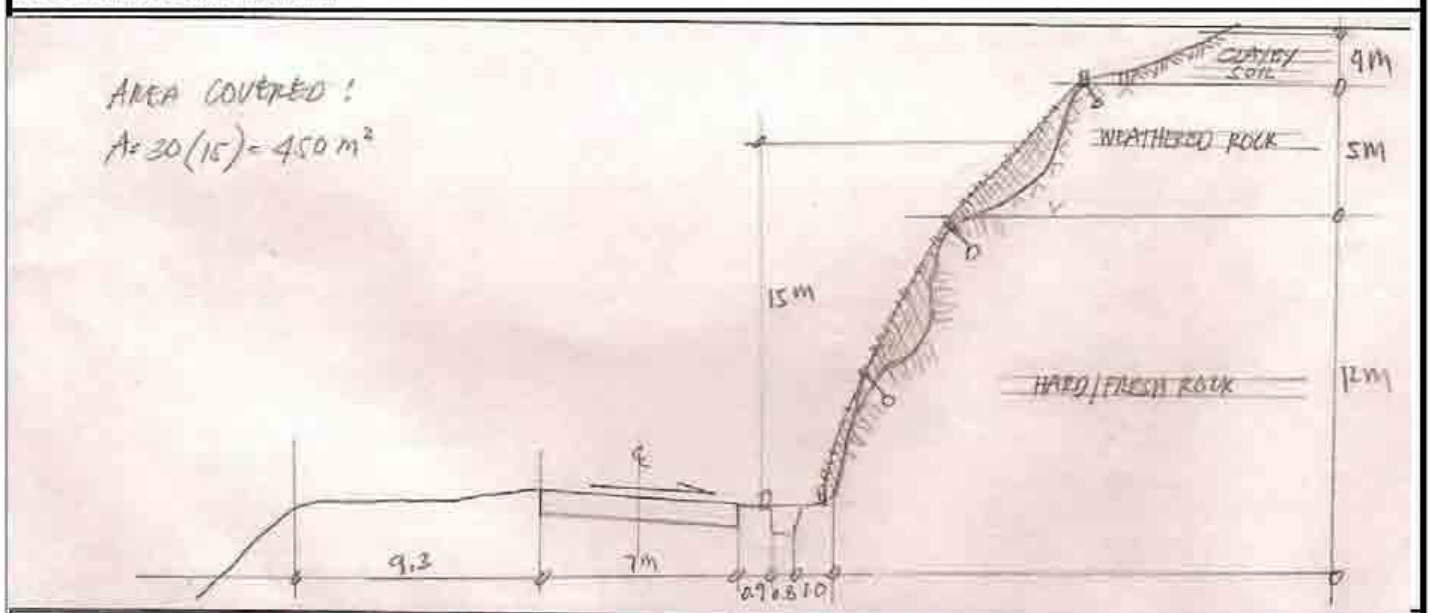
**Inventory Sheet 4-2 Planning of Countermeasures** Alternative II

| Road Name | Cebu-Balamban Transcentral Highway | | | | | |
|---|---|---|---|---|---|---|
| Station from | km | 27 | m | 970 | Side of survey | Right side of road |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Rock Net | $m^2$ | 450 | 450.00 | 202,500.00 |
| 2 | Maintenance +60% | LS | 1 | 101,250.00 | 101,250.00 |
| 3 | | | | | 0 |
| 4 | | | | | 0 |
| 5 | | | | | 0 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 303,750 |

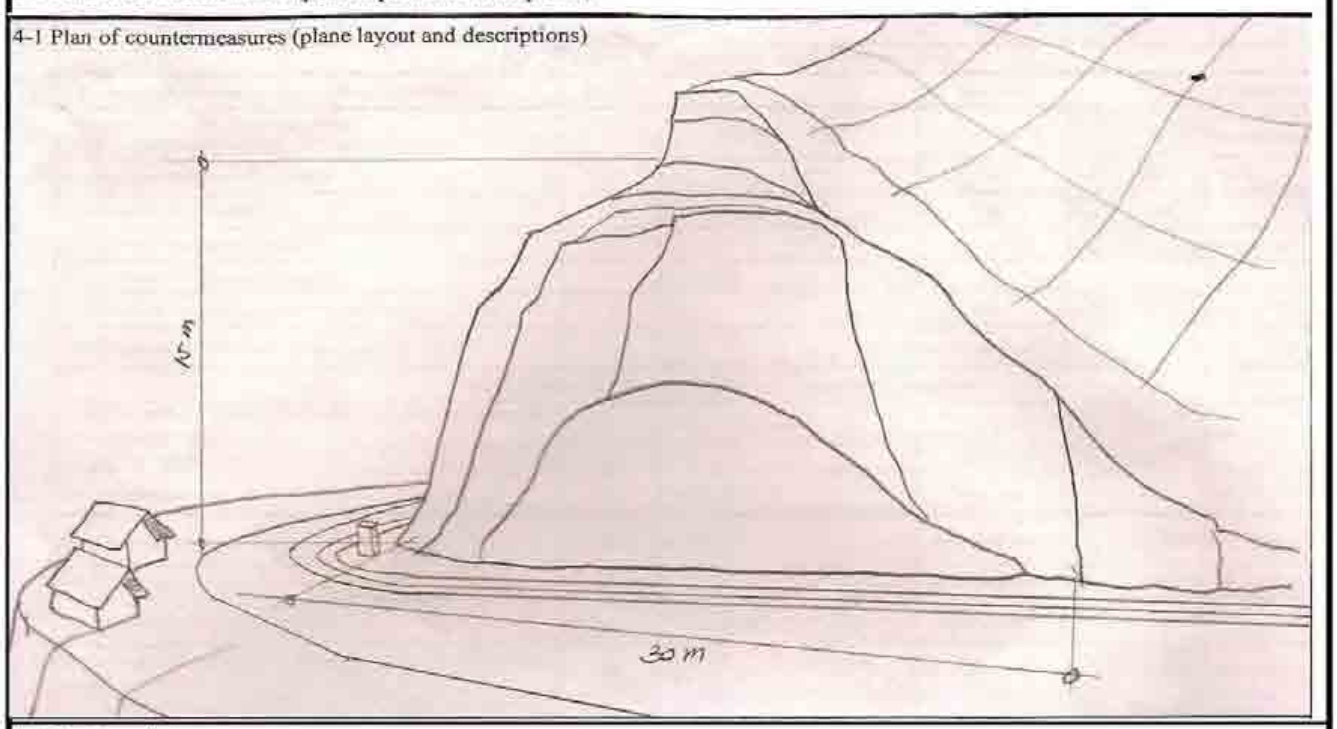
Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.26 Example of Inventory Sheet 4-2: Planning of Countermeasure Alternative II for Rock Slope Collapse**

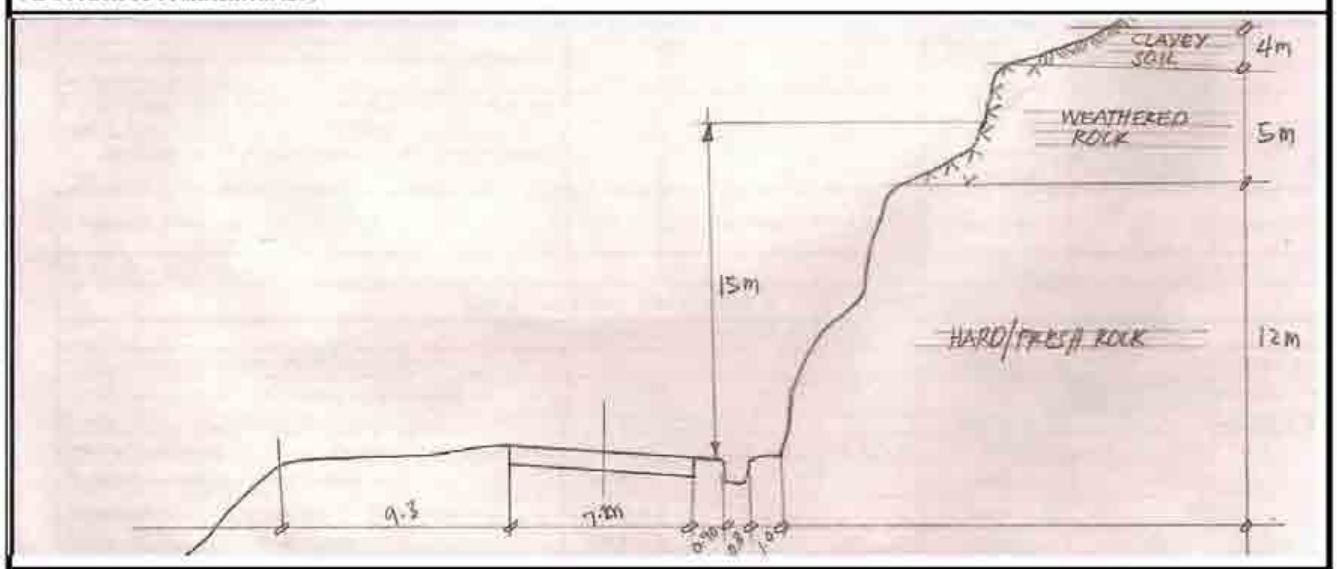
**Inventory Sheet 4-3 Planning of Countermeasures** Alternative III

| Road Name | Cebu-Balamban Transcentral Highway | | | | | |
|---|---|---|---|---|---|---|
| Station from | km | 27 | m | 970 | Side of survey | Right side of road |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Clearing of Road From Debris, Mobilization of Heavy Equipme | days | 3 | 6,584.00 | 19,752.00 |
| 2 | Maintenance + 70% | L-S | 1 | 13,826.40 | 13,826.40 |
| 3 | | | | | 0.00 |
| 4 | | | | | 0 |
| 5 | | | | | 0 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 33,578 |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.27 Example of Inventory Sheet 4-3: Planning of Countermeasure Alternative III for Rock Slope Collapse**

**Inventory Sheet 5-2** **Indicative Feasibility Assessment for RC**

| | | | | | |
|---|---|---|---|---|---|
| **Road Name** | Cebu-Balamban Transcentral Highway | | | | |
| **Km station from** | km | 27 | m | 970 | |
| **Side of Survey** | Right side of road | | | | |

| Items | symbol | equation | Unit | Quantity | Remarks |
|---|---|---|---|---|---|
| *(1) Disaster Frequency and Magnitude* | | | | | |
| ***1-1) Potential frequency of road closure disasters*** | FRCDp | | nos. per year | 0.162 | evaluated in sheet 2 |
| 1-2-1) Coefficient for volume estimation (method of dimension setting for collapsible material) | a | | | Max | 1-2-1) When dimensions of collapsible materials cannot be predicted, 'no input' should be selected. And 'Volume of collapsible material' is estimated by Figure 3.4.2 in the Guide and is directly inputted in the yellow cell below. |
| 1-2-2) Length of collapsible materials | b | | m | 21.0 | |
| 1-2-3) Width of collapsible materials | c | | m | 30.0 | |
| 1-2-4) Depth of collapsible materials | d | | m | 1.5 | |
| 1-2-5) Volume of collapsible materials per RCD | e | e=a*b*c*d | $m^3$ per RCD | 662 | |
| 1-2-6) Ratio of accumulation to collapsible materials | f | | ratio | 0.50 | 1-2-6) Evaluated by the Figure 3.4.3 of the Guide |
| ***1-2) Accumulation volume on the road per RCD*** | g | g=e*f | $m^3$ per RCD | 331 | |
| *(2) Annual Losses without Countermeasure* | | | | | |
| 2-1-1) Reopening cost per accumulation volume of road closure site (excluding fixed cost) | h | | pesos per $m^3$ | 410 | refer 3.4.2 2-1-1) of the Guide |
| Fixed cost for reopening per RCD | i | | pesos per RCD | 600,000 | |
| **2-1) Annual reopening cost** | j | j=FRCDp*(h*g+i) | pesos per year | 119,168 | refer 3.4.3 2-1) of the Guide |
| 2-2-1) Average number of human deaths per RCD | k | k=0.006 | ave. death per RCD | 0.006 | refer 3.4.2 (2) 2-2-1) of the Guide |
| 2-2-2) Unit value of human life lost (death) | l | | pesos per human life | 2,300,000 | refer 3.4.2 (2) 2-2-2) of the Guide |
| **2-2) Annual value of human lives lost** | m | m=FRCDp*k*l | pesos per year | 2,236 | refer 3.4.2 (2) 2-2) of the Guide |
| 2-3-1) Length of survey road (from entry to exit point of detour road to avoid road closure site on survey road) | n | | km | 42 | refer 3.4.2 (2) 2-3-1) of the Guide |
| Length of detour road (from entry to exit point of survey road to avoid road closure site on survey road) | o | | km | 49 | refer 3.4.2 (2) 2-3-2) of the Guide |
| 2-3-2) AADT: Annual Average Daily Traffic on the survey site | p | | vehicles per day | 3,253 | refer 3.4.2 (2) 2-3-3) of the Guide |
| 2-3-3) Nos. of predicted closure days of the whole width of the road on the survey site per RCD | q | | days | 7.0 | refer 3.4.2 (2) 2-3-4) of the Guide |
| 2-3-4) Average Vehicle Operating Cost per km on survey road | r | | pesos per vehicle*km | 8.00 | refer 3.4.2 (2) 2-3-5) of the Guide |
| Average Vehicle Operating Cost per km on detour road | s | | pesos per vehicle*km | 16.00 | |
| **2-3) Annual detour cost** | t | t=FRCDp*p*q*(o*s-n*r) | pesos per year | 1,652,628 | refer 3.4.2 (2) 2-3) of the Guide |
| ***Total Annual Loss*** | u | u=j+m+t | pesos per year | 1,774,032 | refer 3.4.2 (2) of the Guide |
| *(3) Feasibility Indicators of Countermeasures* | | | | | |
| *Countermeasure alternative I* | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v I | | pesos | 2,004,210 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w I | | ratio | 0.9 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x I | x I = u* wI | pesos per year | 1,596,629 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc I | FRCDpwc I = FRCDp*(1- wI) | ratio | 0.016 | refer 3.4.2 (3) 3-4) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR I | | ratio | 5.73 | refer 3.4.2 (3) of the Guide |
| ***Economic net present value at 15% discount rate*** | ENPV I | | pesos | 6,947,495 | |
| ***Economic internal rate of return*** | EIRR I | | percent | 80% | |
| *Countermeasure alternative II* | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v II | | pesos | 303,750 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w II | | ratio | 0.7 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x II | x II = u* wII | pesos per year | 1,241,822 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc II | FRCDpwc II = FRCDp*(1- wII) | ratio | 0.049 | refer 3.4.2 (3) 3-4) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR II | | ratio | 29.43 | |
| ***Economic net present value at 15% discount rate*** | ENPV II | | pesos | 6,494,981 | |
| ***Economic internal rate of return*** | EIRR II | | percent | 409% | |
| *Countermeasure alternative III* | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v III | | pesos | 33,578 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w III | | ratio | 0.3 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x III | x III = u * w III | pesos per year | 532,210 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc II | FRCDpwc III= FRCDp*(1- wIII) | ratio | 0.113 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR III | | ratio | 114.09 | |
| ***Economic net present value at 15% discount rate*** | ENPV III | | pesos | 2,867,564 | |
| ***Economic internal rate of return*** | EIRR III | | percent | 1585% | |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.28 Example of Inventory Sheet 5: Indicative Feasibility Assessment for Rock Slope Collapse**

### 3) Road Slip

As an example, the DIS results for Cebu-Balamban Transcentral Highway (28 km 843m-943m) for Road Slip are shown in Figure 5.29 to 5.34.

Road Slips are the most dominant disaster type in selected slopes for DIS in this pilot DIS.

As shown in the General View (Figure 5.29) and Sheet 3: Sketches (Figure 5.30), rain water flows from the road to the valley side slope and cause Road Slips. Considering these conditions, the countermeasure alternatives were planned as summarized in Table 5.12.

Based on the outputs from Sheets 1 to 4, an indicative feasibility assessment was undertaken, as shown in Figure 5.30.

**Table 5.12 Example of Countermeasure Alternative Planning for Road Slip**

| Alternative | Effectiveness | Risk Reduction Ratio |
|---|---|---|
| Alternative-I | High Effectiveness: Permanent countermeasures to prevent disasters<br><br>- Concrete Retaining Wall<br>- Embankment with Geotextile<br>- Drainage system with Catch Basin | 0.9 |
| Alternative-II | Moderate Effectiveness: Mitigating the disasters to some extent<br><br>- Grouted Riprap Retaining Wall<br>- Drainage System and Catch Basin | 0.7 |
| Alternative-III | Low Effectiveness: Limited treatment<br><br>-Drainage System with Catch Basin | 0.3 |

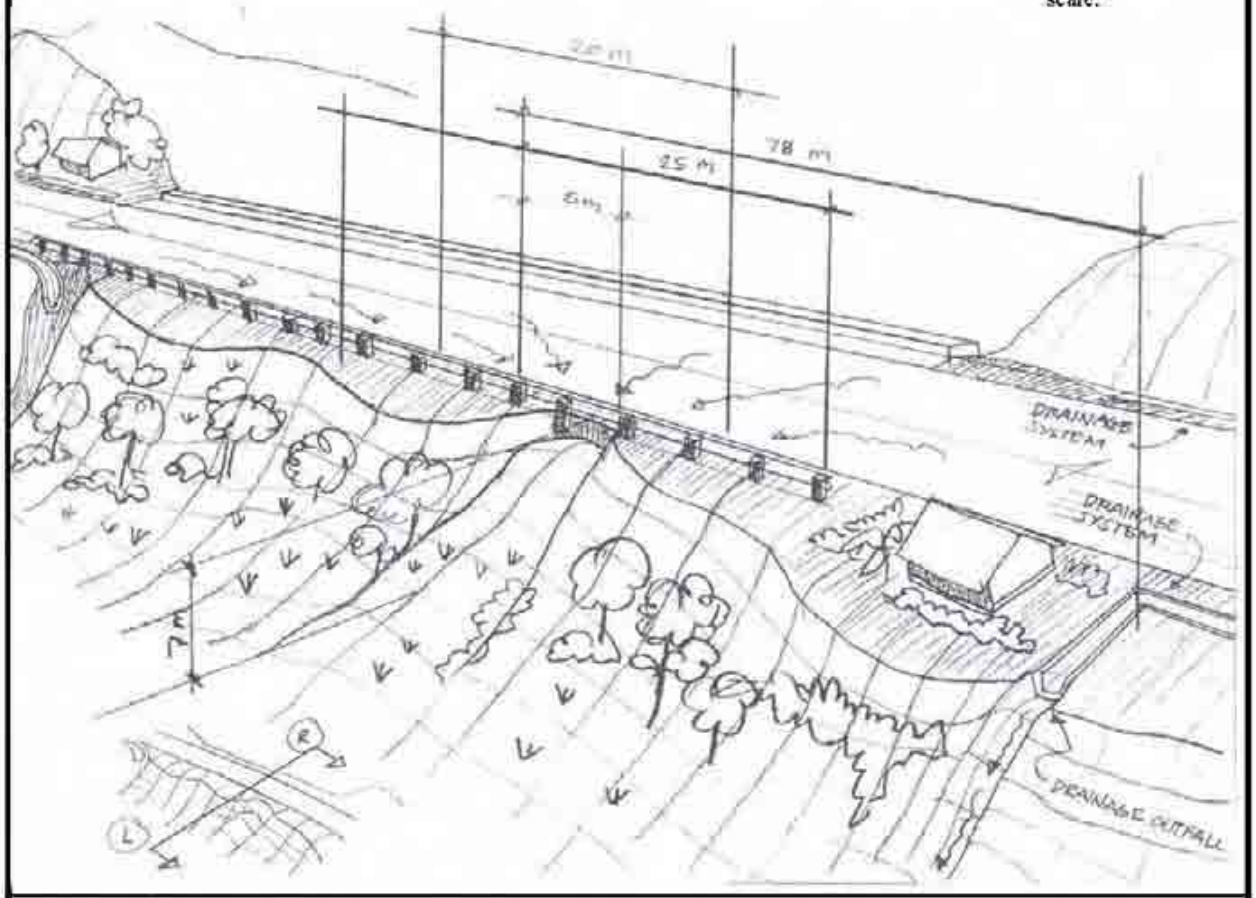
**Figure 5.29 General View of Example DIS Slope for Road Slip**

**Inventory Sheet 3 Sketches**

| | | | | | |
|---|---|---|---|---|---|
| Road Name | Cebu-Balamban Transcentral Highway | | | | |
| Station from | km 28 | m 843 | Side of survey | Left side of road | |
| Name of Inspector/ Coordinator for detailed inventory survey; sheet 3, 4, 5 | | Survey date (d/m/y) | Date | Month | Year |
| Name of inspector | JUDEFER P. CASTAÑOS | | 27 | Nov. | 2006 |

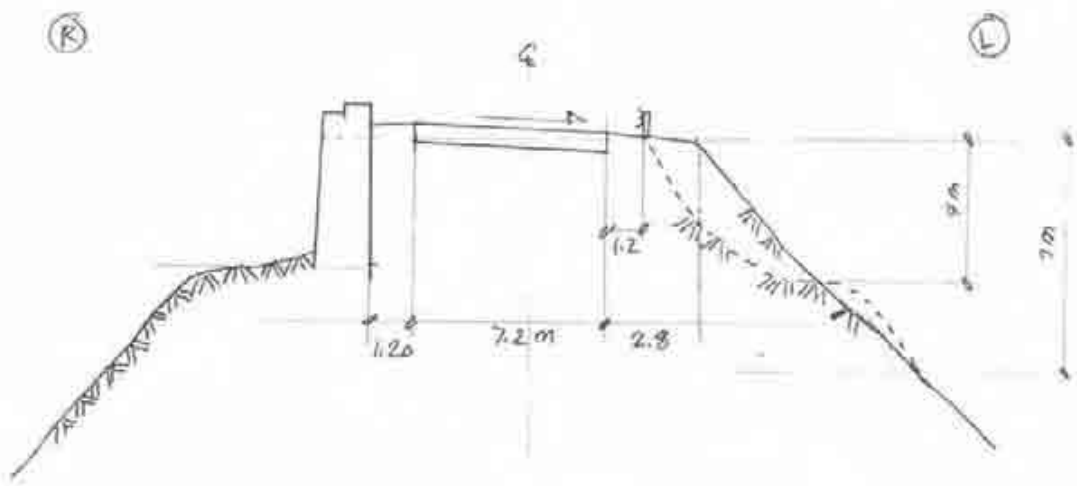
3-1 Front view sketches

scale:




3-2 Cross section sketches

scale:



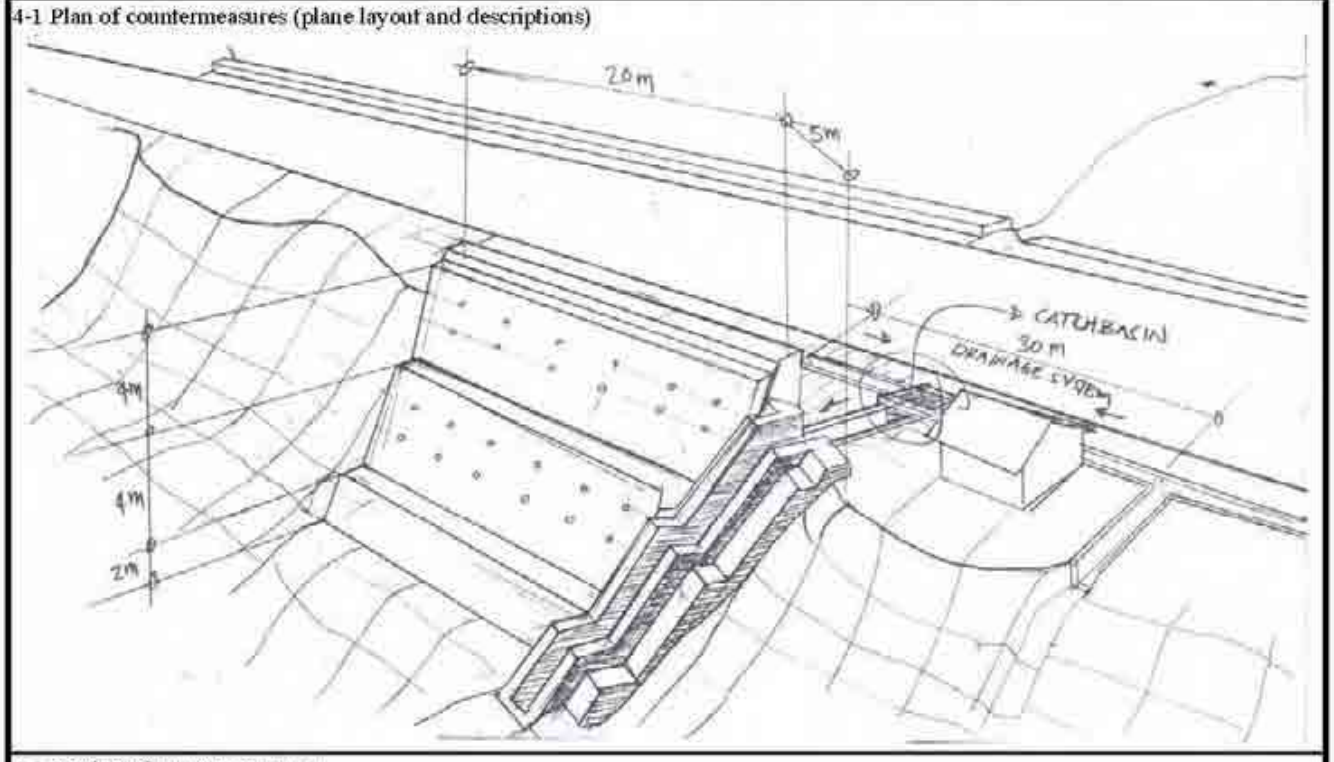

Note
- Numerical value or terms should be inputted.
- Numerical value is automatically inputted.

**Figure 5.30 Example of Inventory Sheet 3: Sketches for Road Slip**

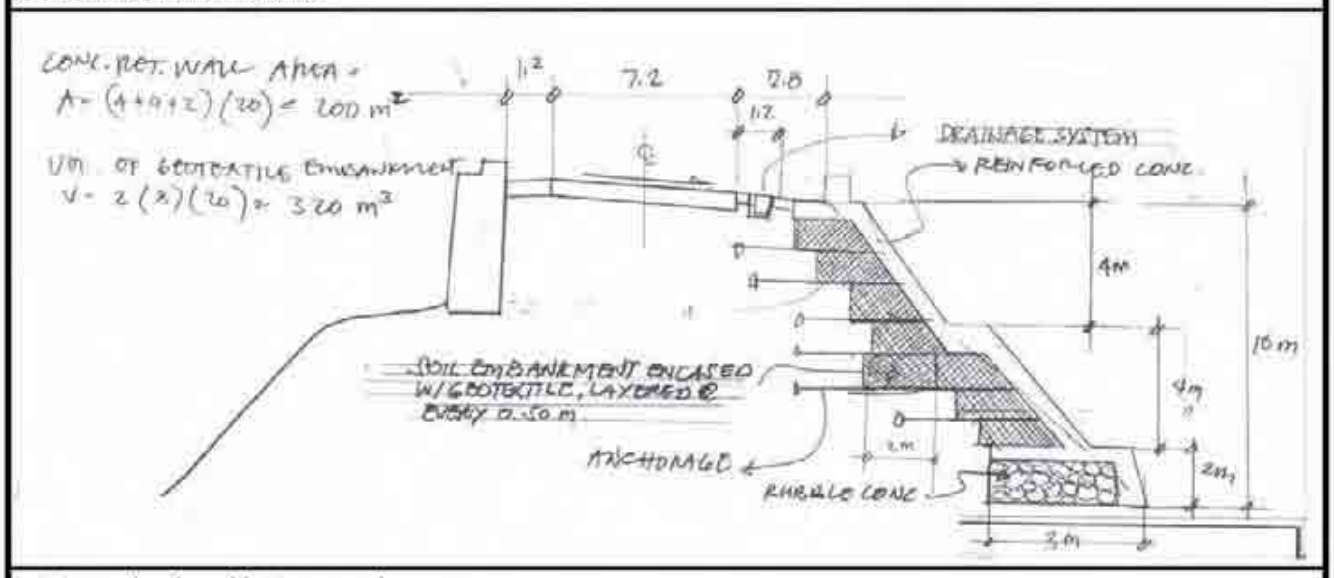
**Inventory Sheet 4-1 Planning of Countermeasures** Alternative I

| Road Name | Cebu-Balamban Transcentral Highway | | | | |
|---|---|---|---|---|---|
| Station from | km | 28 | m 842.7 | Side of survey | Left side of road |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Concrete Retaining Wall | $m^2$ | 200 | 6,976.00 | 1,395,200.00 |
| 2 | Embankment w/ Geotextile (Reinforced Embankment) | $m^3$ | 320 | 1,824.00 | 583,680.00 |
| 3 | Drainage System | lm | 30 | 3,492.00 | 104,760.00 |
| 4 | Catchbasin | each | 1 | 7,452.00 | 7,452.00 |
| 5 | Maintenance +30% | LS | 1 | 627,327.60 | 627,327.60 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 2,718,420 |

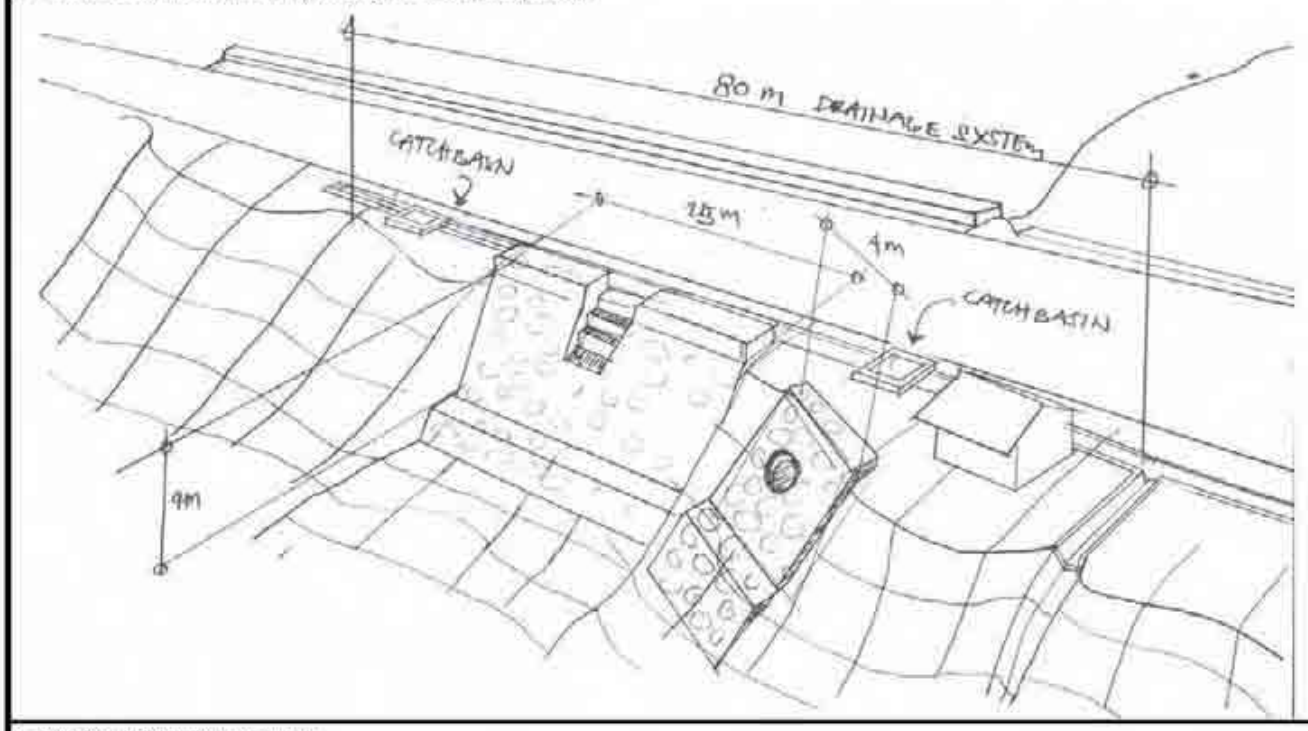
Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.31 Example of Inventory Sheet 3: Planning of Countermeasure Alternative I for Road Slip**

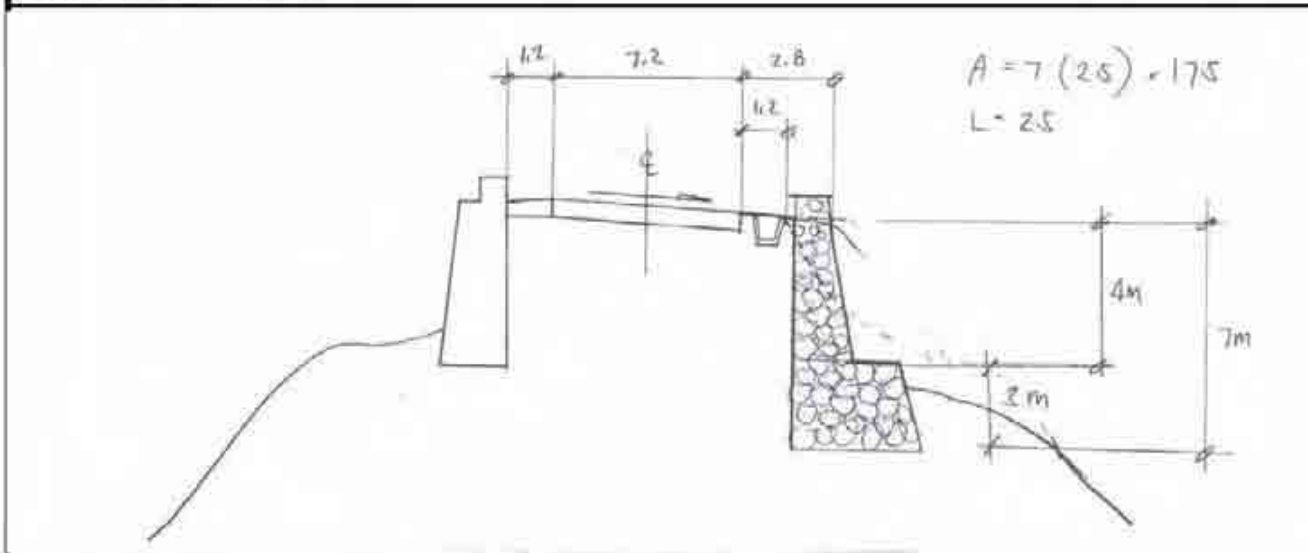
**Inventory Sheet 4-2 Planning of Countermeasures** Alternative II

| Road Name | Cebu-Balamban Transcentral Highway | | | | |
|---|---|---|---|---|---|
| Station from | km 28 | m 842.7 | Side of survey | Left side of road | |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Grouted Riprap Retaining Wall | $m^2$ | 175 | 5,200.00 | 910,000.00 |
| 2 | Drainage System | lm | 80 | 3,492.00 | 279,360.00 |
| 3 | Catchbasin | each | 2 | 7,452.00 | 14,904.00 |
| 4 | Maintenance +60% | LS | 1 | 602,132.00 | 602,132.00 |
| 5 | | | | | 0 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 1,806,396 |

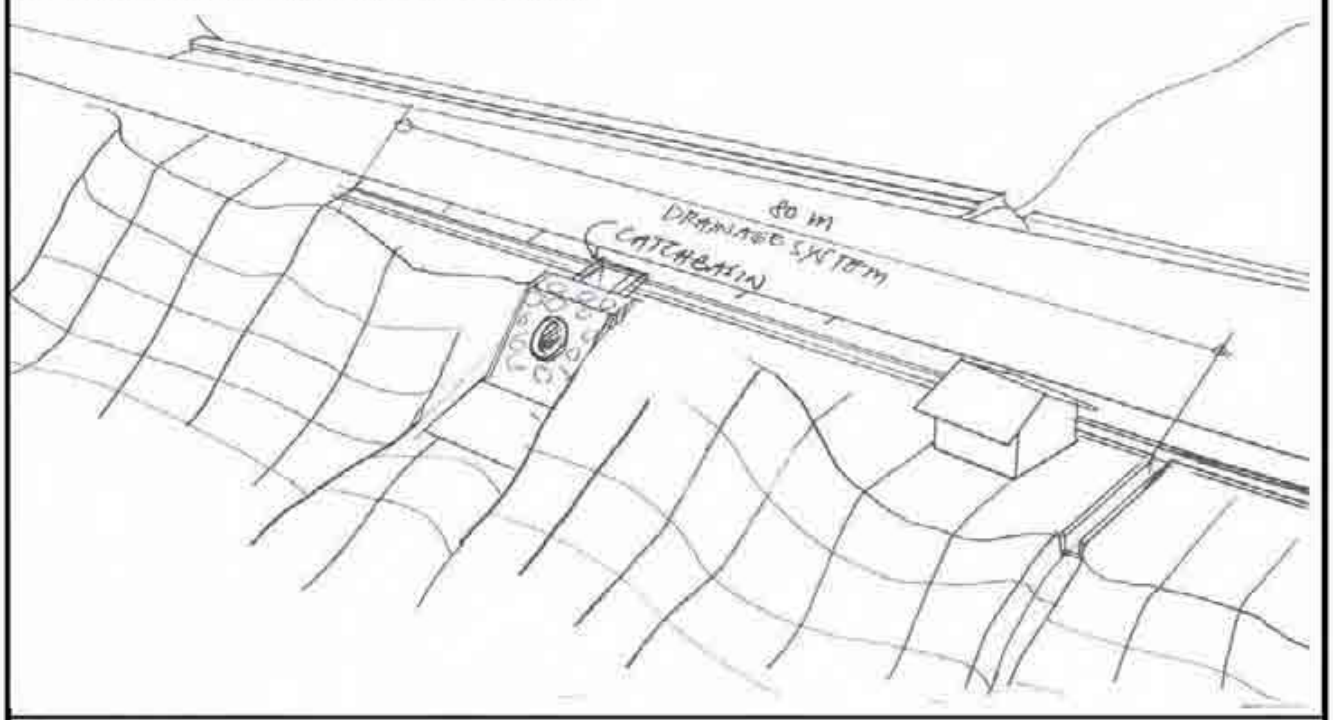
Note
Numerical value or terms should be inputted
Numerical value is automatically inputted

**Figure 5.32 Example of Inventory Sheet 4-2: Planning of Countermeasure Alternative II for Road Slip**

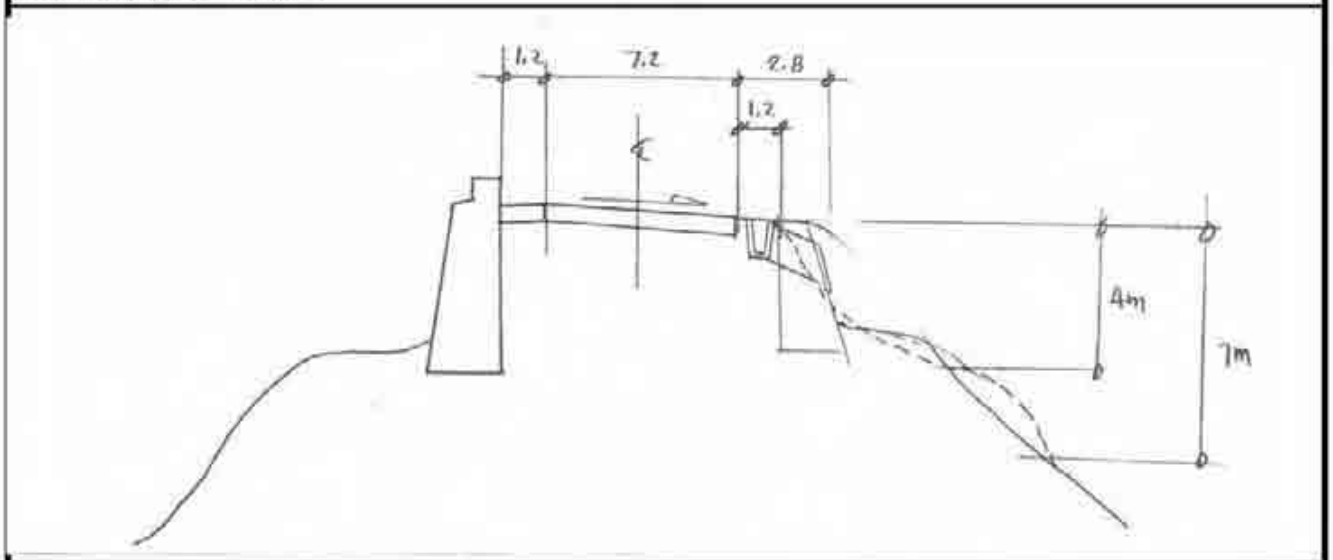
**Inventory Sheet 4-3 Planning of Countermeasures** Alternative III

| Road Name | Cebu-Balamban Transcentral Highway | | | | |
|---|---|---|---|---|---|
| Station from | km | 28 | m 842.7 | Side of survey | Left side of road |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Drainage System | lm | 80 | 3,492.00 | 279,360.00 |
| 2 | Catchbasin | each | 1 | 7,452.00 | 7,452.00 |
| 3 | Maintenance +70% | LS | 1 | 200,768.40 | 200,768.40 |
| 4 | | | | | 0 |
| 5 | | | | | 0 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 487,580 |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.33 Example of Inventory Sheet 4-3: Planning of Countermeasure Alternative III for Road Slip**

**Inventory Sheet 5-4** **Indicative Feasibility Assessment for RS**

| | | | | | |
|---|---|---|---|---|---|
| Road Name | Cebu-Balamban Transcentral Highway | | | | |
| Km station from | km | 28 | m | 842.7 | |
| Side of survey | Left side of road | | | | |

| Items | symbol | equation | Unit | Quantity | Remark |
|---|---|---|---|---|---|
| ***(1) Disaster Frequency and Magnitude*** | | | | | |
| ***1-1) Potential frequency of road closure disaster*** | FRCDp | | nos. per year | 0.067 | sheet 2 |
| ***1-2) Length of road closure site*** | LRC | | m | 25 | refer 3.4.2 1-2) of the Guide |
| ***(2) Annual Losses Without Countermeasure*** | | | | | |
| 2-1-1) Reopening cost per length of road closure site (excluding fixed cost) | h | | pesos per m | 71 | refer 3.4.2 2-1-1) of the Guide |
| Fixed cost for reopening per RCD | i | | pesos per RCD | 600,000 | |
| **2-1) Annual reopening cost** | j | j=FRCDp*(h*LRC+i) | pesos per year | 40,319 | refer 3.4.3 2-1) of the Guide |
| 2-2-1) Average number of human deaths per RCD | k | k=0.006 | ave. death per RCD | 0.004 | refer 3.4.2 (2) 2-2-1) of the Guide |
| 2-2-2) Unit value of human life lost (death) | l | | pesos per human life | 2,300,000 | refer 3.4.2 (2) 2-2-2) of the Guide |
| **2-2) Annual value of human lives lost** | m | m=FRCDp*k*l | pesos per year | 616 | refer 3.4.2 (2) 2-2) of the Guide |
| 2-3-1) Length of survey road (from entry to exit point of detour road to avoid road closure site on survey road) | n | | km | 42 | refer 3.4.2 (2) 2-3-1) of the Guide |
| Length of detour road (from entry to exit point of survey road to avoid road closure site on survey road) | o | | km | 49 | refer 3.4.2 (2) 2-3-2) of the Guide |
| 2-3-2) AADT: Annual Average Daily Traffic on the survey site | p | | vehicles per day | 3,253 | refer 3.4.2 (2) 2-3-3) of the Guide |
| 2-3-3) Nos. of predicted closure days of the whole width of the road on the survey site per RCD | q | | days | 9.0 | refer 3.4.2 (2) 2-3-4) of the Guide |
| 2-3-4) Average Vehicle Operating Cost per km on survey road | r | | pesos per vehicle*km | 8.00 | refer 3.4.2 (2) 2-3-5) of the Guide |
| Average Vehicle Operating Cost per km on detour road | s | | pesos per vehicle*km | 16.00 | |
| **2-3) Annual detour cost** | t | t=FRCDp*p*q*(o*s-n*r) | pesos per year | 878,778 | refer 3.4.2 (2) 2-3) of the Guide |
| ***Total Annual Loss*** | u | u=j+m+t | pesos per year | 919,714 | refer 3.4.2 (2) of the Guide |
| ***(3) Feasibility Indicators of Countermeasures*** | | | | | |
| ***Countermeasure alternative I*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v I | | pesos | 2,718,420 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w I | | ratio | 0.9 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x I | x I = u* wI | pesos per year | 827,742 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDwc I | FRCDpwc I = FRCDp*(1- wI) | nos. per year | 0.007 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR I | | ratio | 2.19 | |
| ***Economic net present value at 15% discount rate*** | ENPV I | | pesos | 2,141,473 | |
| ***Economic internal rate of return*** | EIRR I | | percent | 30% | |
| ***Countermeasure alternative II*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v II | | pesos | 1,806,396 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w II | | ratio | 0.7 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x II | x II = u* wII | pesos per year | 643,800 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc II | FRCDpwc II = FRCDp*(1- wII) | nos. per year | 0.020 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR II | | ratio | 2.57 | |
| ***Economic net present value at 15% discount rate*** | ENPV II | | pesos | 1,933,356 | |
| ***Economic internal rate of return*** | EIRR II | | percent | 36% | |
| ***Countermeasure alternative III*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v III | | pesos | 487,580 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w III | | ratio | 0.3 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x III | x III = u * w III | pesos per year | 275,914 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc III | FRCDpwc III = FRCDp*(1 - wIII) | nos. per year | 0.047 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR III | | ratio | 4.07 | |
| ***Economic net present value at 15% discount rate*** | ENPV III | | pesos | 1,077,789 | |
| ***Economic internal rate of return*** | EIRR III | | percent | 57% | |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.34 Example of Inventory Sheet 5: Indicative Feasibility Assessment for Road Slip**

**4) Debris Flow**

As an example, the DIS results for Daang Maharlika (LZ) (211 km 197m-201m) for Debris Flow are shown in Figure 5.35 to 5.40.

The countermeasure alternatives were planned as summarized in Table 5.13.

Based on the outputs from Sheets 1 to 4, an indicative feasibility assessment was undertaken, as shown in Figure 5.40.

**Table 5.13 Example of Countermeasure Alternative Planning for Debris Flow**

| Alternative | Effectiveness | Risk Reduction Ratio |
|---|---|---|
| Alternative-I | High Effectiveness: Permanent countermeasures to prevent disasters<br><br>- Concrete check dam | 0.95 |
| Alternative-II | Moderate Effectiveness: Mitigating the disasters to some extent<br><br>- Gabion check dam | 0.65 |
| Alternative-III | Low Effectiveness: Limited treatment<br><br>- Slope cutting | 0.1 |

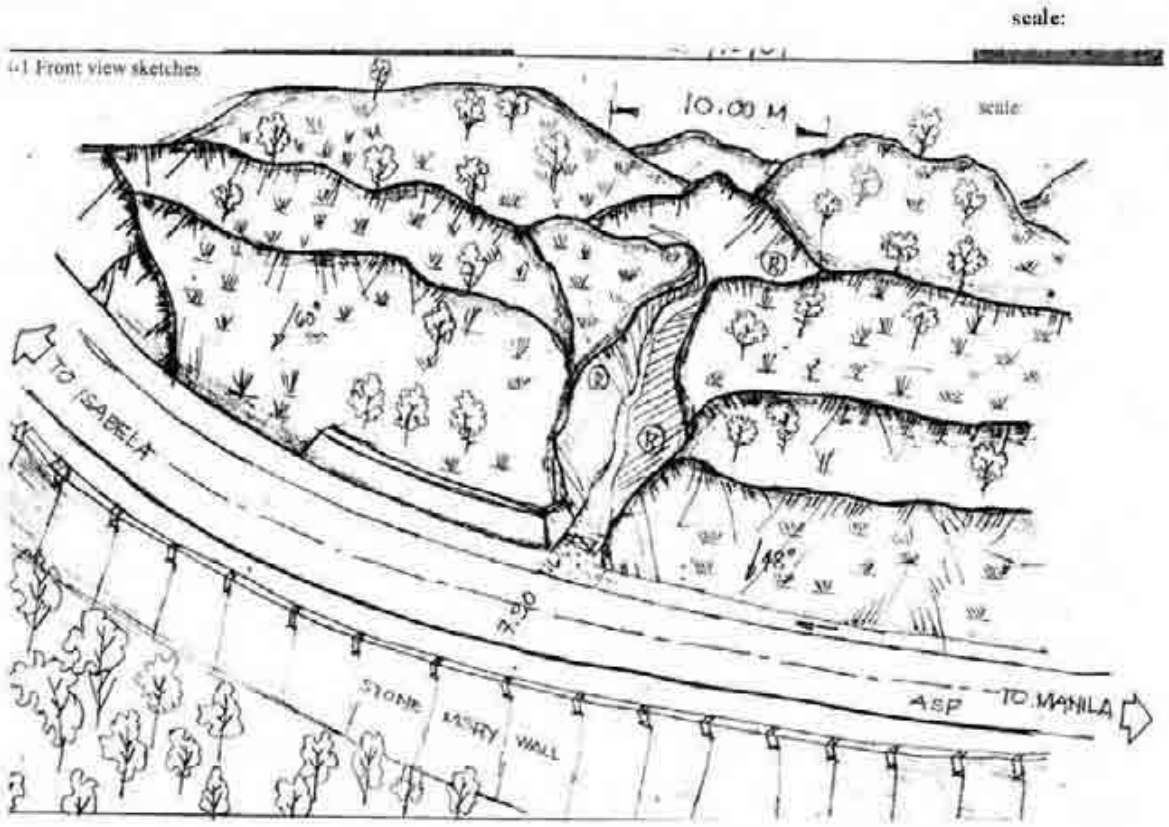
**Figure 5.35 General View of Example DIS Slope for Debris Flow**

**Inventory Sheet 3 Sketches**

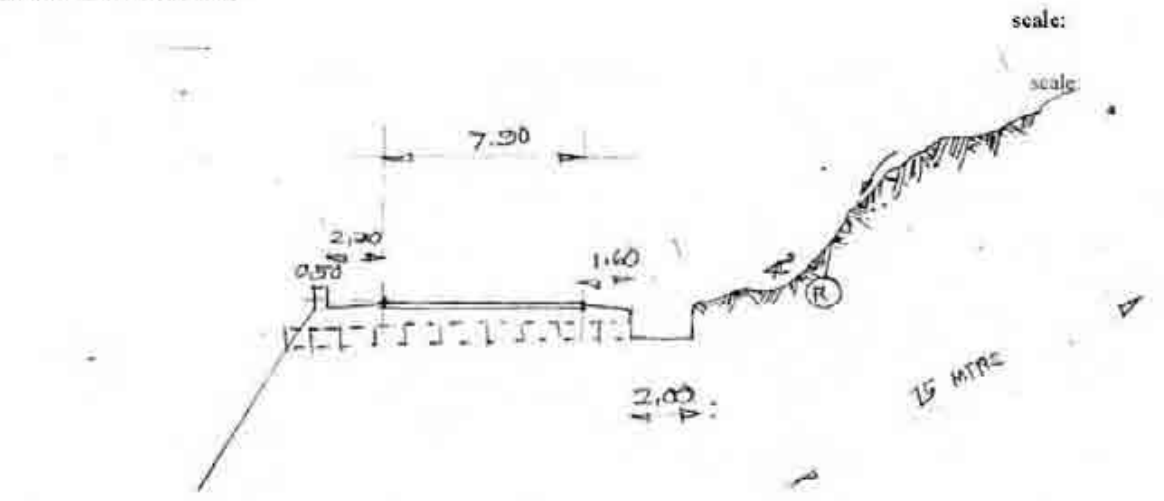
| Road Name | Daang Maharlika (LZ) | | | |
|---|---|---|---|---|
| Station from | km 211 | m 197 | Side of survey | Right side of road |

| Name of Inspector/ Coordinator for detailed inventory survey; sheet 3, 4, 5 | | Survey date (dd/mm/yy) | Date | Month | Year |
|---|---|---|---|---|---|
| Name of Inspector | Simon Quijano | | 17 | Jan. | 2007 |

3-1 Front view sketches




3-2 Cross section sketches



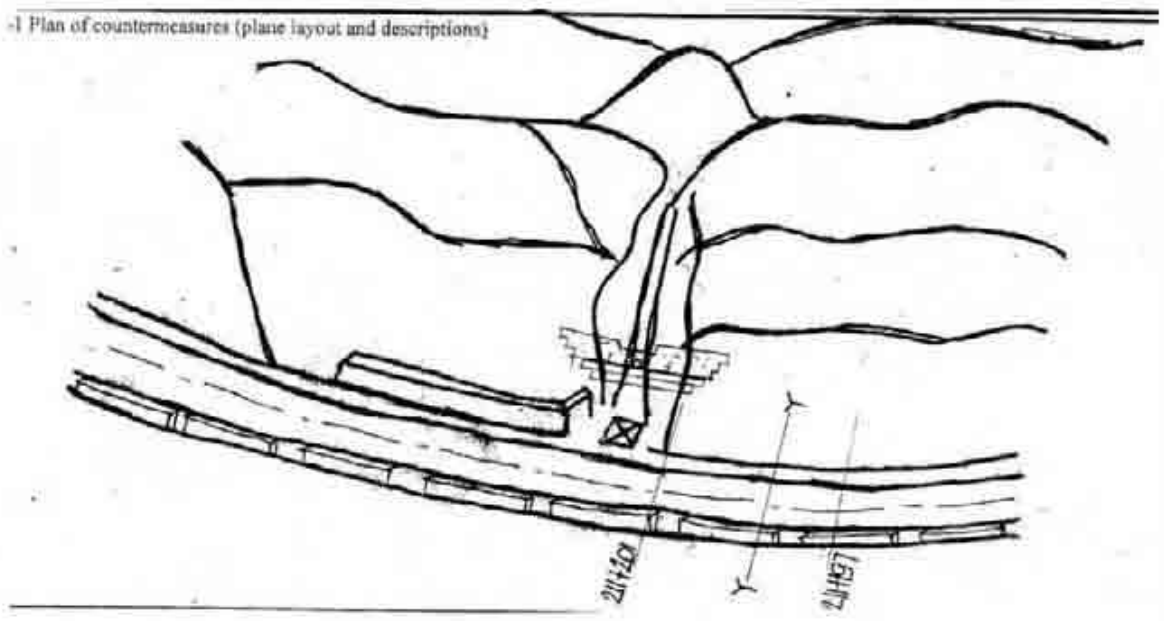

Note
- Numerical value or terms should be inputted.
- Numerical value is automatically inputted.

**Figure 5.36 Example of Inventory Sheet 3: Sketches for Debris Flow**

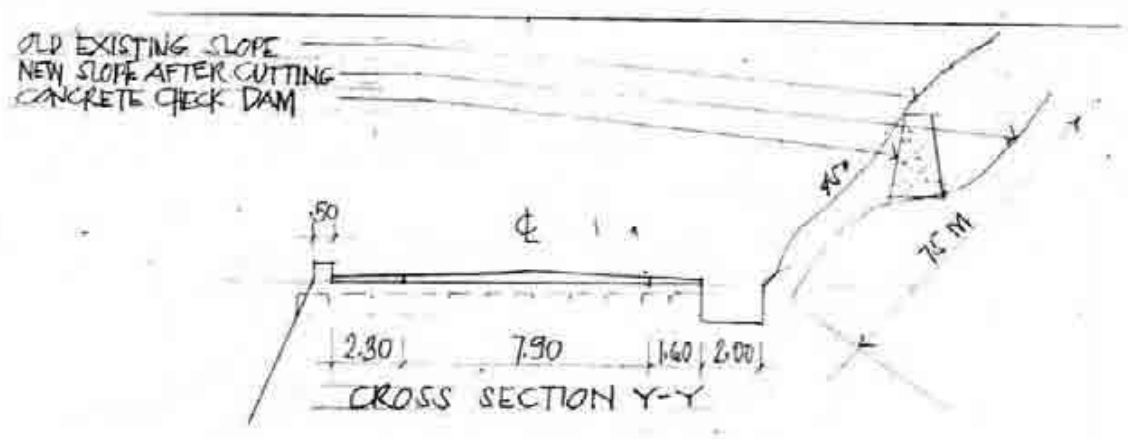
**Inventory Sheet 4-1 Planning of Countermeasures** Alternative I

| Road Name | Daang Maharlika (LZ) | | | | |
|---|---|---|---|---|---|
| Station from | km | 211 m | 197 | Side of survey | Right side of road |

4-1 Plan of countermeasure (plane layout and description)




4-2 Section of countermeasure




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Cutting | m3 | 600 | 516 | 309,600 |
| 2 | Concrete Check dam | ls | 1 | 560,832 | 560,832 |
| 3 | Maintenance Cost | | | | |
| 4 | 5% (6-10 yrs) | | 1 | 43,522 | 43,522 |
| 5 | 10% (11-15 yrs) | | 1 | 87,043 | 87,043 |
| 6 | 15% (16-20 yrs) | | 1 | 130,565 | 130,565 |
| 7 | | | | | 0 |
| Total Cost | | | | | 1,131,562 |

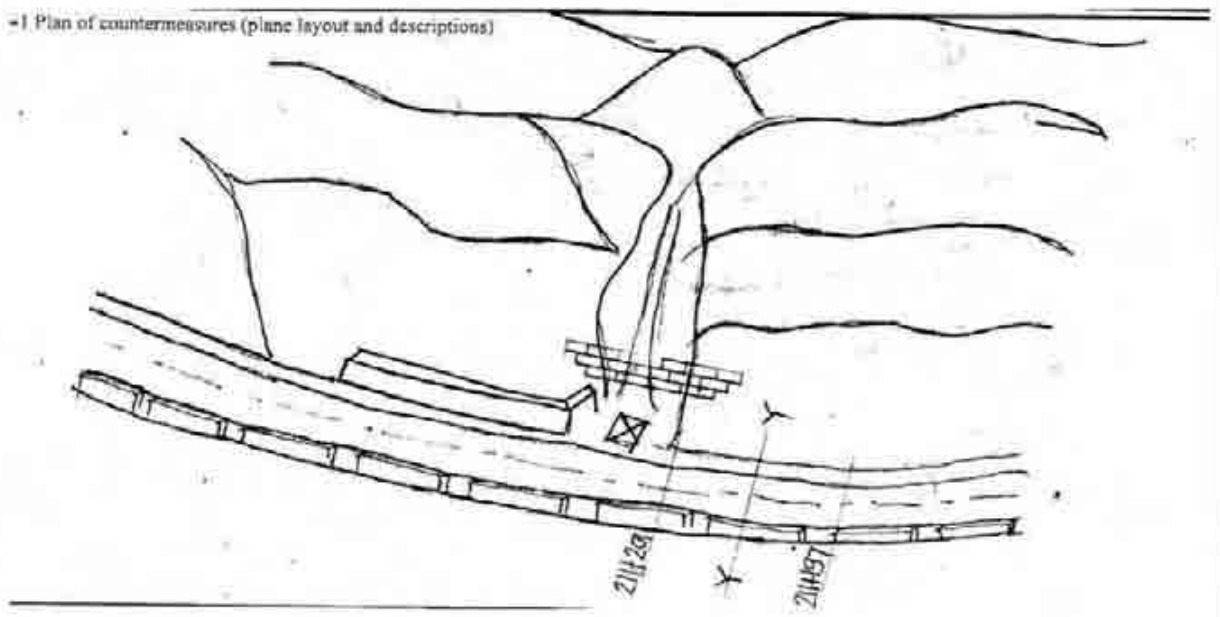
Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.37 Example of Inventory Sheet 4-1: Planning of Countermeasure Alternative I for Debris Flow**

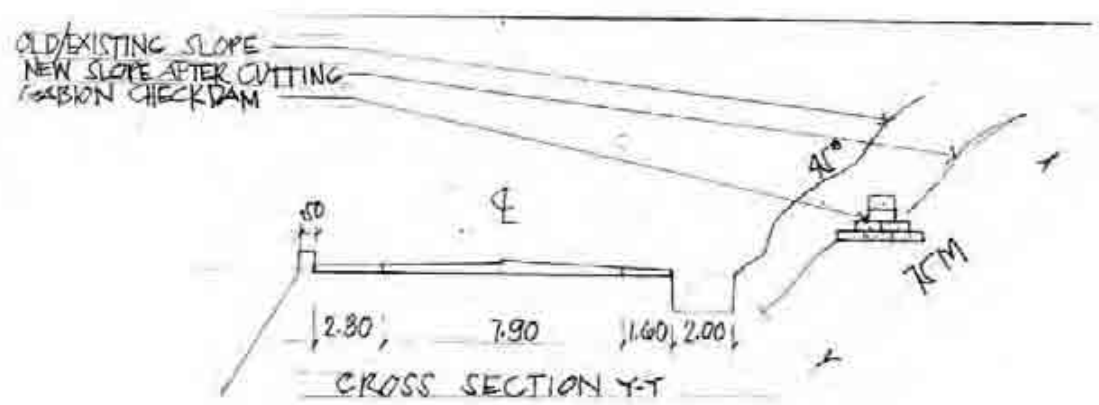
**Inventory Sheet 4-2 Planning of Countermeasure** Alternative II

| Road Name | Daang Maharlika (L.Z.) | | | | |
|---|---|---|---|---|---|
| Station from | km | 211 m | 197 | Side of survey | Right side of road |

4-1 Plan of countermeasure (plane layout and descriptions)




4-2 Section of Countermeasure




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Cutting | m3 | 600 | 516 | 309,600 |
| 2 | Gabion Check dam | ls | 1 | 214,836 | 214,836 |
| 3 | Maintenance Cost | | | | 0 |
| 4 | 5% (6-10 yrs) | | 1 | 26,222 | 26,222 |
| 5 | 10% (11-15 yrs) | | 1 | 52,444 | 52,444 |
| 6 | 15% (16-20 yrs) | | 1 | 78,665 | 78,665 |
| 7 | | | | | 0 |
| Total Cost | | | | | 681,767 |

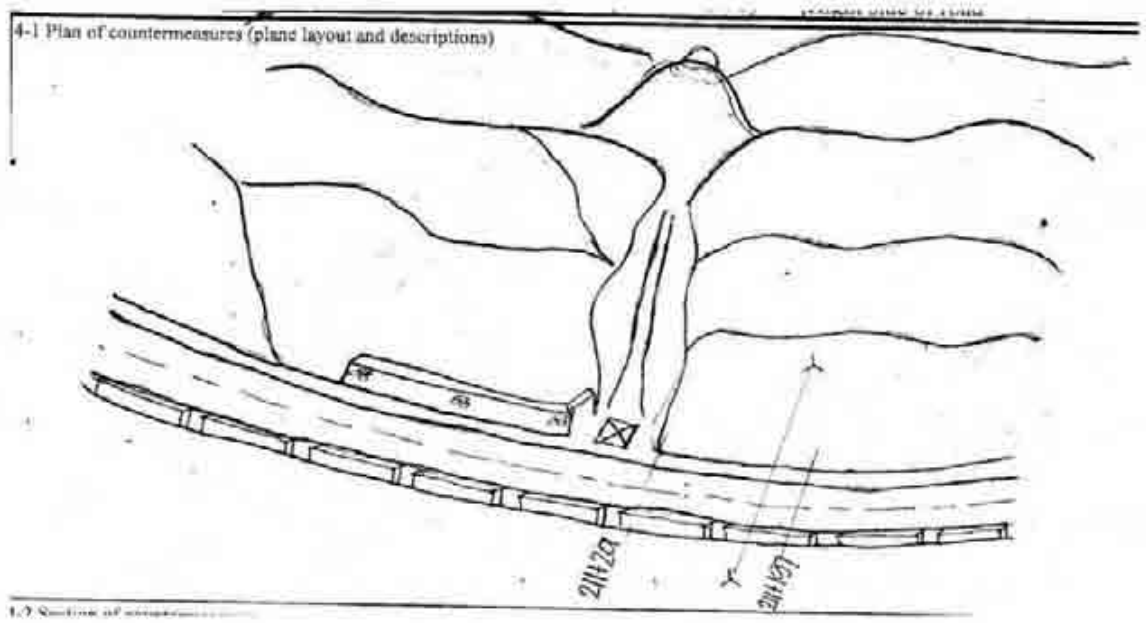
Note
Numerical value or terms should be inputted
Numerical value is automatically inputted

**Figure 5.38 Example of Inventory Sheet 4-2: Planning of Countermeasure Alternative II for Debris Flow**

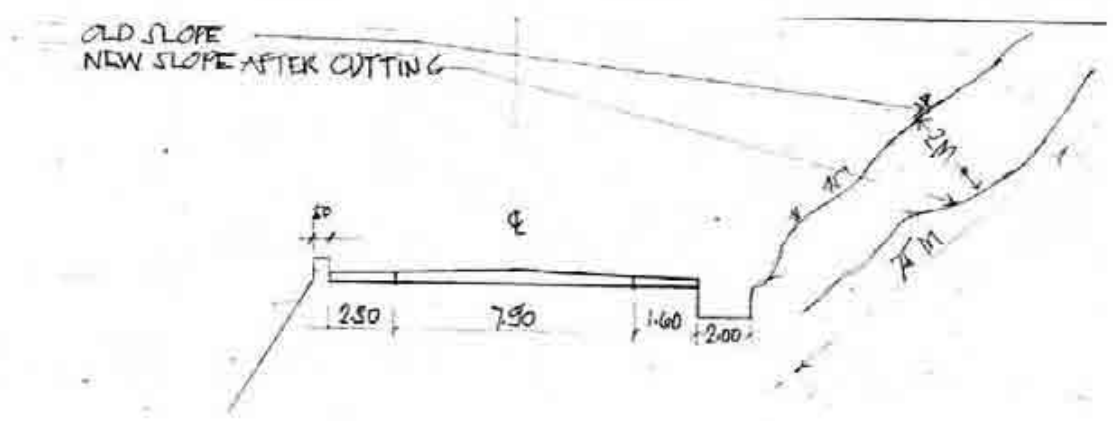
**Inventory Sheet 4-3 Planning of Countermeasure** Alternative III

| Road Name | Daang Maharlika (LZ) | | |
|---|---|---|---|
| Station from | km 211 m 197 | Side of survey | Right side of road |

4-1 Plan of countermeasure (plane layout and descriptions)




4-2 Section of countermeasure




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Cutting | m3 | 600 | 516 | 309,600 |
| 2 | | | | | |
| 3 | Maintenance Cost | | | | |
| 4 | 5% (6-10 yrs) | | 1 | 15,480 | 15,480 |
| 5 | 10% (11-15 yrs) | | 1 | 30,960 | 30,960 |
| 6 | 15% (16-20 yrs) | | 1 | 46,440 | 46,440 |
| 7 | | | | | 0 |
| Total Cost | | | | | 402,480 |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.39 Example of Inventory Sheet 4-3: Planning of Countermeasure Alternative III for Debris Flow**

**Inventory Sheet 5-5** **Indicative Feasibility Assessment for DF**

| | | | | |
|---|---|---|---|---|
| Road Name | Daang Maharlika (LZ) | | | |
| Km station from | km | 211 | m | 197 |
| Side of survey | Right side of road | | | |

| Items | symbol | equation | Unit | Quantity | Remark |
|---|---|---|---|---|---|
| ***(1) Disaster Frequency and Magnitude*** | | | | | |
| ***1-1) Potential frequency of road closure disaster*** | FRCDp | | nos. per year | 0.247 | sheet 2 |
| ***1-2) Length of road closure site*** | LRC | | m | 4 | refer 3.4.2 1-2) of the Guide |
| ***(2) Annual Losses Without Countermeasure*** | | | | | |
| 2-1-1) Reopening cost per length of road closure site (excluding fixed cost) | h | | pesos per m | 170 | refer 3.4.2 2-1-1) of the Guide |
| Fixed cost for reopening per RCD | i | | pesos per RCD | 680 | |
| **2-1) Annual reopening cost** | j | j=FRCDp*(h*LRC+i) | pesos per year | 336 | refer 3.4.3 2-1) of the Guide |
| 2-2-1) Average number of human deaths per RCD | k | k=0.006 | ave. death per RCD | 0.004 | refer 3.4.2 (2) 2-2-1) of the Guide |
| 2-2-2) Unit value of human life lost (death) | l | | pesos per human life | 2,300,000 | refer 3.4.2 (2) 2-2-2) of the Guide |
| **2-2) Annual value of human lives lost** | m | m=FRCDp*k*l | pesos per year | 2,272 | refer 3.4.2 (2) 2-2) of the Guide |
| 2-3-1) Length of survey road (from entry to exit point of detour road to avoid road closure site on survey road) | n | | km | 71 | refer 3.4.2 (2) 2-3-1) of the Guide |
| Length of detour road (from entry to exit point of survey road to avoid road closure site on survey road) | o | | km | 326 | refer 3.4.2 (2) 2-3-2) of the Guide |
| 2-3-2) AADT: Annual Average Daily Traffic on the survey site | p | | vehicles per day | 2,755 | refer 3.4.2 (2) 2-3-3) of the Guide |
| 2-3-3) Nos. of predicted closure days of the whole width of the road on the survey site per RCD | q | | days | 1.0 | refer 3.4.2 (2) 2-3-4) of the Guide |
| 2-3-4) Average Vehicle Operating Cost per km on survey road | r | | pesos per vehicle*km | 7.80 | refer 3.4.2 (2) 2-3-5) of the Guide |
| Average Vehicle Operating Cost per km on detour road | s | | pesos per vehicle*km | 9.55 | |
| **2-3) Annual detour cost** | t | t=FRCDp*p*q*(o*s-n*r) | pesos per year | 1,741,701 | refer 3.4.2 (2) 2-3) of the Guide |
| ***Total Annual Loss*** | u | u=j+m+t | pesos per year | 1,744,310 | refer 3.4.2 (2) of the Guide |
| ***(3) Feasibility Indicators of Countermeasures*** | | | | | |
| ***Countermeasure alternative I*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v I | | pesos | 1,131,562 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w I | | ratio | 0.95 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x I | x I = u* wI | pesos per year | 1,657,094 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDwc I | FRCDpwc I = FRCDp*(1- wI) | nos. per year | 0.012 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR I | | ratio | 10.54 | |
| ***Economic net present value at 15% discount rate*** | ENPV I | | pesos | 8,035,426 | |
| ***Economic internal rate of return*** | EIRR I | | percent | 146% | |
| ***Countermeasure alternative II*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v II | | pesos | 681,767 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w II | | ratio | 0.65 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x II | x II = u* wII | pesos per year | 1,133,801 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc II | FRCDpwc II = FRCDp*(1- wII) | nos. per year | 0.086 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR II | | ratio | 11.97 | |
| ***Economic net present value at 15% discount rate*** | ENPV II | | pesos | 5,578,323 | |
| ***Economic internal rate of return*** | EIRR II | | percent | 166% | |
| ***Countermeasure alternative III*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v III | | pesos | 402,480 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w III | | ratio | 0.1 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x III | x III = u * w III | pesos per year | 174,431 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc III | FRCDpwc III = FRCDp*(1- wIII) | nos. per year | 0.222 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR III | | ratio | 3.12 | |
| ***Economic net present value at 15% discount rate*** | ENPV III | | pesos | 599,427 | |
| ***Economic internal rate of return*** | EIRR III | | percent | 43% | |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.40 Example of Inventory Sheet 5: Indicative Feasibility Assessment for Debris Flow**

**5) River Erosion**

As an example, the DIS results of Kennon Rd (215 km 132 m- 327 m) for River Erosion are shown in Figure 5.41 to 5.45.

The countermeasure alternatives were planned as summarized in Table 5.14.

Based on the outputs from Sheets 1 to 4, the indicative feasibility assessment was undertaken, as shown in Figure 5.45.

**Table 5.14 Example of Countermeasure Alternative Planning for River Erosion**

| Alternative | Effectiveness | Risk Reduction Ratio |
|---|---|---|
| Alternative-I | High Effectiveness: Permanent countermeasures to prevent disasters<br><br>-Grouted riprap and crib wall | 0.9 |
| Alternative-II | Moderate Effectiveness: Mitigating the disasters to some extent<br><br>- Grouted riprap | 0.6 |
| Alternative-III | Low Effectiveness: Limited treatment<br><br>-Embankment on riverside | 0.01 |

**Figure 5.41 General View of Example DIS Slope for River Erosion**

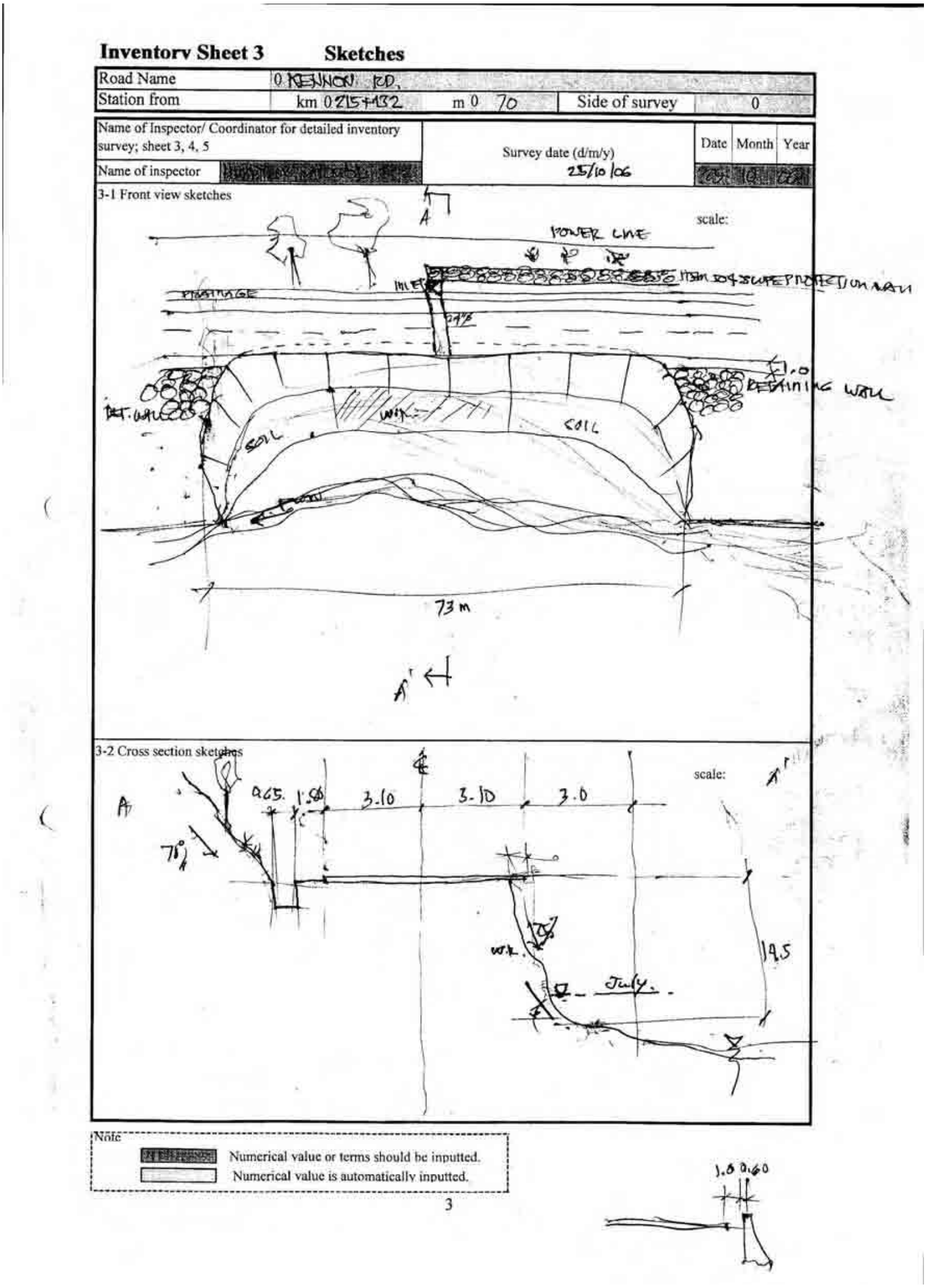


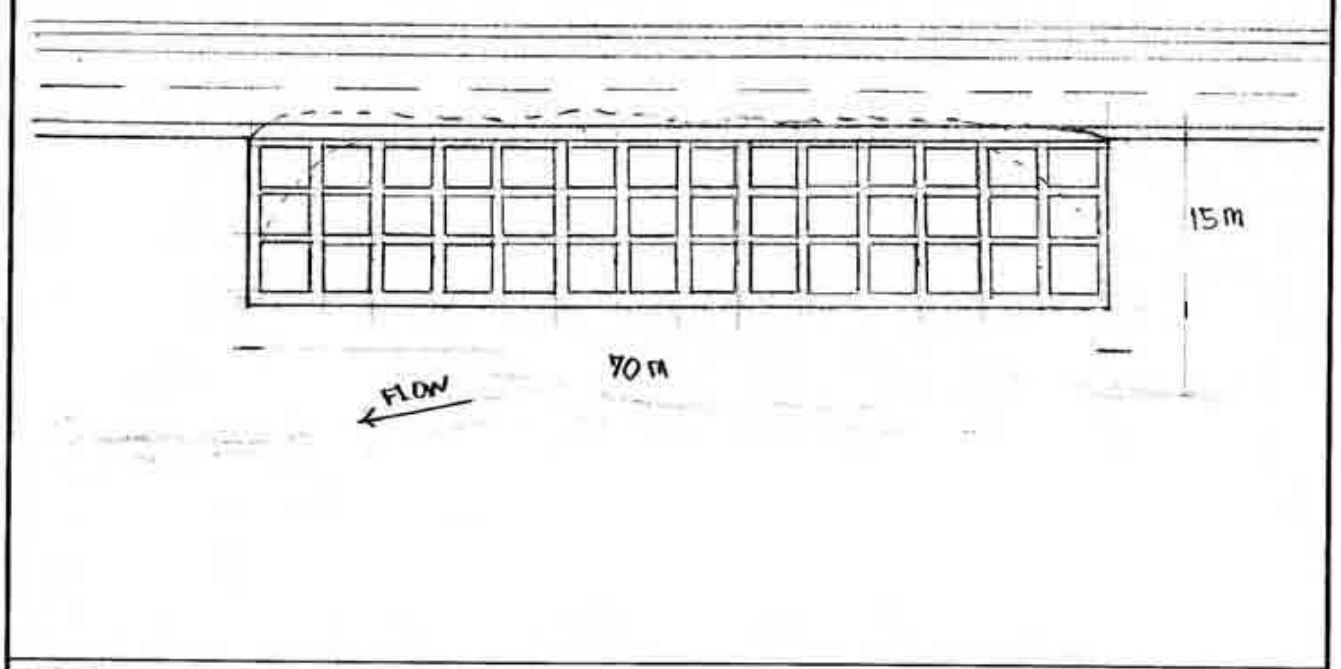

**Figure 5.42 Example of Inventory Sheet 3: Sketches for River Erosion**

PREPARED BY: HENRY V. APOSTOL

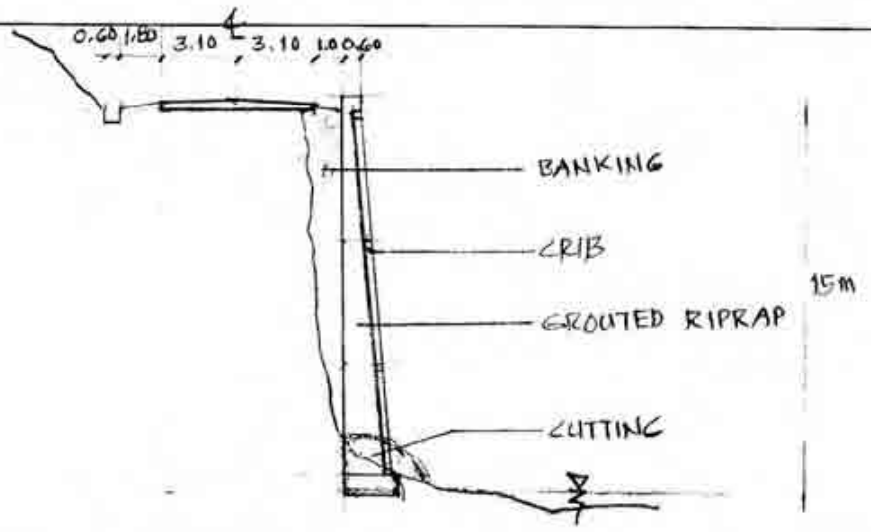
**Inventory Sheet 4-1 Planning of Countermeasures** Alternative 1

| | | | |
|---|---|---|---|
| Road Name | 0 KENNON ROAD | | |
| Station from | km215+820 m 70 0 | Side of survey | 0 EIGHT |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| DF1.2 1 | CUTTING | $m^3$ | 500 | ₱ 430.00 | ₱ 215,000.00 |
| LS2 2 | BANKING | $m^3$ | 680 | ₱ 450.00 | ₱ 306,000.00 |
| RF3 3 | GROUTED RIPRAP | m | 1,100 | ₱1,680.00 x 5/6 | ₱2,053,200.00 |
| RCC 4 | CRIB WALL | $m^2$ | 1,050 | ₱ 2,270.00 | ₱2,383,500.00 |
| 5 | | | SUB | TOTAL | ₱4,963,700.00 |
| 6 | MAINTENANCE COST (n = 5yrs) 5% | | | | ₱ 248,185.00 |
| 7 | MAINTENANCE COST (n = 10yrs) 10% | | | | ₱ 496,370.00 |
| | MAINTENANCE COST (n = 15yrs) 15% | | | | ₱ 744,555.00 |
| | MAINTENANCE COST (n = 20 yrs) 20% | | | | ₱ 992,740.00 |
| | | | | TOTAL | ₱ 7,445,550.00 |

Note:
- Numerical value or terms should be inputted.
- Numerical value is automatically inputted.

4-1

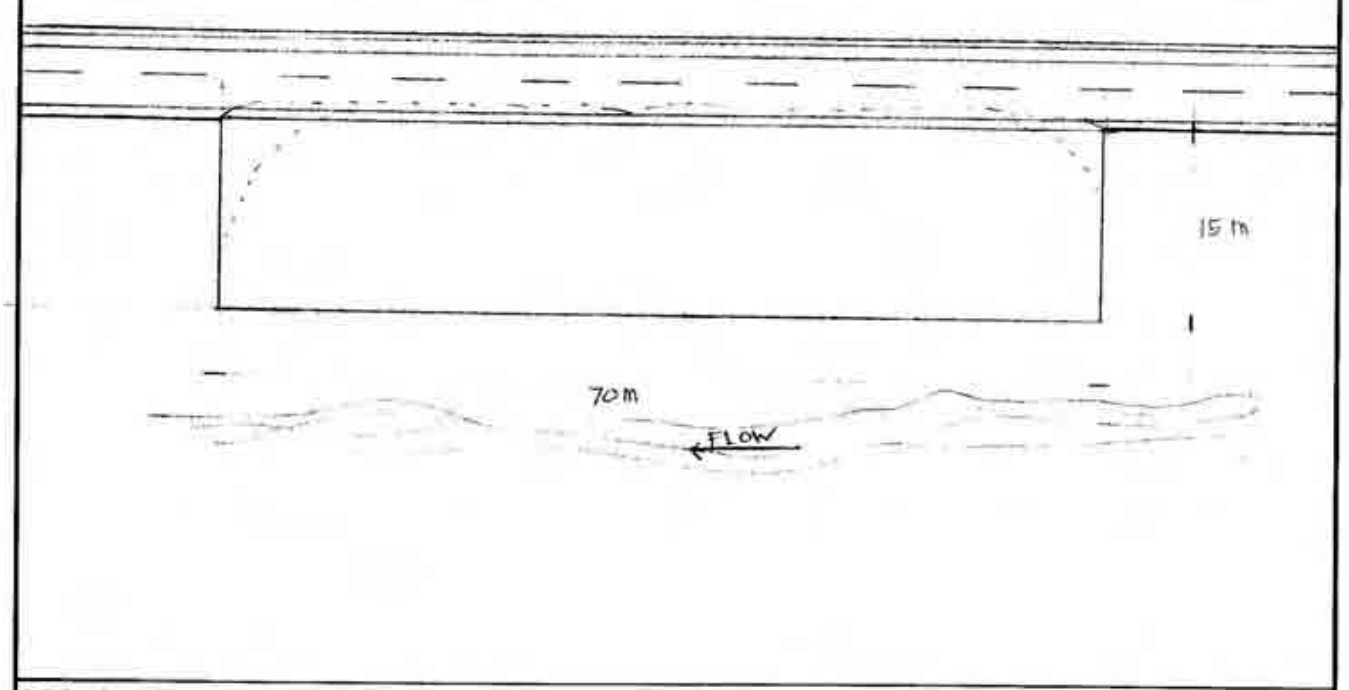
**Figure 5.43 Example of Inventory Sheet 4-1: Planning of Countermeasure Alternative I for River Erosion**

PREPARED BY : HENRY V. ATOMOL

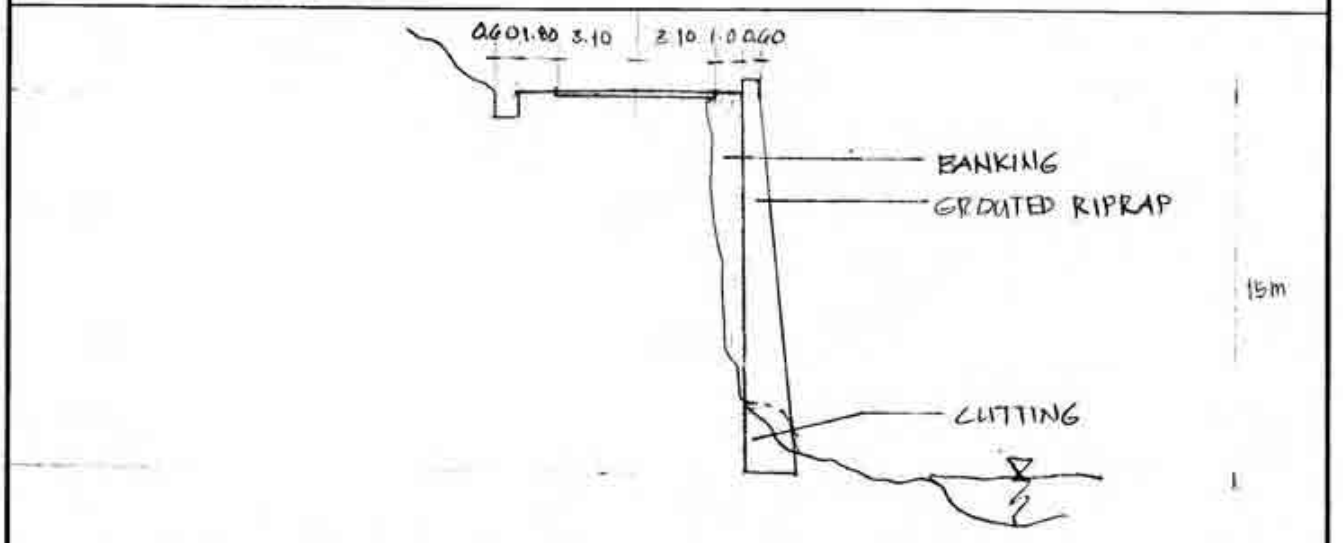
**Inventory Sheet 4-2 Planning of Countermeasures** Alternative 2

| | | | | | |
|---|---|---|---|---|---|
| Road Name | 0 KENNON ROAD | | | | |
| Station from | km 215+520 | m 70.0 | Side of survey | 0 RIGHT | |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| DF121 | CUTTING | m3 | 500 | ₱ 430.00 | ₱ 215,000.00 0 |
| LS222 | BANKING | m3 | 680 | ₱ 450.00 | ₱ 306,000.00 0 |
| RE333 | GROUTED RIPRAP | m | 1,100 | ₱ 1,680.00 x 15 | ₱ 2,058,200.00 0 |
| 4 | | | SUB-TOTAL | | ₱ 2,580,200.00 - |
| 5 | MAINTENANCE COST (n=5 yrs) | 10% | | | ₱ 258,020.00 |
| 6 | — do — (n=10 yrs) | 15% | | | ₱ 387,030.00 |
| 7 | — do — (n=15 yrs) | 20% | | | ₱ 516,040.00 |
| | — do — (n = 20 yrs Cost) | 30% | | | ₱ 774,060.00 |
| | | | | TOTAL = | ₱ 4,515,350.00 |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

4-2

**Figure 5.44 Example of Inventory Sheet 4-2: Planning of Countermeasure Alternative II for River Erosion**

**Inventory Sheet 5-6** **Indicative Feasibility Assessment for RE**

| | | | | | |
|---|---|---|---|---|---|
| Road Name | Kennon Road | | | | |
| Km station from | km | 215 | m | 132 | |
| Side of survey | Right side of road | | | | |

| Items | symbol | equation | Unit | Quantity | Remark |
|---|---|---|---|---|---|
| ***(1) Disaster Frequency and Magnitude*** | | | | | |
| ***1-1) Potential frequency of road closure disaster*** | FRCDp | | no./year | 0.024 | sheet 2 |
| ***1-2) Length of road closure site*** | LRC | | m | 70 | refer 3.4.2 1-2) of the Guide |
| ***(2) Annual Losses Without Countermeasure*** | | | | | |
| 2-1-1) Reopening cost per length of road closure site (excluding fixed cost) | h | | pesos/m | 5,000 | refer 3.4.2 2-1-1) of the Guide |
| Fixed cost for reopening per RCD | i | | pesos/RCD | 230,000 | |
| **2-1) Annual reopening cost** | j | j=FRCDp*(h*LRC+i) | pesos/year | 13,630 | refer 3.4.3 2-1) of the Guide |
| 2-2-1) Average number of human death per RCD | k | k=0.004 | ave. death/RCD | 0.004 | refer 3.4.2 (2) 2-2-1) of the Guide |
| 2-2-2) Unit value of human life lost (death) | l | | pesos/human life | 2,300,000 | refer 3.4.2 (2) 2-2-2) of the Guide |
| **2-2) Annual value of human life lost** | m | m=FRCDp*k*l | pesos/year | 216 | refer 3.4.2 (2) 2-2) of the Guide |
| 2-3-1) Length of survey road (from entry to exit point of detour road to avoid road closure site on survey road) | n | | km | 70 | refer 3.4.2 (2) 2-3-1) of the Guide |
| Length of detour road (from entry to exit point of survey road tc avoid road closure site on survey road) | o | | km | 190 | refer 3.4.2 (2) 2-3-2) of the Guide |
| 2-3-2) AADT: Annual Average Daily Traffic on the survey site | p | | vehicles/day | 1,000 | refer 3.4.2 (2) 2-3-3) of the Guide |
| 2-3-3) Nos. of predicted closure days of the whole width of the road on the survey site per RCD | q | | days | 15.0 | refer 3.4.2 (2) 2-3-4) of the Guide |
| 2-3-4) Average Vehicle Operating Cost/unit of AADT/km in survey road | r | | pesos/unit of AADT/km | 10.00 | refer 3.4.2 (2) 2-3-5) of the Guide |
| Average Vehicle Operating Cost/unit of AADT/km in detour road | s | | pesos/unit of AADT/km | 20.00 | |
| **2-3) Annual detour cost** | t | t=FRCDp*p*q(o*s-n*r) | pesos/year | 1,092,750 | refer 3.4.2 (2) 2-3) of the Guide |
| ***Total Annual Loss*** | u | u=j+m+t | pesos/year | 1,106,596 | refer 3.4.2 (2) of the Guide |
| ***(3) Feasibility Indicators of Countermeasures*** | | | | | |
| ***Countermeasure alternative I*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v I | | pesos | 7,445,550 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w I | | ratio | 0.9 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x I | x I = u* wI | pesos/year | 995,937 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc I | FRCDpwc I = FRCDp*(1- wI) | no./year | 0.002 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR I | | ratio | 0.96 | |
| ***Economic net present value at 15% discount rate*** | ENPV I | | pesos | -1,053,611 | |
| ***Economic internal rate of return*** | EIRR I | | percent | 12% | |
| ***Countermeasure alternative II*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v II | | pesos | 4,515,350 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w II | | ratio | 0.6 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x II | x II = u* wII | pesos/ year | 663,958 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc II | FRCDpwc II = FRCDp*(1- wII) | no./year | 0.009 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR II | | ratio | 0.00 | |
| ***Economic net present value at 15% discount rate*** | ENPV II | | pesos | -3,926,391 | |
| ***Economic internal rate of return*** | EIRR II | | percent | - | |
| ***Countermeasure alternative III*** | | | | | |
| 3-1) Cost of countermeasure with 20 years maintenance | v III | | pesos | 100,000 | evaluated in sheet 4 |
| 3-2) Risk reduction ratio in RCD due to countermeasure | w III | | ratio | 0.01 | refer 3.4.2 (3) 3-2) of the Guide |
| 3-3) Decrease in annual loss due to countermeasure | x III | x III = u * w III | pesos/ year | 11,066 | refer 3.4.2 (3) 3-3) of the Guide |
| ***Potential frequency of road closure disaster with countermeasure*** | FRCDpwc II | FRCDpwc III = FRCDp*(1- wIII) | no./year | 0.023 | refer 3.4.2 (3) of the Guide |
| ***Benefit/cost ratio at 15% discount rate*** | BCR III | | ratio | 16.75 | |
| ***Economic net present value at 15% discount rate*** | ENPV III | | pesos | 0 | |
| ***Economic internal rate of return*** | EIRR III | | percent | 233% | |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

5

**Figure 5.45 Example of Inventory Sheet 5: Indicative Feasibility Assessment for River Erosion**

### 6) Costal Erosion

As an example, the DIS results of Toledo-Barili-Santander Rd (171 km 960 m- 172 km 66 m) for Costal Erosion are shown in Figure 5.46 to 5.51.

The countermeasure alternatives were planned as summarized in Table 5.15.

Based on the outputs from Sheets 1 to 4, a indicative feasibility assessment was undertaken, as shown in Figure 5.51.

**Table 5.15 Example of Countermeasure Alternative Planning for Costal Erosion**

| Alternative | Effectiveness | Risk Reduction Ratio |
|---|---|---|
| Alternative-I | High Effectiveness: Permanent countermeasures to prevent disasters<br><br>- Reinforced retaining wall | 0.9 |
| Alternative-II | Moderate Effectiveness: Mitigating the disasters to some extent<br><br>- Grouted Riprap<br>- Rock armor protection | 0.6 |
| Alternative-III | Low Effectiveness: Limited treatment<br><br>-Grouted riprap (repair damaged portion) | 0.2 |

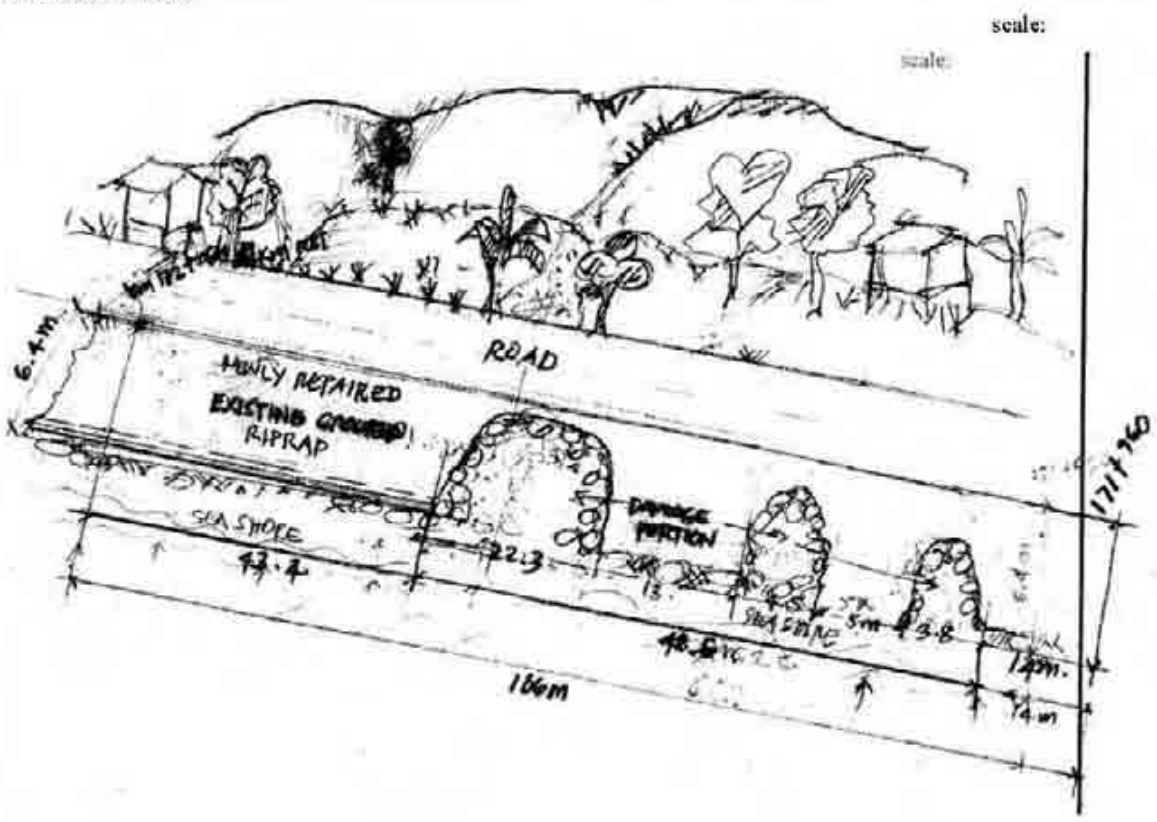
**Figure 5.46 General View of Example DIS Slope for Costal Erosion**

**Inventory Sheet 3 Sketches**

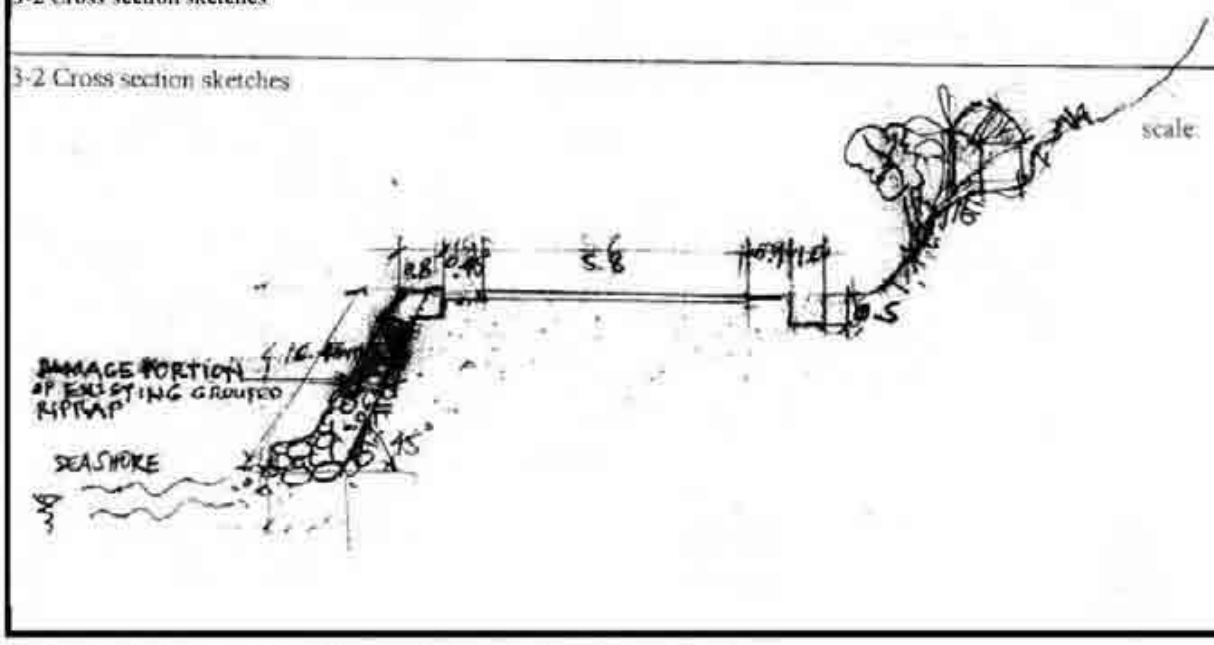
| | | | | | |
|---|---|---|---|---|---|
| Road Name | Toledo-Barili-Santander Rd | | | | |
| Station from | km 171 | m 960 | Side of survey | Left side of road | |

| | | | | | |
|---|---|---|---|---|---|
| Name of Inspector/ Coordinator for detailed inventory survey; sheet 3, 4, 5 | | Survey date (d/m/y) | Date | Month | Year |
| Name of inspector | Wilma B. Campos | | 23 | Nov. | 2006 |

3-1 Front view sketches




3-2 Cross section sketches



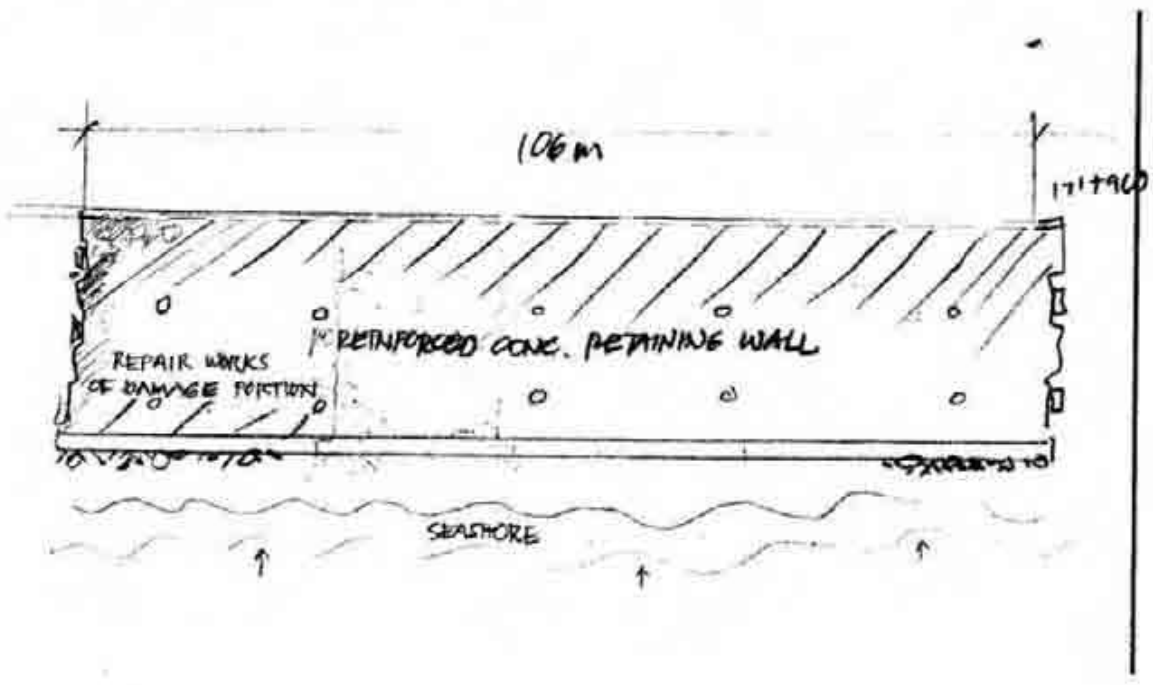

Note
- Numerical value or terms should be inputted.
- Numerical value is automatically inputted.

**Figure 5.47 Example of Inventory Sheet 3: Sketches for Costal Erosion**

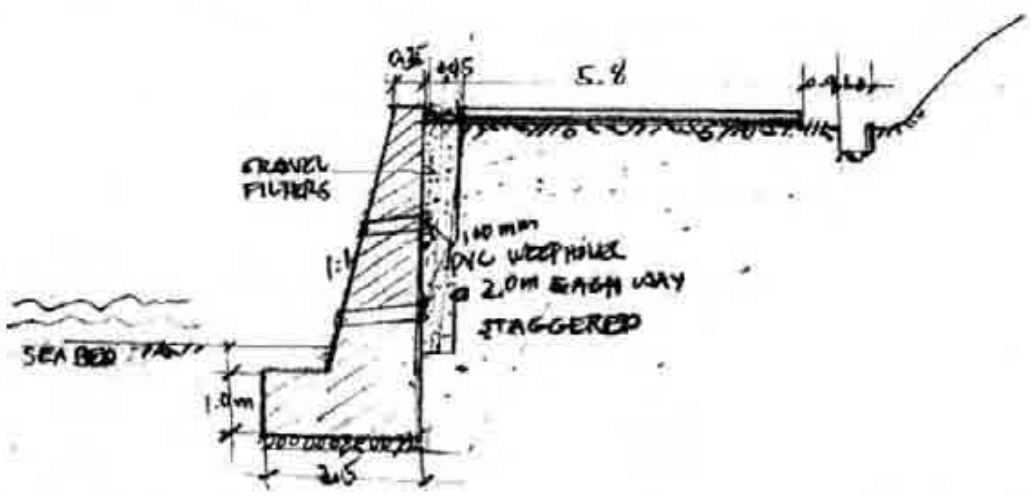
**Inventory Sheet 4-1 Planning of Countermeasures** Alternative I

| Road Name | Toledo-Barili-Santander Rd | | | | | |
|---|---|---|---|---|---|---|
| Station from | km | 171 | m | 960 | Side of survey | Left side of road |

4-1 Plan of countermeasures (plane layout and descriptions)




4-2 Section of countermeasures




4- 3 Cost estimation with 20 years maintenance

| No. | Work | Unit | Quantity | Unit price (pesos) | Amount (pesos) |
|---|---|---|---|---|---|
| 1 | Reinforced retaining wall | m2 | 678.4 | 6,976 | 4,732,518 |
| 2 | Maintenance Cost | | 1 | 2,366,259 | 2,366,259 |
| 3 | | | | | 0 |
| 4 | | | | | 0 |
| 5 | | | | | 0 |
| 6 | | | | | 0 |
| 7 | | | | | 0 |
| Total Cost | | | | | 7,098,778 |

Note
Numerical value or terms should be inputted.
Numerical value is automatically inputted.

**Figure 5.48 Example of Inventory Sheet 3: Planning of Countermeasure Alternative I for Costal Erosion**