Bluff's Creek Water Quality Improvement Plan
Phase 1 Report

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Date Submitted: November 30, 2008

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Project Goal and Objectives

The overall goal of the Bluff's Creek Water Quality Improvement Plan was to build upon existing monitoring records and baseline data in order to develop a rehabilitation plan designed to decrease phosphorous levels and improve water quality within Bluff's Creek. In addition the plan makes various recommendations intended to enhance available fish habitat, thereby working to rehabilitate the aquatic ecosystem and coldwater fishery in Lake Simcoe. It is the intent that the rehabilitation recommendations will be implemented on Bluff's Creek in the coming years.

Method

Historical information and reports pertaining to the Bluff's Creek watershed were gathered with the help of our project partners. Current benthic invertebrate data was collected at four sites in order to compare to the historical information. Water chemistry, with specific reference to phosphorous levels, will be tested in spring 2009 and incorporated into the rehabilitation plan at that time. It was our intention to gather this data in 2008, however funding for this project was not granted in time for the optimal spring testing period.

Bluff's Creek tributaries span through privately owned lands. The planning department of the Township of Oro Medonte provided us with a map of the watershed, south of highway 11, indicating the corresponding property lines. This map was reviewed, and areas of interest were numbered. From there aerial photos were produced and a list of names and addresses was developed. Landowners were contacted during the day, with little to no luck. A second attempt was made in the early evening to reach landowners when they were home from work. Any landowner not contacted by phone was sent a letter requesting access to the property. In total, 22 landowners were contacted and 7 were receptive to our project. Due to accessibility restrictions, 3 reaches were chosen for further in-depth investigation.

Of the three stream reaches that we were granted access to, general sites visits were conducted. The purpose of a site visit was to become familiar with the area surrounding the channel. These visits were conducted with the aid of Doug Forder from Ontario Streams; the Stewardship Rangers; Kids for Turtles executives Bob Bowles and Pat Pautsch; and volunteer Rory Ford. Bluff's Creek tributaries were toured looking for potential impacts on the quality of the stream. Aspects such as online ponds; perched culverts; stream blockages; access sediment loading; erosion scars; and exposed stream banks were focused on. These problems were noted, and pictures were taken.

A more in-depth evaluation of the selected stream reaches was conducted in November 2008 by Ontario Streams' staff. Habitat mapping was completed, during which the width and depth of the channel; substrate type; available habitat; in-stream and overhead cover; and any interesting features or potential problems in and around the stream were noted. Photographs were taken of areas of interest for future reference. The collected information was used to create a final rehabilitation plan for each reach including recommendations for future remediation. These plans are included in Appendix A, B and C.

Study Site Description

General

Bluff's Creek is a coldwater stream located in the southerly end of Orillia in the Oro Creeks North subwatershed. It originates in the Oro Moraine and drains into Lake Simcoe at Shingle Bay. Between source and lake, the watercourse flows through the rural Oro-Medonte landscape for approximately 13.6km, traversing agricultural land, wooded areas and wetlands. The average gradient of the creek is 6.9m/km and the total drainage area of the watershed is 8280ha. The creek is in close proximity to well travelled roads such as Highway 11.

The quality of water in Bluff's Creek has been compromised by human activity such as agricultural practices; development; pollutants such as salt and other contaminants from roads; etc. This has resulted in an increase in the amount of phosphorous in the creek and in Lake Simcoe and degradation to the creek's fishery.

The phase 1 study area for this project is shown in Figure 1.

Fishery

Bluff's Creek is an existing coldwater fishery with brook trout, brown trout and rainbow trout. Historic records show that in 1975, brook trout (20), mottled sculpin(2) and central mudminnow (1) were caught at Site 2 during an electrofishing survey within what is now our current study area. At sites further upstream brook trout (4), white perch (1) were caught at Site 6; and brook trout (1), white sucker (4), brook stickleback (1), creek chub (7), and blacknose dace (50) were sampled at Site 7. Figure 2 shows the location of these monitoring sites. In July 1990, brook trout, mottled sculpin and central mudminnow again dominated a monitoring site corresponding with Site 2, located closest to this project's study area.

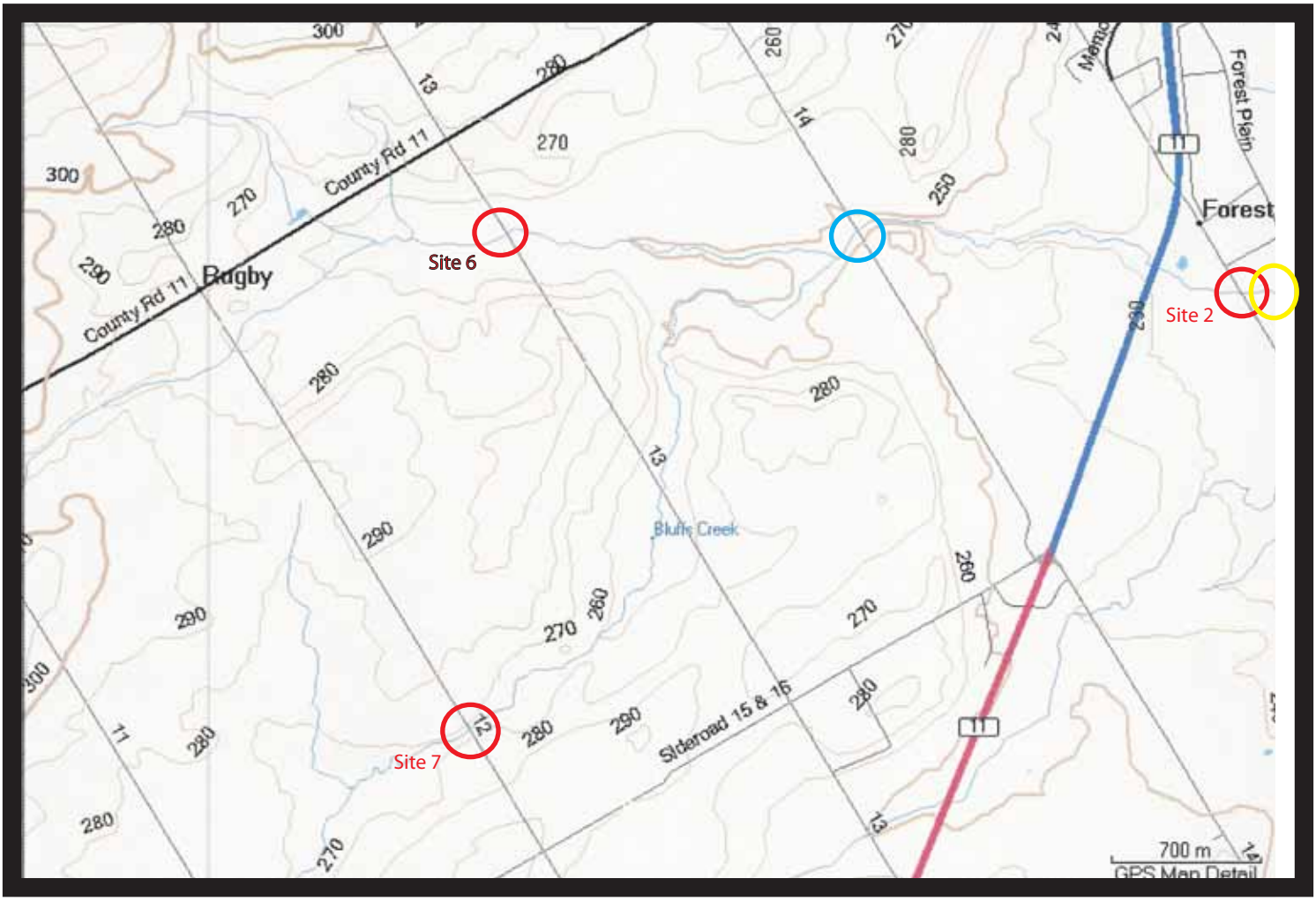
Records provided to us by the Ministry of Natural Resources show that brook trout were stocked into Bluff's Creek annually between 1963 and 1971 in quantities ranging from 210 to 2000. Additionally, 2400 trout were stocked in 1957; 4500 in 1989; and 4000 in 1991.

Benthos

The historic 1975 Bluff's Creek study sampled aquatic benthic invertebrates at several sites throughout the watershed. Again, the data from Site 2 and upstream Sites 6 and 7 were used as a baseline to compare with future monitoring. In 2008 the 1975 raw data was analyzed using the Hilsenhoff Biotic Index as well as the Percent Model Affinity (PMA). A Hilsenhoff biotic index value of 2.93 was calculated at Site 2, indicating a non-impacted water quality, while a PMA of 54.1 indicated a "slightly impacted" water quality. Site 6 had a biotic index value of 3.7, also indicating a non-impacted water quality, while a PMA of 58.0 again indicated a "slightly impacted" site. Site 7 had a slightly impacted water quality with a value of 4.1 and a PMA of 38.4 indicating a moderately impacted site.

On July 24, 2008 a benthic invertebrate sample was taken by Ontario Streams' staff at the stream crossing at Line 14, just downstream of where the Site 6 and Site 7 tributaries converge. This sample was taken using a surber sampler and the rapid bioassessment method. Proceeding in a downstream to upstream direction, three, one-minute samples were taken at three separate riffles. The collected invertebrates and debris were placed in one container and stored in 70% alcohol until they could be later sorted and identified under a microscope, again by an Ontario Streams' biologist. The

Figure 1: Bluff's Creek Water Quality Improvement Plan, Phase 1 Study Area Location



1975 Historical Sites

2008 Surber Sampler Site

2008 Kick and Sweep Sites

Figure 2: Historic and Current Monitoring Locations On Bluff's Creek

invertebrates were identified using the Aquatic Flora and Invertebrate Fauna of the Speed River Watershed by G.L. Mackie and then analyzed using the Hilsenhoff Biotic Index. A biotic index value of 4.29 was derived for this site indicating a "non-impacted" water quality flowing into the study area. The Percent Model Affinity (PMA) matrix was also used to analyze this data. A PMA of 68.4 corroborated the Hilsenhoff and also indicated a "non-impacted" water quality.

Within the Phase 1 study area, current conditions were found to be too sandy to employ the surber sampler and the rapid bioassessment method, therefore the Ontario Federation of Anglers and Hunters (OFAH) aided us in taking three benthic invertebrate samples downstream of Line 15 using the Kick and Sweep method and a D-net. This site approximately coincides with the historic Site 2. Of the three samples, two were taken in riffles and one was taken in a pool. Three minutes were timed for the taking of each sample across the wetted width of the channel. OFAH then identified each sample down to the Order level. Ontario Streams' staff analyzed this data using the PMA matrix. The upstream riffle had a PMA value of 44.6, or "moderately impacted". A PMA of 50.4 was calculated for the downstream riffle, indicating a "slightly impacted" water quality. Finally, the pool produced a "moderately impacted" PMA of 38.9. Therefore it can be concluded that some water quality degradation has occurred within the study area since the 1975 study, and there currently exists impacts on Bluff's Creek between Line 14 and Line 15 which cause a deterioration in aquatic health.

Water Chemistry

Historic records from a 1975 study indicate that an air temperature of 31.0C, a water temperature of 17.0C with a dissolved oxygen content of 10.4mg/L was measured at the Site 2 monitoring site within our current study area (See Figure 2). A pH of 7.6, turbidity of 11.0 J.T.U., alkalinity of 150.0mg/L and T.D.S of 268.3mg/L were also measured.

Historic Site 6 had a slightly cooler water temperature of 15C, which is expected when comparing upstream and downstream sites such as these. Site 6 also had a slightly lower dissolved oxygen content of 10.0mg/L. The pH, alkalinity and T.D.S were all comparable to Site 2 values at 7.4, 140.0mg/L and 268.3mg/L respectably. Site 6 had a slightly lower turbidity of 8.0 J.T.U. compared to 11.0 J.T.U. at Site 2.

Historic Site 7 values were measured on a warmer day with an air temperature of 36.0C. The water temperature was significantly higher than the other two sites at 27.0C. The dissolved oxygen content was the same as Site 6 at 10.0mg/L and the pH was the same as Site 2 at 7.6. An increased turbidity (18.0 J.T.U.) and T.D.S. (285.2 mg/L) were the two notable differences between Site 7 and the other monitoring stations. This data indicates that in 1975, the Site 7 branch of Bluff's Creek was experiencing disturbances, likely agricultural practices and/or cattle access, which were degrading the water quality. However, the excess sediment was depositing out of the water column prior to Site 2.

Phosphorous levels are a particular concern for Bluff's Creek and Lake Simcoe in general. This project focuses on reducing phosphorous inputs to the watercourse. Unfortunately, funding and project approval in 2008 were granted too late for the optimal spring timing window to measure this chemical. Therefore, testing will be completed in the spring of 2009 and incorporated into future monitoring and rehabilitation plans at that time.

In-Stream Habitat Characteristics

The 1975 study on Bluff's Creek found that the site closest to our current study area had a 75% sand substrate, with 5% gravel, 10% rubble and 10% clay comprising the rest. Approximately 85% of the

surveyed banks were found to be stable. In-stream cover consisted of 5% undercut bank, 5% rock cover 10% in-stream log and tree cover and 2% organic debris. Surrounding the creek it was observed that 20% of the land area was densely covered, 40% was partially open and 40% was open.

Compared to sites further upstream in the watershed in 1975, this site was considerably more sand based. There was less rock cover in-stream, however the cover provided by undercut banks; logs and trees; and organic debris were all comparable. The amount of onshore cover was much more variable throughout the watershed and there was no obvious trend as to the "dense", "partially open" and "open" categories at the upstream versus downstream sites.

Field observations in 2008 at the study area sites found that sand was still the dominate substrate. Sand accounted for almost 100% of the observed substrate. Some rock, gravel and underlying clay were found in sporadic patches closer to Hwy 11 in contrast to downstream of 15th Line. The majority of streambanks appear to be stable, with some minor erosion occurring at select sites, and one major erosion site approximately 30m downstream of Hwy 11. Submerged logs provided the dominant form of in-stream cover. Surrounding the watercourse the land area was predominantly "partially open" to "open". Patches of forest cover occasionally surrounded the watercourse, however there was little in the way of undercover or groundcover and would therefore not be characterized as "dense".

Vegetation

Records indicate that *Elodea* sp., Water lily, Swamp Potato, Duckweed, *Potomogeton sp*., Tape grass, Cattail, Canada Waterweed, Smartweed and Richardson's Pondweed are historic species found within the Bluff's Creek watershed.

During field assessments conducted as part of this project, various habitats were observed within our specific study areas. Forest dominated by cedar and maple; wet meadows consisting of various types of long grasses, sedges, and red osier dogwood; and manicured lawns were all observed within the study area. Air photos also indicate that the headwater tributaries of Bluff's Creek flow through or near to agricultural fields and/or pasture lands.

Soil

The soil type surrounding the 2008 study area of Bluff's Creek appears to be heavily dominated by sand.

Recommendations

The following site descriptions and rehabilitation recommendations supplement the individual rehabilitation plans contained in Appendices A-C. The locations of each reach are identified in Figure 3. The overall intent of the rehabilitation plans is to decrease the amount of sediment, and ultimately phosphorous, entering the watercourse by decreasing erosion and increasing filtration of runoff by riparian buffers. These actions will have a direct positive effect on downstream water quality leading into Lake Simcoe. The secondary objective of the rehabilitation plans is to enhance fish habitat within Bluff's Creek for cold water species such as brook trout through improved water quality, decreased habitat fragmentation, and the provision of additional overhead cover.

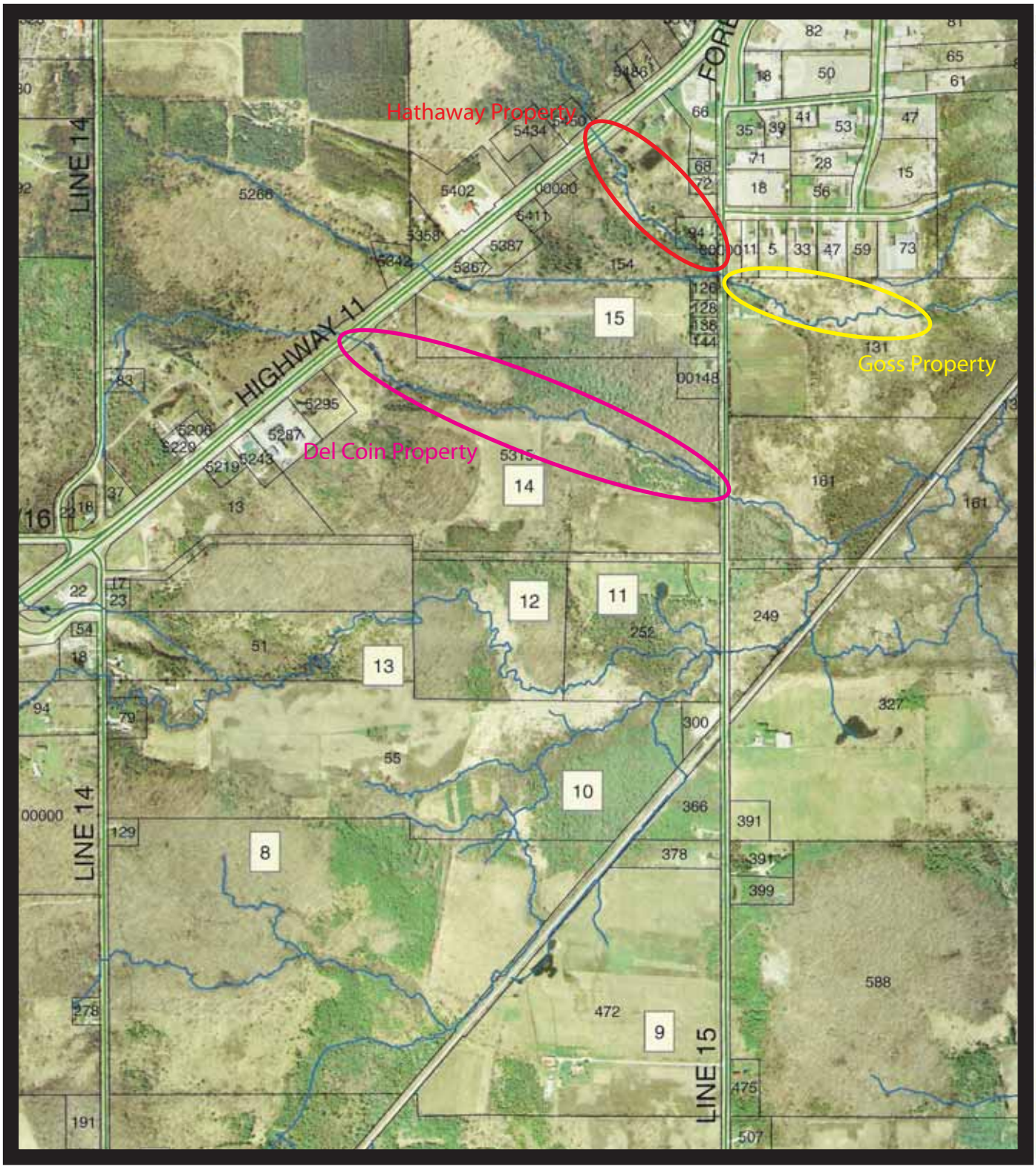


Figure 3: Location of Assessed Phase 1 Rehabilitation Reaches on Bluff's Creek

The recommendation highlights for each of the three assessed reaches are summarized individually below. The Ontario Stream Rehabilitation Manual and projects previously implemented by Ontario Streams have been used as guides in the selection and design of suggested rehabilitation structures.

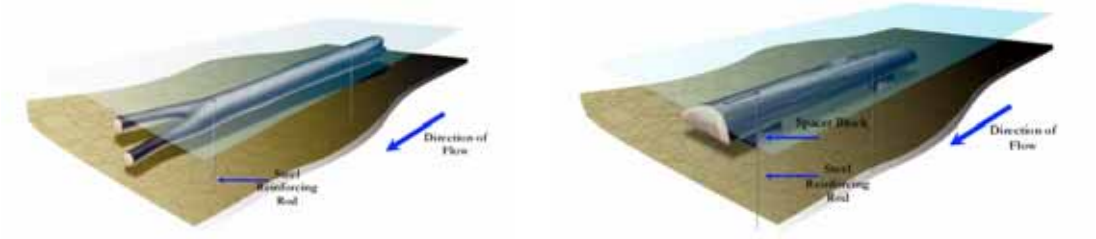
Hathaway Property

This reach extends from Line 15 upstream to Hwy 11 and is identified in Figure 3. The creek passes through two property boundaries, both of which we have obtained access to. It is a cold water stream with many groundwater springs, as indicated by the presence of an abundance of watercress growing throughout the reach. There are minor erosion sites located sporadically throughout, with one major erosion site existing near the upstream end of the reach. Upstream of the major erosion site small amounts of gravel can be found mixed in with the still predominantly sandy substrate. Downstream of the erosion site the substrate is quite sandy, indicating that this is a source of sedimentation within the watercourse.

Overall there is a promising number of deep pools and in-stream woody debris cover to provide fish habitat for coldwater species such as brook trout. A sufficient riparian buffer extends on both sides of the stream consisting of cedar forest or wet meadow. The landowner has indicated that the creek overtops its banks each spring, thus limiting the amount of tree cover that has been able to establish in the meadow area.

Overall this reach appears to be in good shape, however there are some recommendations to further enhance existing fish habitat, as well as to stabilize and protect the eroding banks currently present. The rehabilitation plan included in Appendix A outlines the location and details of each recommendation, however the highlights include:

1. Minor actions such as the removal of the broken fence pole immediately upstream of Line 15, as well as the removal of the T-bars, fallen fence and debris buildup at the top end of this reach, are easy ways to naturalize this stream.
2. There are many sections within this reach where fish habitat could be enhanced with the addition of overhead, in-stream cover. The section of the creek immediately upstream of Line 15 where it first enters cedar forest cover has been identified as a possible location for in-stream log cover to be added. The diagrams below show examples of in-stream log cover taken from the Ontario Stream Rehabilitation Manual. The logs can be found on-site and secured within the water column with duck-bill anchors and air craft cable.



3. Moving upstream, the next noteworthy site is where a man-made rock weir has been built. As the stream cascades over this structure, it gains velocity and as a result is contributing to an erosion problem on the opposite exposed bank. By repositioning some of this rock to decrease the vertical

head of the weir and the projection of the flow, much of the problem can be eliminated. In addition, the securing of woody debris, such as a fallen tree or large branches as cedar sweeps, in the bend can help to deflect further flow and provide additional protection to the bank. The woody debris will also act as overhead cover and habitat to local fish species. It is also recommended that some shade tolerant shrubs such as red osier dogwood and/or alternate leaf dogwood are planted on the bank in question as their root systems will further stabilize the soil.

4. Several other bends through the middle section of this reach are experiencing minor to moderate erosion and have been recommended for securing in-stream woody debris in bends and/or live staking of willow and dogwood shrubs as described in #3 above. Their locations are identified in the rehabilitation plan included in Appendix A. The overall goal of this approach is to decrease erosion and sedimentation, and enhance fish cover within the creek by implementing structures with a natural-looking appearance. Examples of such structures are depicted in the photographs below.

5. A minor eroding slope has been recommended for re-grading and subsequent shrub planting. Woody debris is first secured at the toe of the slope to protect any soil from entering the stream. The bank is then graded down over top of this material. By re-grading the vulnerable bank to a more gradual slope, the area will gain stability. The slope should immediately be seeded with an annual grass seed and covered with coir erosion control matting to provide short-term stability. The bank should then by heavily planted with willow shrubs to provide long-term stability.
6. The wet meadow area where the landowner indicated that tree cover could not naturally establish could be supplemented with the planting of cedar and silver maple. Both of these species are well suited to periodic flooding.
7. The major erosion site located near the top end of this reach is a tall, steep sandy cliff. Upstream of this site gravel can sporadically be found within the substrate. Downstream of the site however the substrate is almost 100% sand. It is recommended that a method that has been successfully implemented by Ontario Streams on the East Humber River in Vaughan be emulated here. This method uses rootwads, bioengineered brush bundles, and woody debris to create a rough face that deflects the main force of the stream flow away from the eroding bank. At the same time, any storm waters that overtop the strategically placed barrier, settle out and deposit sediment behind, and slowly fill in the space overtime. The root wads and woody debris will be anchored in place using T-bars, aircraft cable and nails/spikes. It was noted that there did not appear to be any naturally occurring rootwads near to this site to easily use in this structure. Therefore, the material will likely need to be gathered elsewhere and transported.

The series of photographs above show the progression of the East Humber structure.

Goss Property

Bluff's Creek flows from the Hathaway Property, crosses Line 15 and enters the Goss Property. The stream meanders through this large property for over 600m before it becomes branched due to current beaver activity. We were unable to continue mapping past this point due to the swampy conditions.

The assessed reach appeared to be a classic E channel, with steep banks and the depth of the creek being too deep for staff to walk through and measure at most points. The water was quite cold with many patches of watercress indicating groundwater springs. It was noted that the patches of watercress were less abundant than what was found in the upstream property.

The property owners have left a narrow buffer between the creek and their mowed backyard. The stream then flows through a more natural field of long grasses and red osier dogwood. Numerous snags dot the field, likely created by flooding caused by past beaver activity. There is evidence of several abandoned and degraded beaver dams as you move downstream, with recent beaver activity and intact dams located at the downstream end of this reach.

The recommendations outlined in Appendix B for this section of Bluff's Creek include:

1. Remove the section of wire fence that has fallen into the creek by the road.
2. Encourage this landowner to expand the width of the riparian buffer between the creek and their mowed lawn. If they are receptive, a planting plan could be created in 2009 and future funds could be raised to purchase the necessary trees and shrubs.
3. One minor erosion site was noted on the downstream side of the footbridge that crosses this stream. If this is tackled before the problem is exacerbated, merely live staking the spot with willow and red osier dogwood shrubs should be sufficient in providing enough support to stabilize the bank.
4. The area surrounding the creek is a beaver meadow with no tree cover, with the exception of snags and a few cedars and spruce. Some red osier dogwood patches exist directly along the creek, but the rest of the local vegetation is dominated by long grasses. There is the option of reforesting this area with native trees and shrubs. This planting would provide further shading to the creek, thus helping to keep the water temperatures cool during the warm summer months. The vegetation would also help to further stabilize the surrounding sandy soils and aid in filtration of runoff. In 2009 a planting plan should be created. As the potential planting area is quite large, the plan could be phased in over several years depending upon the availability of funds. The planting plan should focus on riparian species well suited to sandy conditions, but avoid species such as poplar, ash and birch which are all favorites for beavers.
5. The abandoned and degrading beaver dams should be removed in order to eliminate barriers to fish passage. The active beaver dams pose a larger problem. If an active beaver dam is dismantled it is

very likely that the beavers will simply rebuild in the same spot using newly cut material. Beaver dams area natural feature, and therefore it is suggested that the area is monitored and the beavers are allowed the opportunity to move on naturally. This is likely to happen as there does not appear to be an abundance of food in the area and the succession of abandoned dams upstream indicate that the beavers are slowly moving downstream on their own.

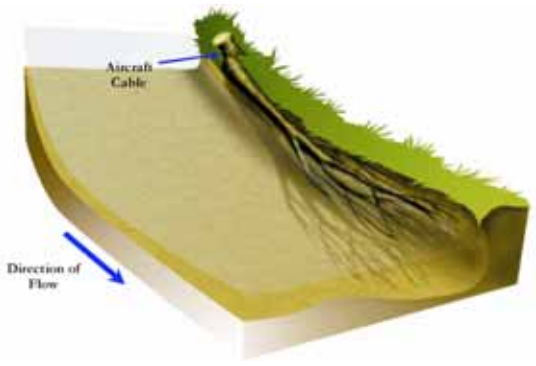
Del Coin Property

The Del Coin property is located to the south of the other two reaches on Line 15. This is a very large property extending from Line 15 to Hwy 11. The section of Bluff's Creek that flows through the Del Coin property is part of a different tributary than the previous two reaches. This tributary meets up with the main branch of Bluff's Creek downstream of Line 15.

The assessed section of this tributary was much narrower and shallower than the main branch of Bluff's Creek. The substrate was still predominantly sandy. Watercress was limited to a couple of patches near the upstream end of the reach. Past beaver activity is apparent with a degrading abandoned beaver dam being located approximately 60m upstream from Line 15. The area surrounding this portion of the creek consists of a tall grass, wet field. The channel itself is overgrown by grasses and is difficult to follow. Upstream of this beaver pond the stream flows through a cedar dominated forest with little groundcover apparent. There is minor erosion occurring throughout most of this section. There are several barriers to fish passage at the top end of this reach, including a perched culvert under a farm access road; an active beaver dam; two online ponds; and a second perched culvert under Hwy 11.

Of the three reaches assessed in 2008, the rehabilitation of this property has the most potential to create a significant positive impact on the downstream ecosystem. The rehabilitation plan included in Appendix C refers to the following recommendations.

1. The abandoned beaver dam at the downstream end of the reach should be manually removed. In its current state, the stream flows under the dam, however it is likely still acting as a barrier to fish passage. The online pond created by the dam is very shallow and poorly shaded. This provides an opportunity for the water to be unnecessarily warmed by sunlight during the summer months.
2. As previously stated above, as the creek flows through the section of cedar dominated forest, many of the banks are experiencing minor erosion. By using natural logs and fallen branches found on site, woody debris and cedar sweeps can be secured in these bends in such a way that they help to deflect the main force of the flow away from the vulnerable area. This method has been successfully used by Ontario Streams and its various volunteer groups in many stream rehabilitation projects. The debris can be installed in such a way that it appears quite natural as depicted in the adjacent picture. Live staking of the eroding stream bank in conjunction with the use of woody debris has also been suggested in one instance. It is suggested that cuttings from shade tolerant shrub species such as red osier dogwood or alternate leaf dogwood are implemented. These actions will help to prevent erosion, and thus limit the amount of excess sediment entering the stream, while also providing enhanced cover for local fish species.



3. The perched culvert underneath the farm access road is a barrier to fish passage and should ultimately be removed and replaced by a properly positioned new culvert. In its current state, the 0.45m drop at the culvert outlet has scoured an extremely deep pool (>1.5m), thus making the installation of a downstream step-pool or rocky ramp fishway problematic. In 2009, a detailed design and implementation plan for the culvert replacement should be created. This plan will likely describe in detail the sediment control and pumping of the current around the culvert while the road and pipe are dug out and the elevation and slope of the new culvert.
4. The upstream beaver dam is acting as a second barrier to fish movement, while also backing up water in an upstream pool which gives it the opportunity to warm. However, this dam shows signs of current beaver activity. This leaves us with the same problem encountered at the Goss Property. The site should be monitored and the dam removed once the beavers have moved on naturally.
5. The two consecutive man-made online ponds at the top end of this reach are acting as a barrier to fish passage, while also creating a large unnatural surface area allowing water temperatures to rise. The ponds were originally created and used by a previous property owner for a bait fish business. The current property owner does not use the ponds. One option is to construct a by-pass channel around the ponds. The second, and preferred, option is to eliminate the ponds completely and naturalize the newly exposed stream channel. The landowner has informally agreed to the total elimination of the ponds. Therefore in 2009 a topographic survey and detailed design plans for the removal of the berms and culverts damming up the creek; and sediment controls to be implemented during the course of the project; should be created. This plan will likely involve the use of fill from the adjacent hill to re-grade some of the surrounding slope and former pond area. In the meantime, the ponds can be slowly dewatered in 2009. It is emphasized that this should be done very slowly so as to not cause deposited sediment within the ponds to be washed downstream. As the level of the ponds is lowered and the former pond bottom is exposed, the mud flats can be temporarily stabilized by sowing grass seed.
6. The final obstacle to fish passage within this stream reach is the box culvert underneath Hwy 11. There is a 0.40m vertical drop at the outlet of the culvert that acts as the first barrier. In addition, the depth within the wide cement bottomed culvert is estimated as 3mm. This depth is much too shallow to allow fish passage and therefore acts as a second barrier. It is recommended that after the removal of the downstream online ponds it is possible to eliminate the box culvert as a barrier by installing a step-pool fishway downstream of its outlet. This fishway would turn the outlet drop into a series of smaller passable “steps” while at the same time backing up the water slightly into the culvert itself and deepening that section of stream as well. Approval from the Ministry of Transportation would be required before implementing this component of the project as Hwy 11 falls under their jurisdiction and the step-pool fishway would affect the inside of the culvert.

Other Recommendations

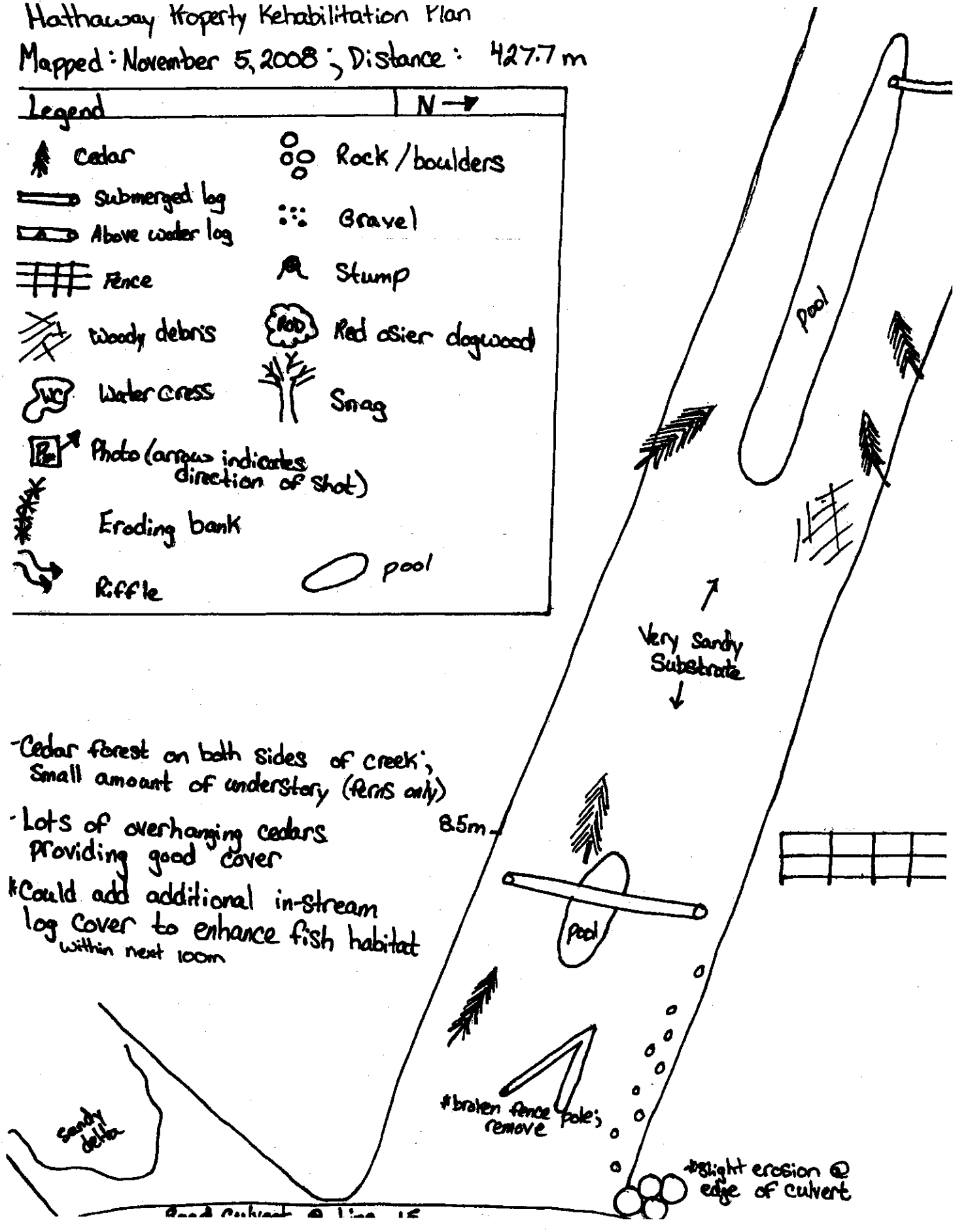
In 2008, the landowner contact and stream assessment focused on the downstream portion of the Bluff’s Creek watershed. In 2009 and beyond it is suggested that the method followed in 2008 be replicated throughout the headwater areas of the creek.

It is known that cattle are allowed access to the stream, or within close proximity to the stream, on several upstream properties. These observations were made from the road at Line 13. It is suggested that in 2009 a public outreach initiative be designed to educate these landowners to the effects of their land use practices and introduce them to the possible help that a group like Kids for Turtles could provide. Public meetings and/or information mail outs could be implemented. Ideally, cattle fencing; riparian planting; and bank re-stabilization efforts in these areas will have a large positive impact on the downstream Bluff’s Creek ecosystem.

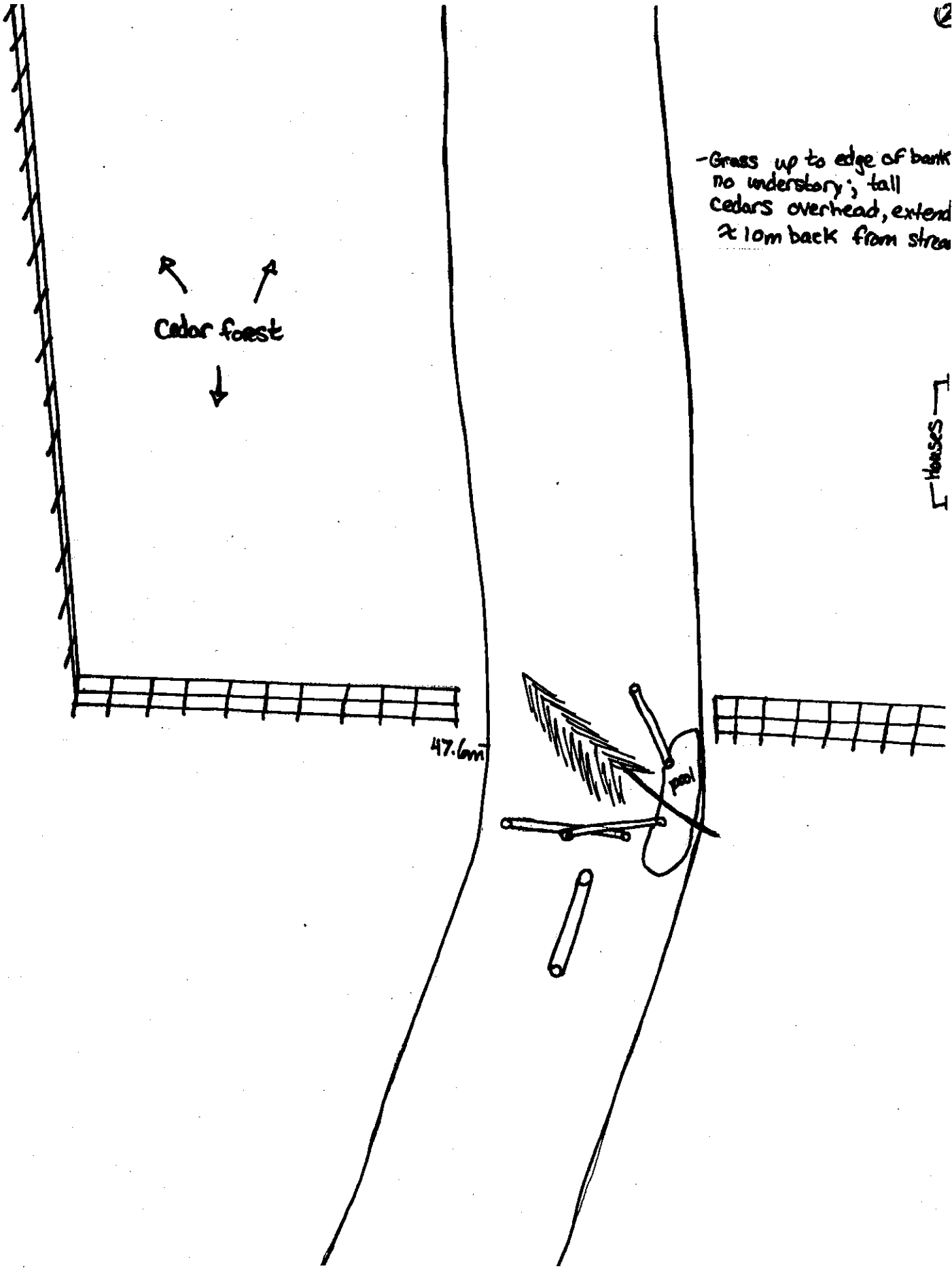
Appendix A: Hathaway Property Rehabilitation Plan

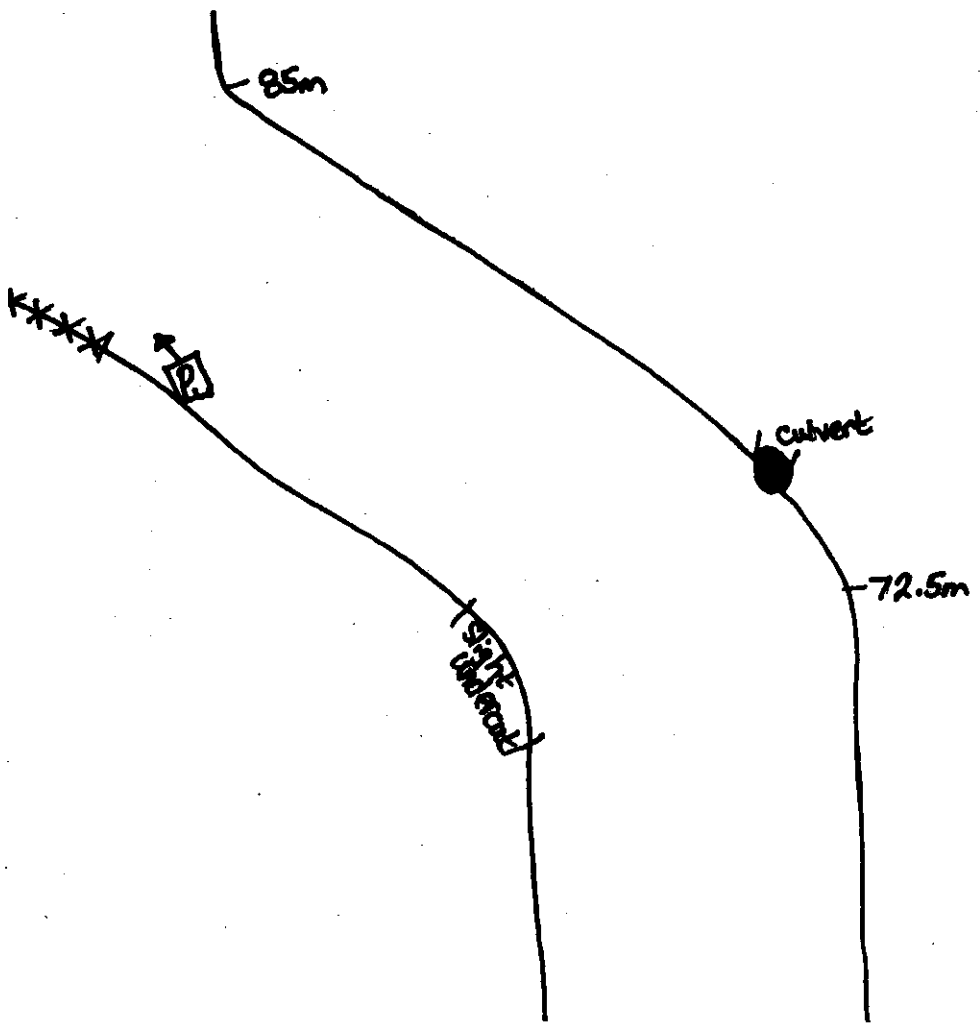
Hathaway Property Rehabilitation Plan

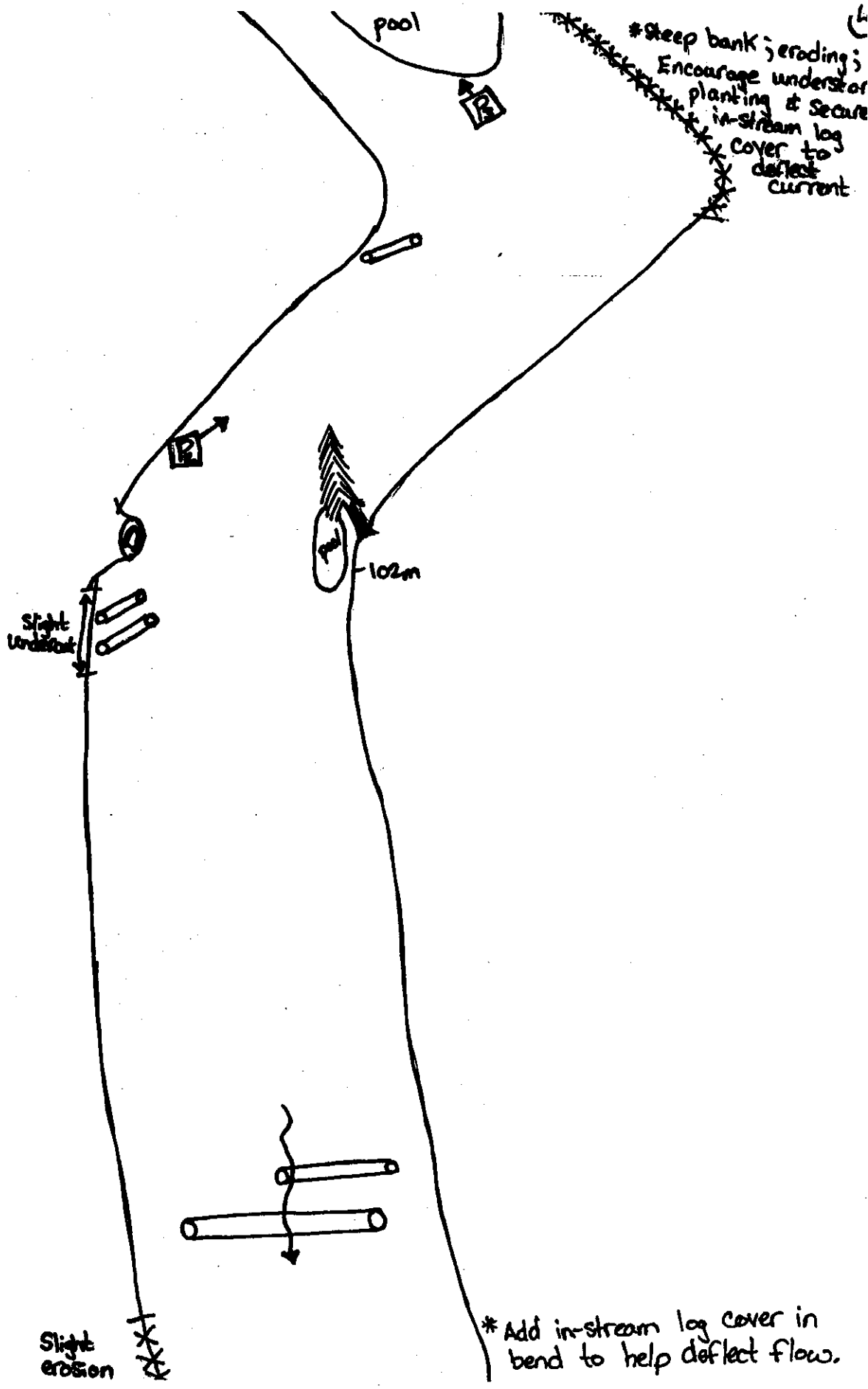
Mapped: November 5, 2008; Distance: 427.7 m

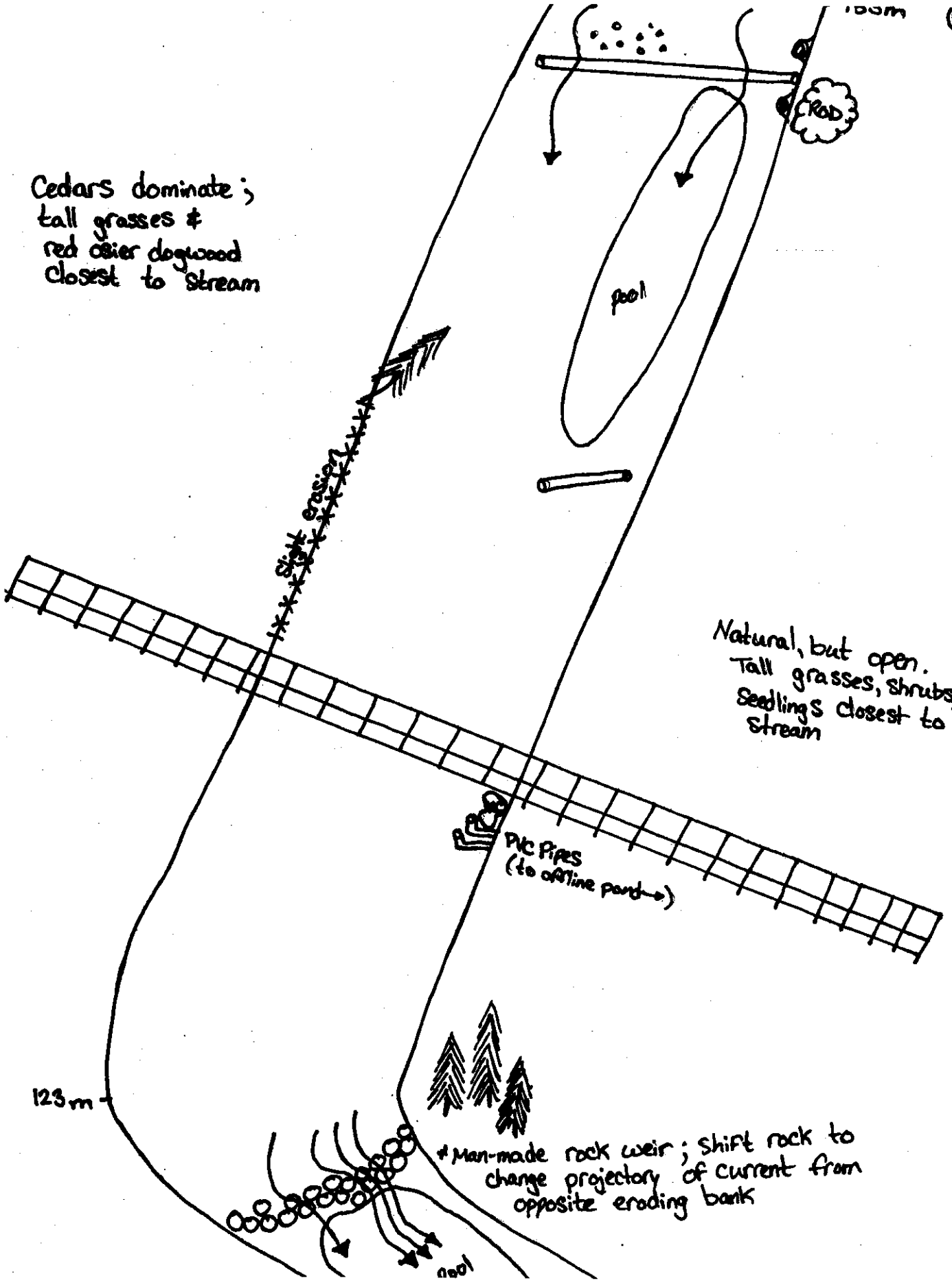


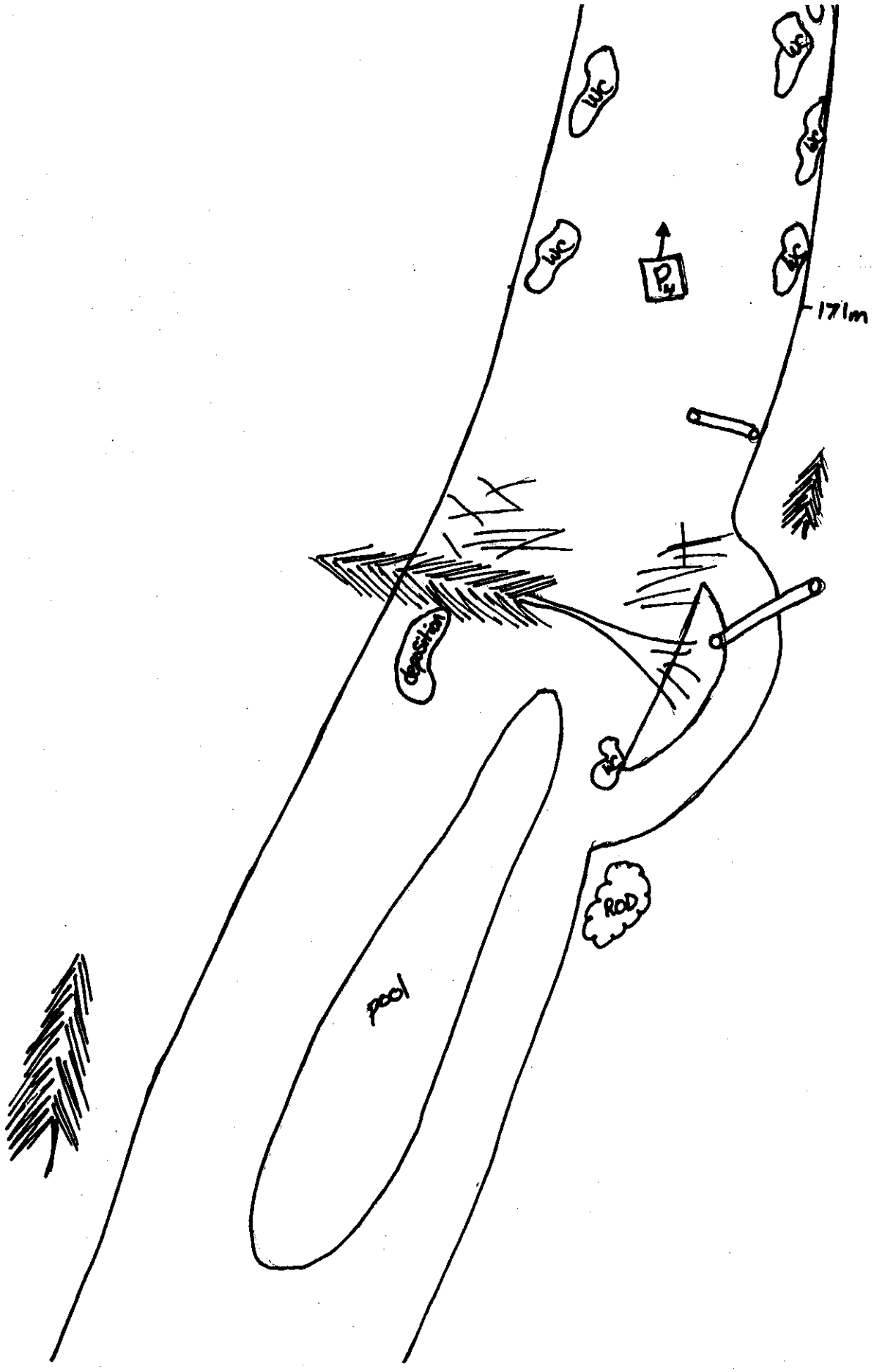
- Cedar forest on both sides of creek; small amount of understory (ferns only)
- Lots of overhanging cedars providing good cover
- *Could add additional in-stream log cover to enhance fish habitat within next 100m


-Grass up to edge of bank
no understory; tall
cedars overhead, extend
≈ 10m back from strea
Cedar forest
Houses
47.6m
pool


85m
Culvert
72.5m
Road


pool
*Steep bank; eroding; Encourage understor planting & Secure in-stream log cover to deflect current
P
P
Pool
102m
Slight undercut
Slight erosion
* Add in-stream log cover in bend to help deflect flow.


Cedars dominate;
tall grasses &
red osier dogwood
closest to stream
ROD
pool
silt + easier
Natural, but open.
Tall grasses, shrubs,
Seedlings closest to
stream
PVC Pipes
(to offline pond)
123m
* Man-made rock weir; shift rock to
change projectory of current from
opposite eroding bank
pool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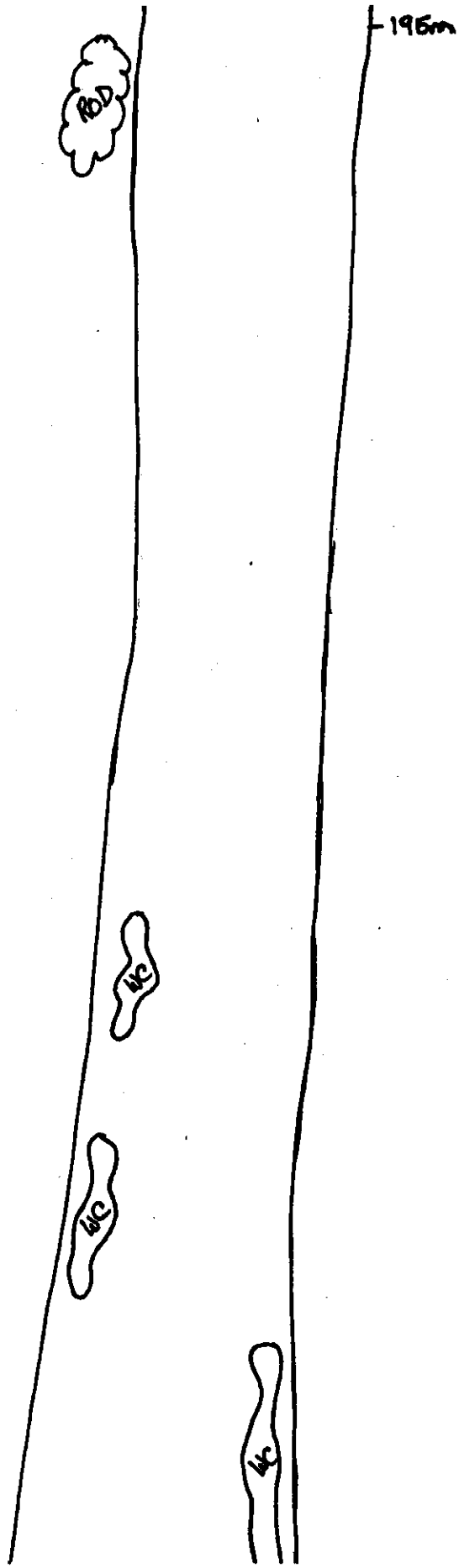
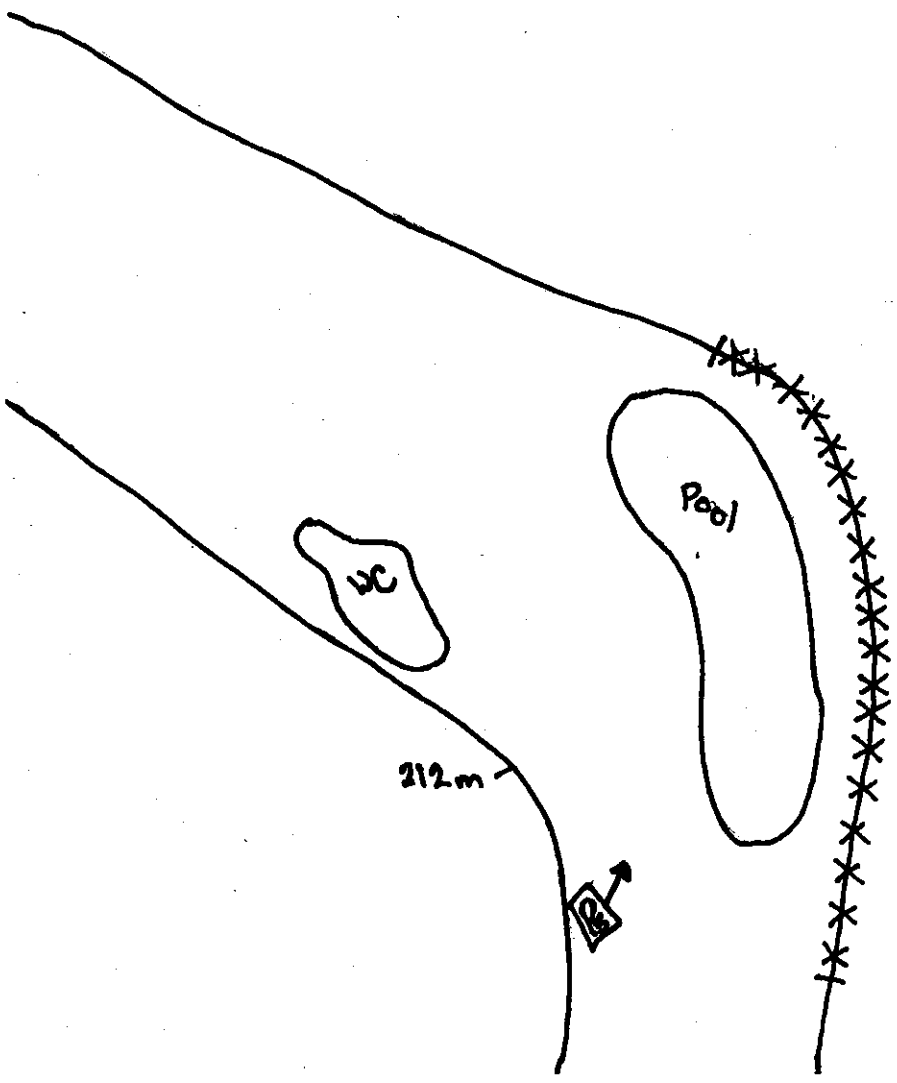
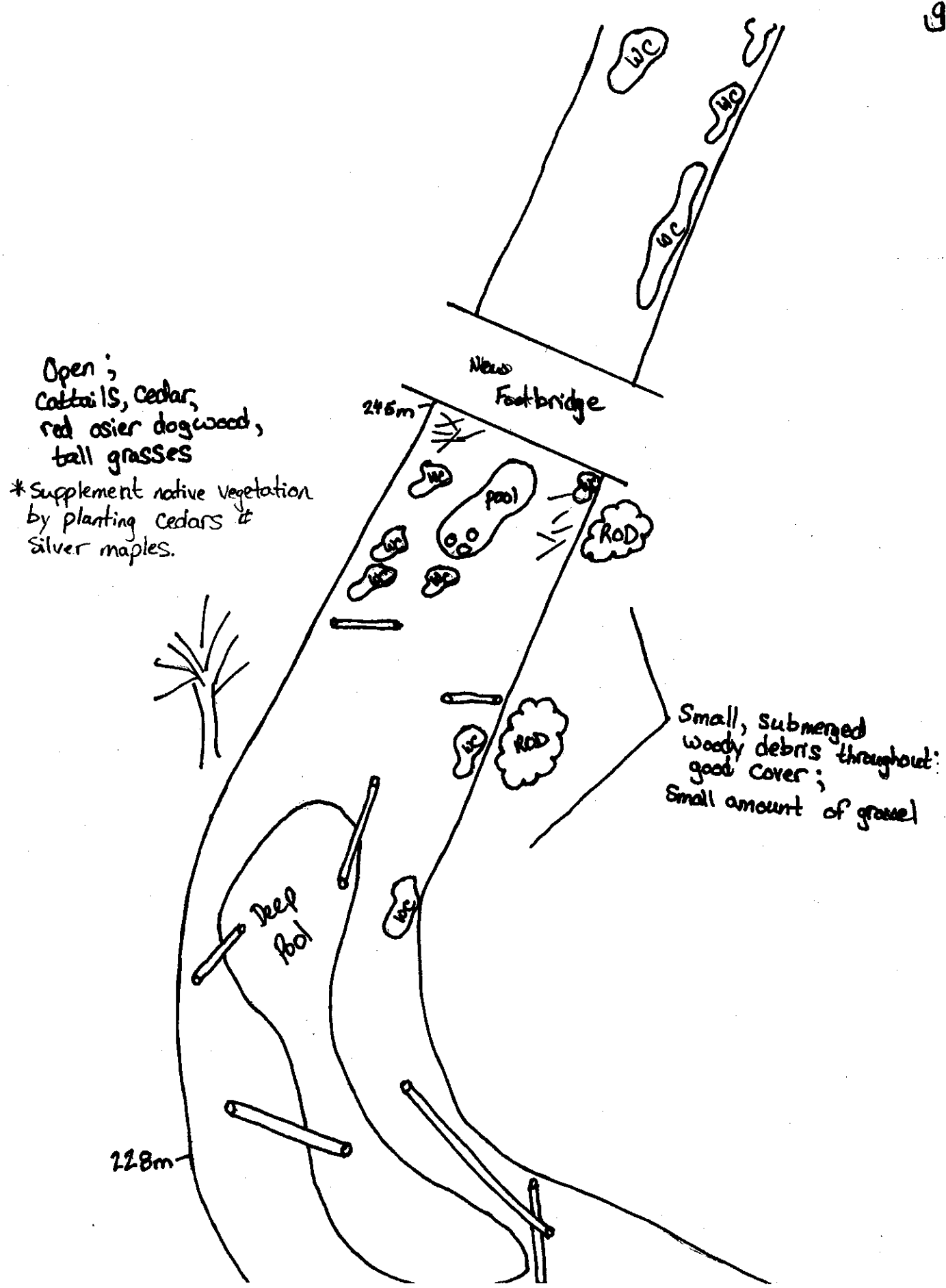
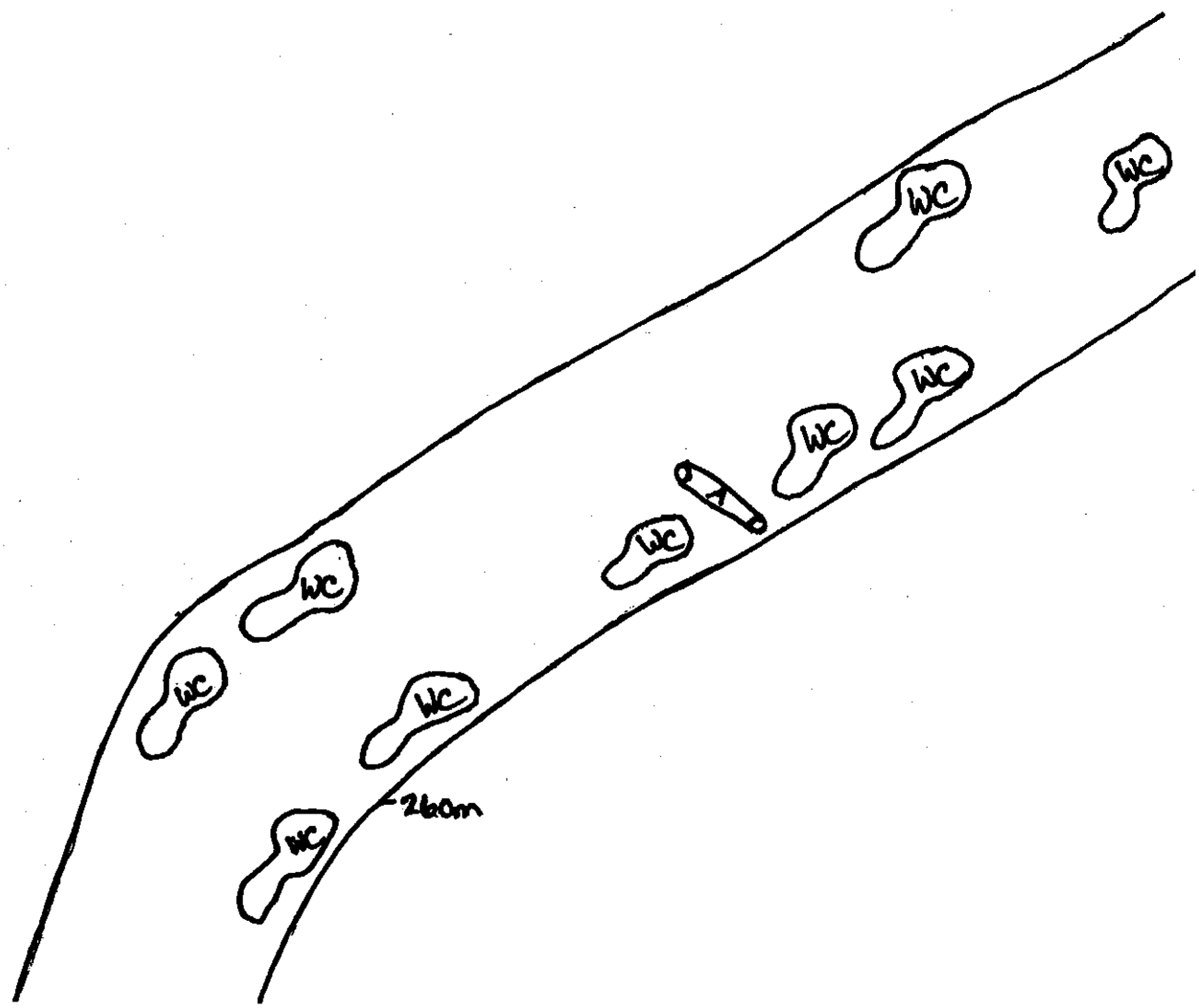
WC
WC
P
171m
depression
ROD
pool

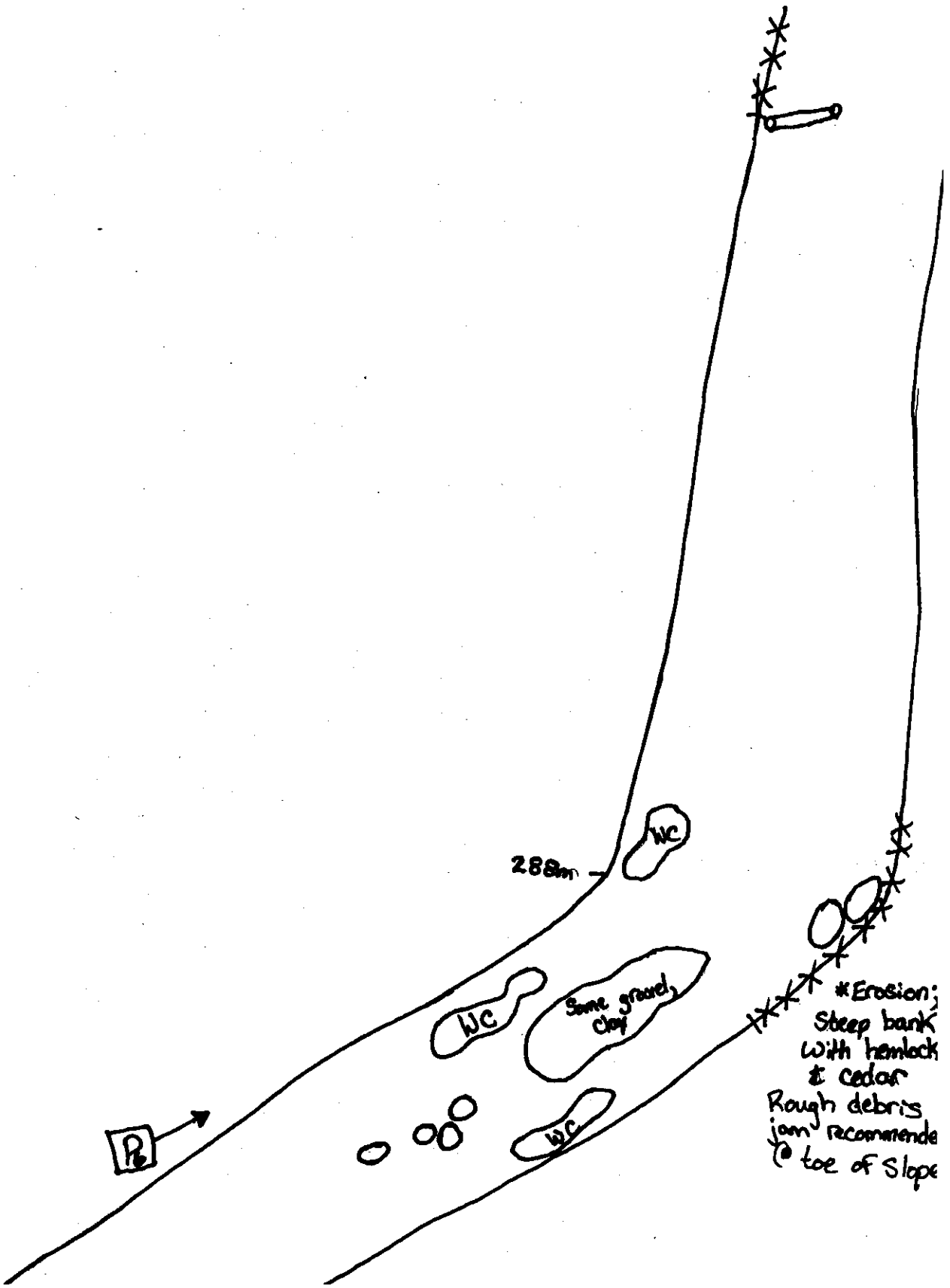

195m
ROD
WC
WC
WC

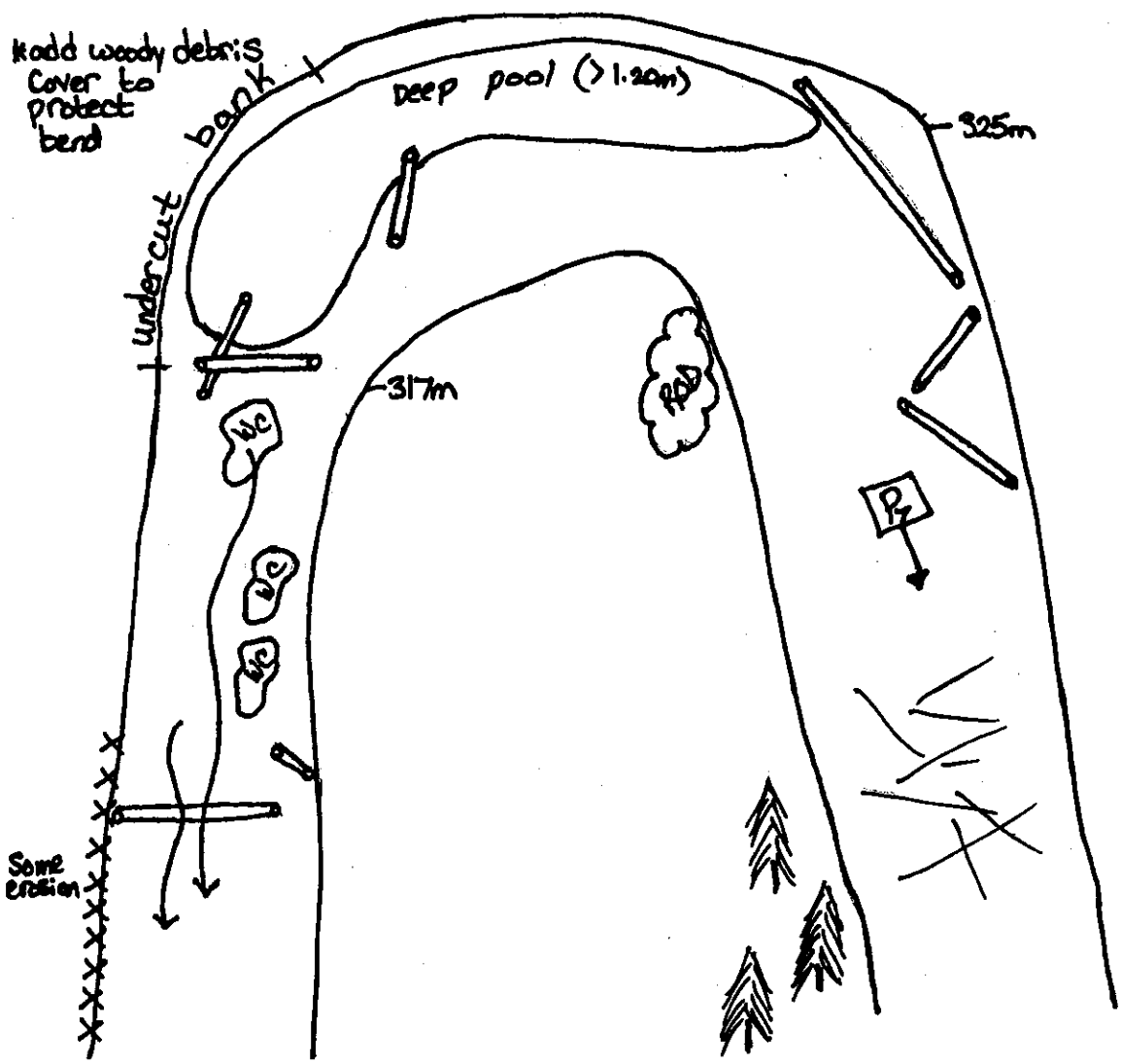


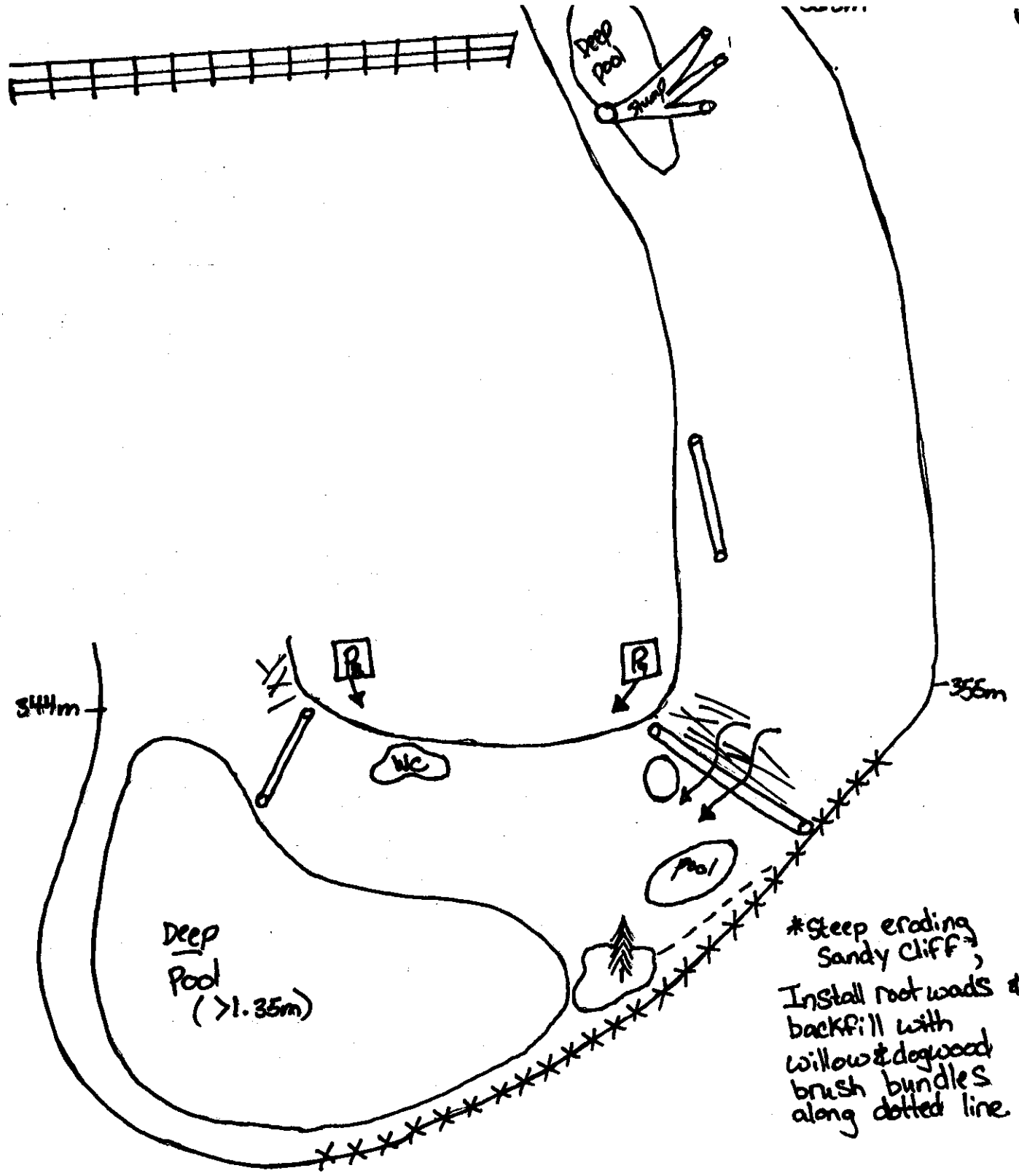
* Slight erosion; Regrading & heavy planting of willow shrubs recommended.

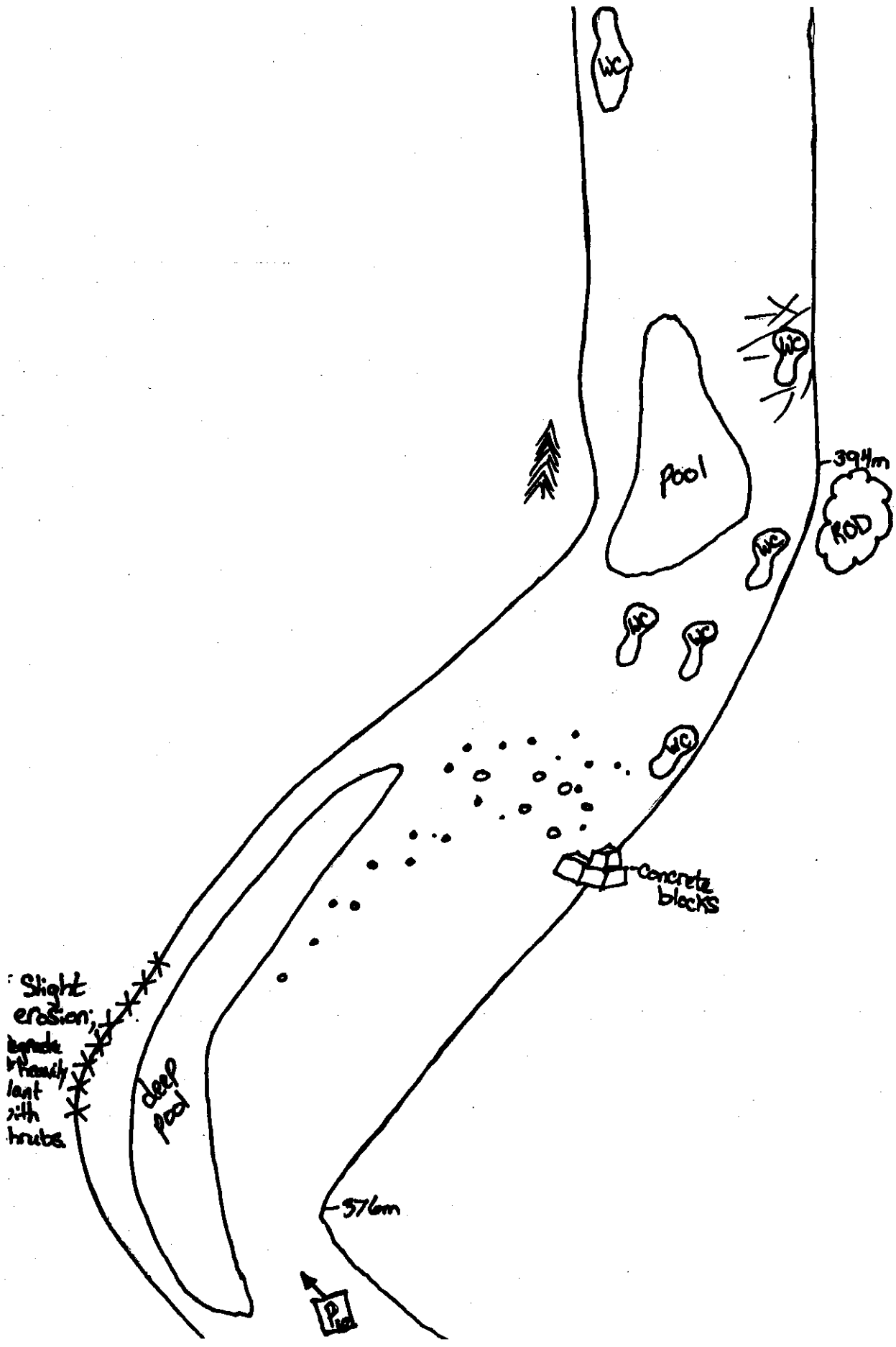

WC
WC
WC
Open;
Cattails, Cedar,
red osier dogwood,
tall grasses
*Supplement native vegetation by planting cedars & silver maples.
New
Footbridge
245m
WC
pool
RoD
WC
WC
WC
RoD
WC
Small, submerged woody debris throughout: good cover;
Small amount of gravel
Deep
Pool
WC
228m

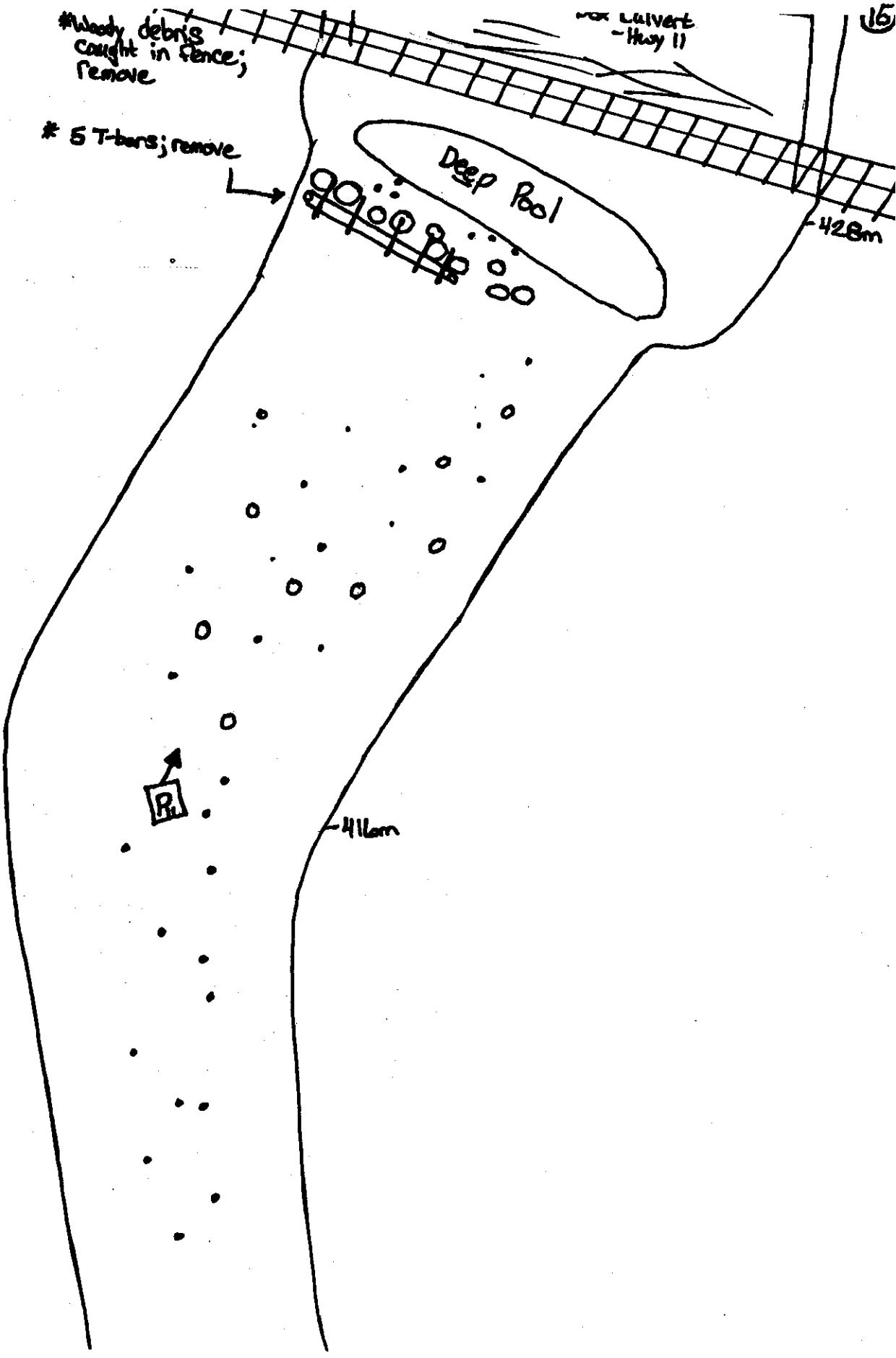

WC
WC
WC
WC
WC
WC
WC
WC
WC
260m


288m
WC
WC
WC
Some gravel, clay
R
*Erosion;
Steep bank
with hemlock
& cedar
Rough debris
jam recommende
@ toe of Slope


Add woody debris
Cover to
protect
bend
bank
undercut
deep pool (>1.20m)
325m
317m
RP
WC
Some
erosion


Deep Pool
Jump
R
R
344m
355m
HC
Pool
Deep
Pool
(>1.35m)
*Steep eroding Sandy Cliff;
Install root wads & backfill with willow & dogwood brush bundles along dotted line


WC
WC
pool
394m
ROD
WC
WC
WC
WC
concrete blocks
Slight erosion; banks heavily lent with bushes
deep pool
576m
P


#Woody debris caught in fence; remove
* 5 T-bars; remove
Deep Pool
-428m
-411cm
R1

Appendix A - Hathaway Property Rehabilitation Plan Photographs

Photo 1: Slight erosion

Photo 2: Steep eroding bank opposite man-made rock weir

Photo 3: Man-made rock weir causing downstream erosion

Photo 4: Watercress abundant stretch

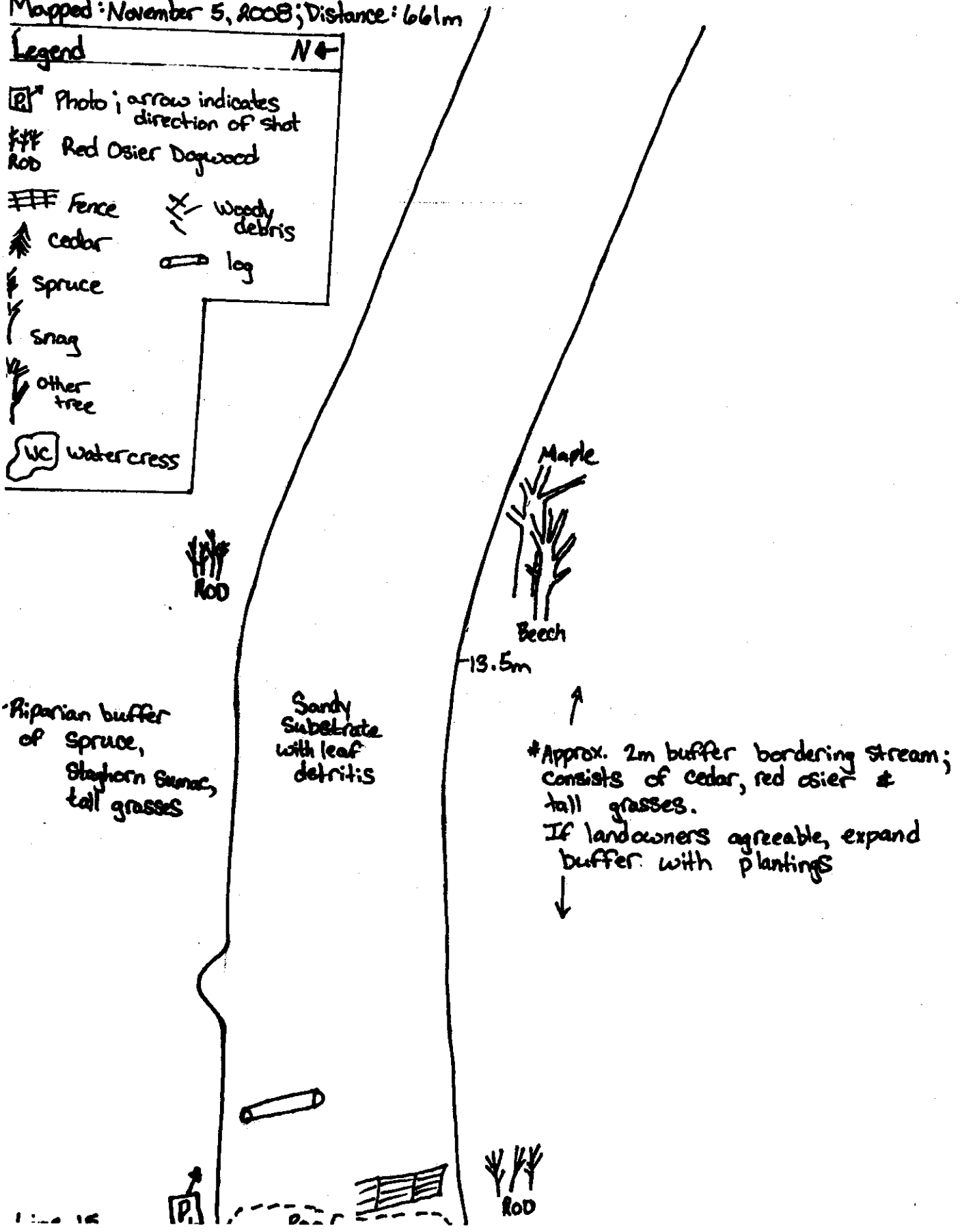
Photo 5: Slight erosion; re-grading and planting recommended

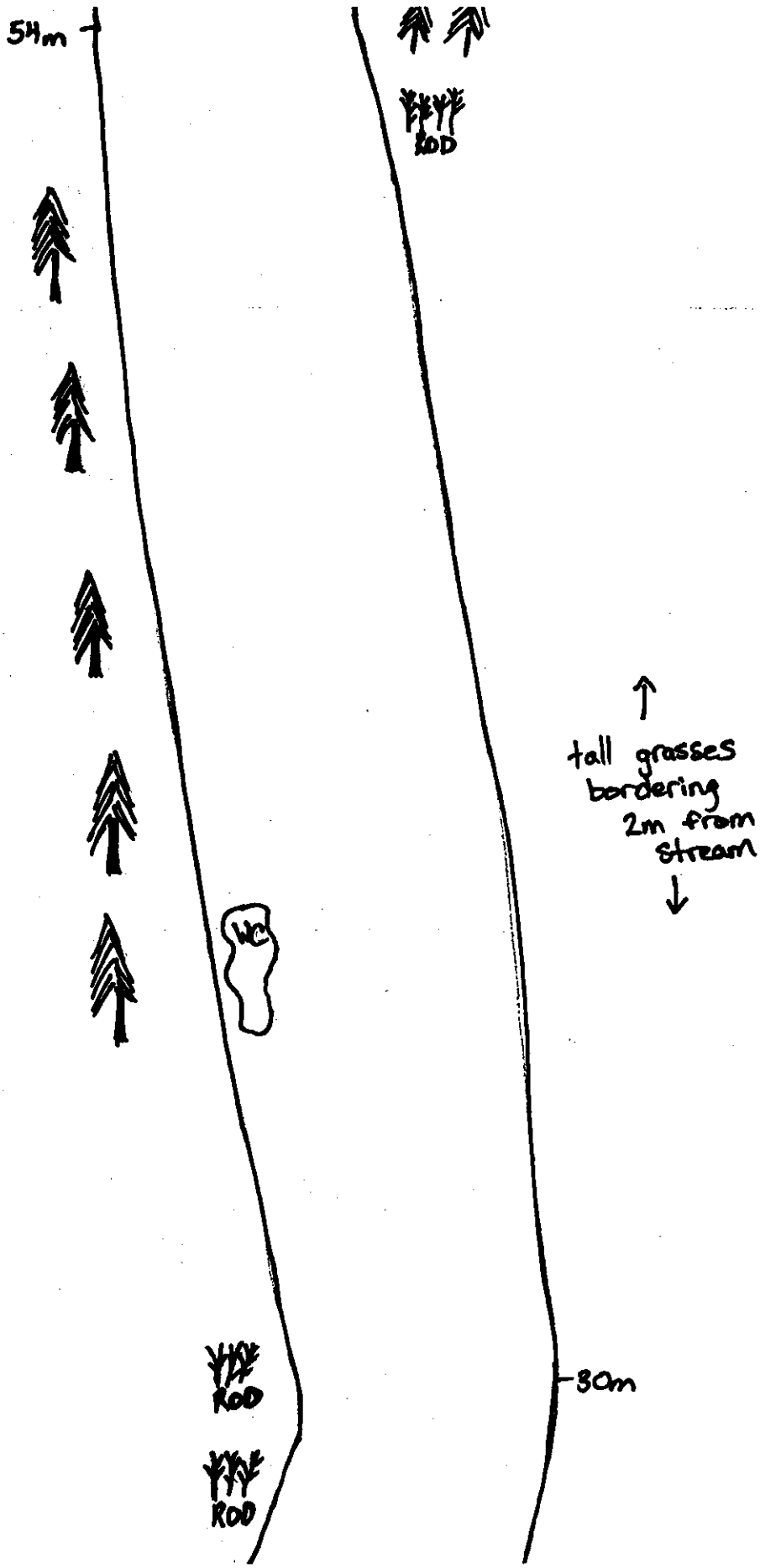
Photo 6: Steep eroding bank; debris jam recommended

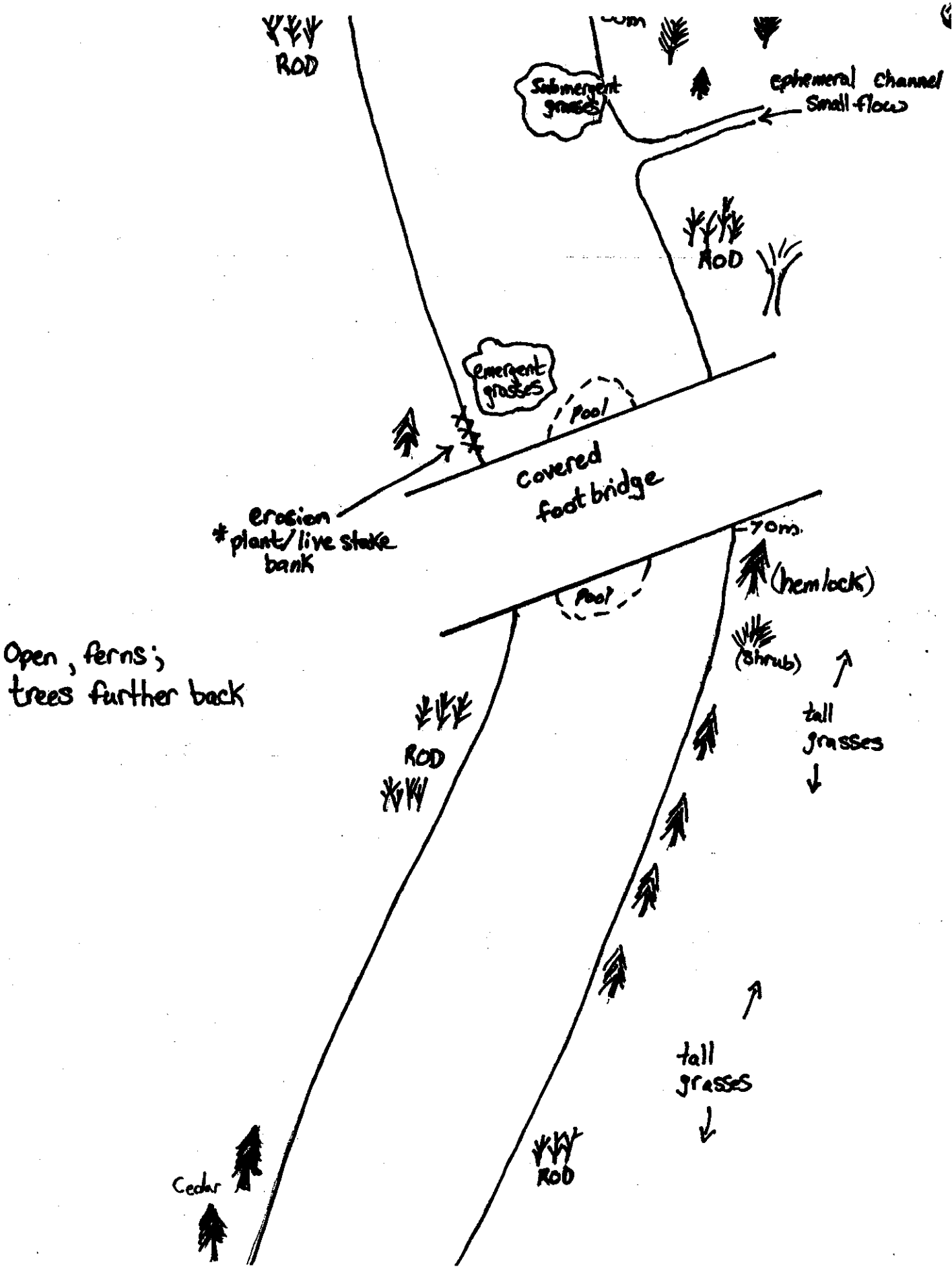
Appendix B: Goss Property Rehabilitation Plan

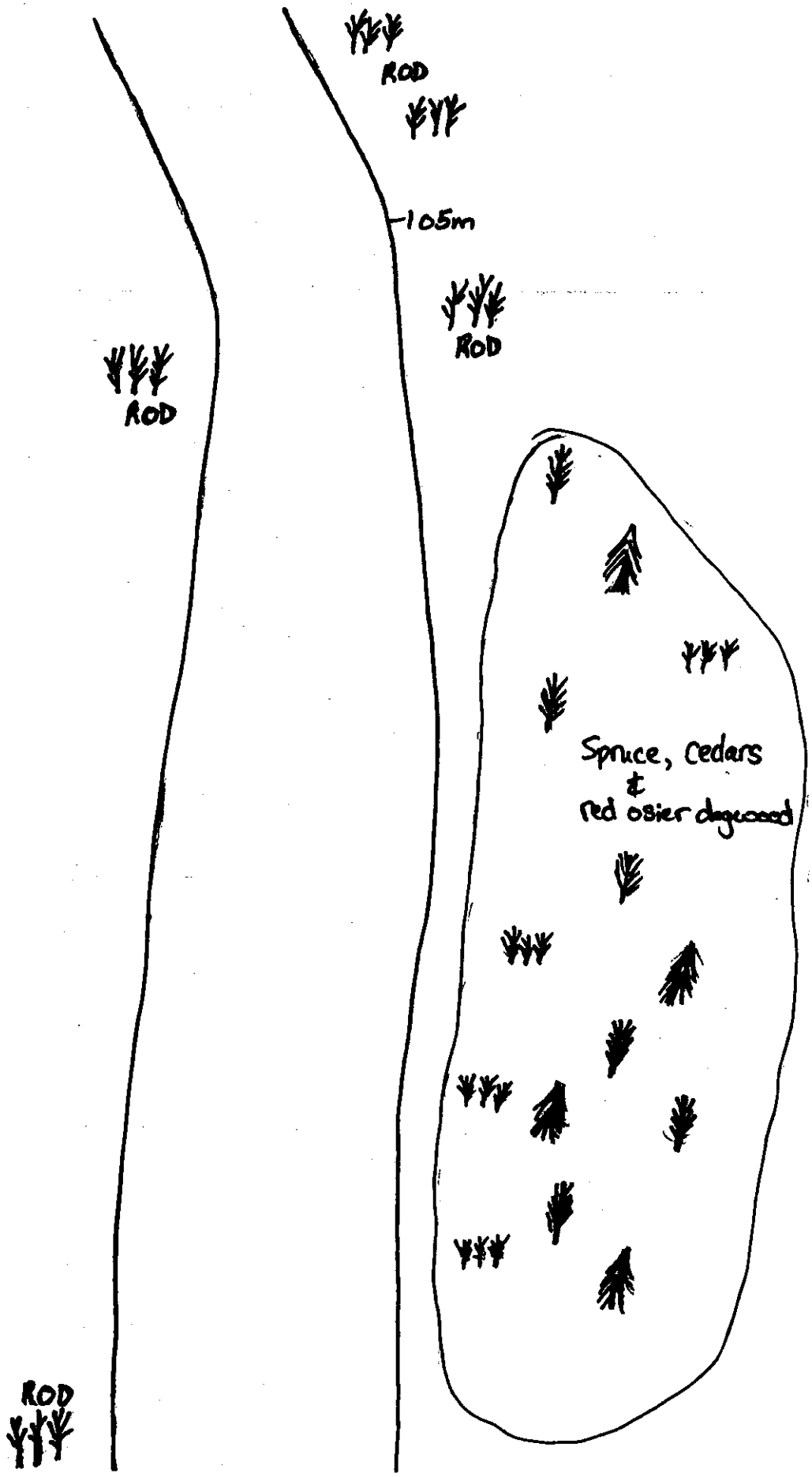
Goss Property Rehabilitation Plan

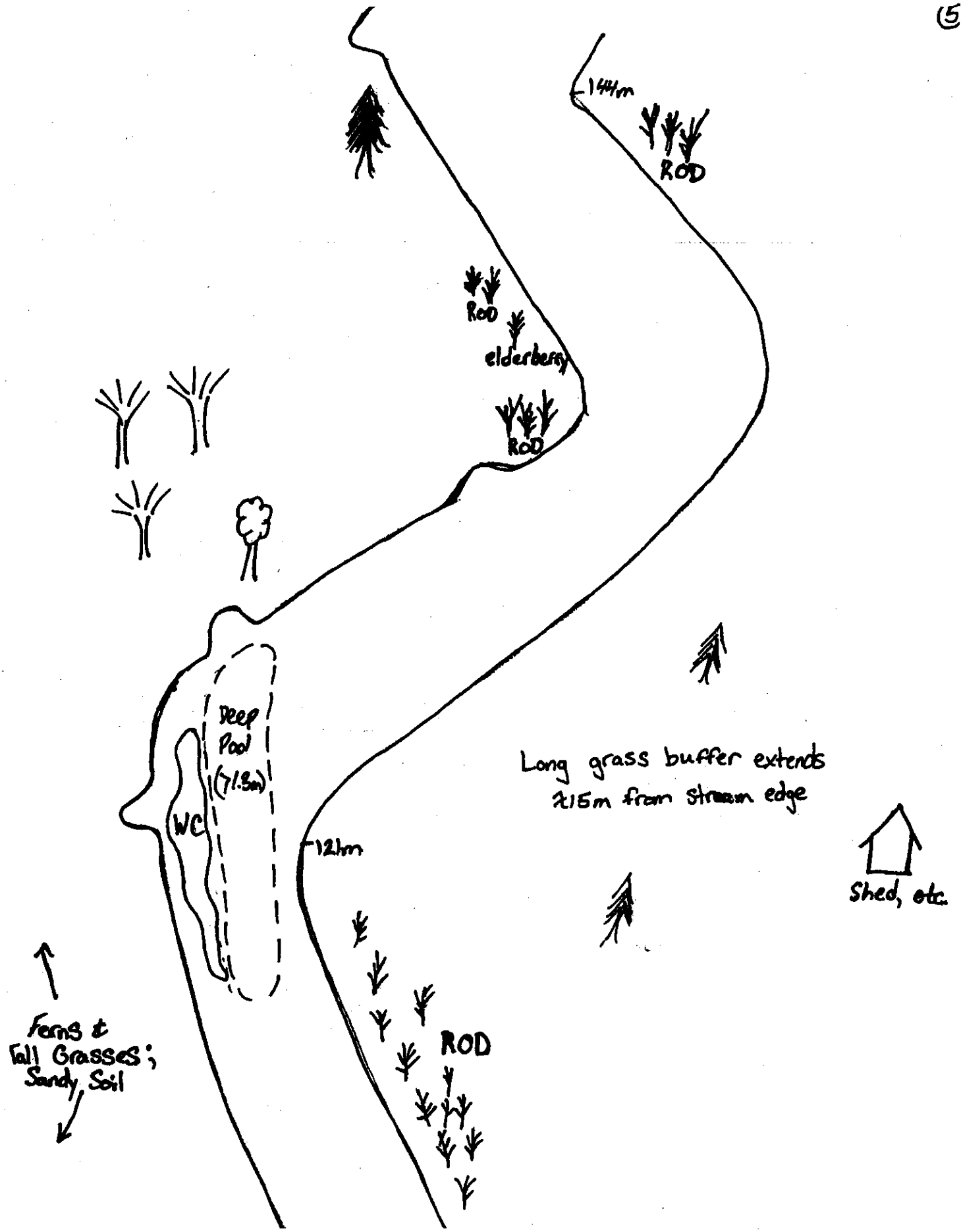
Mapped: November 5, 2008; Distance: 661m

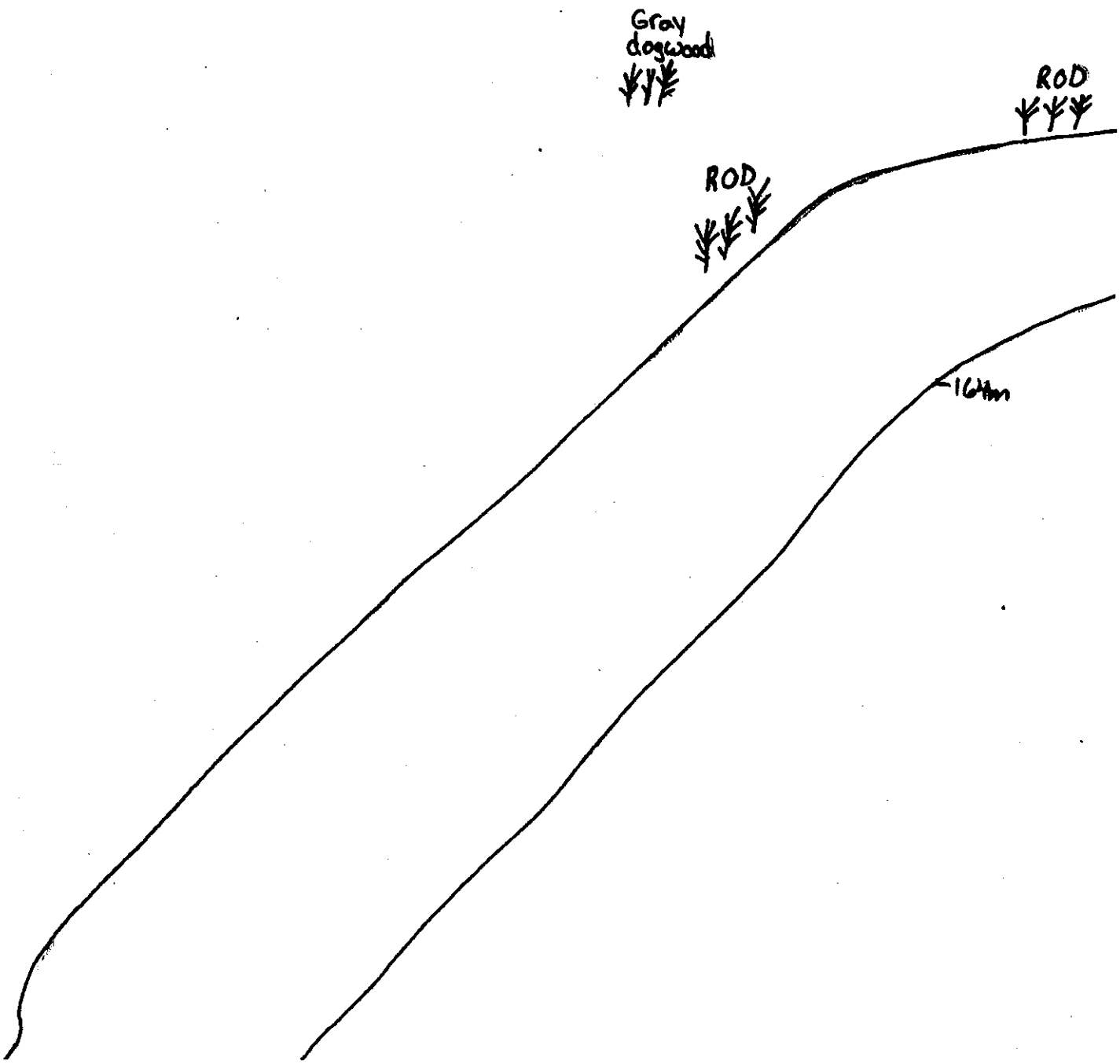


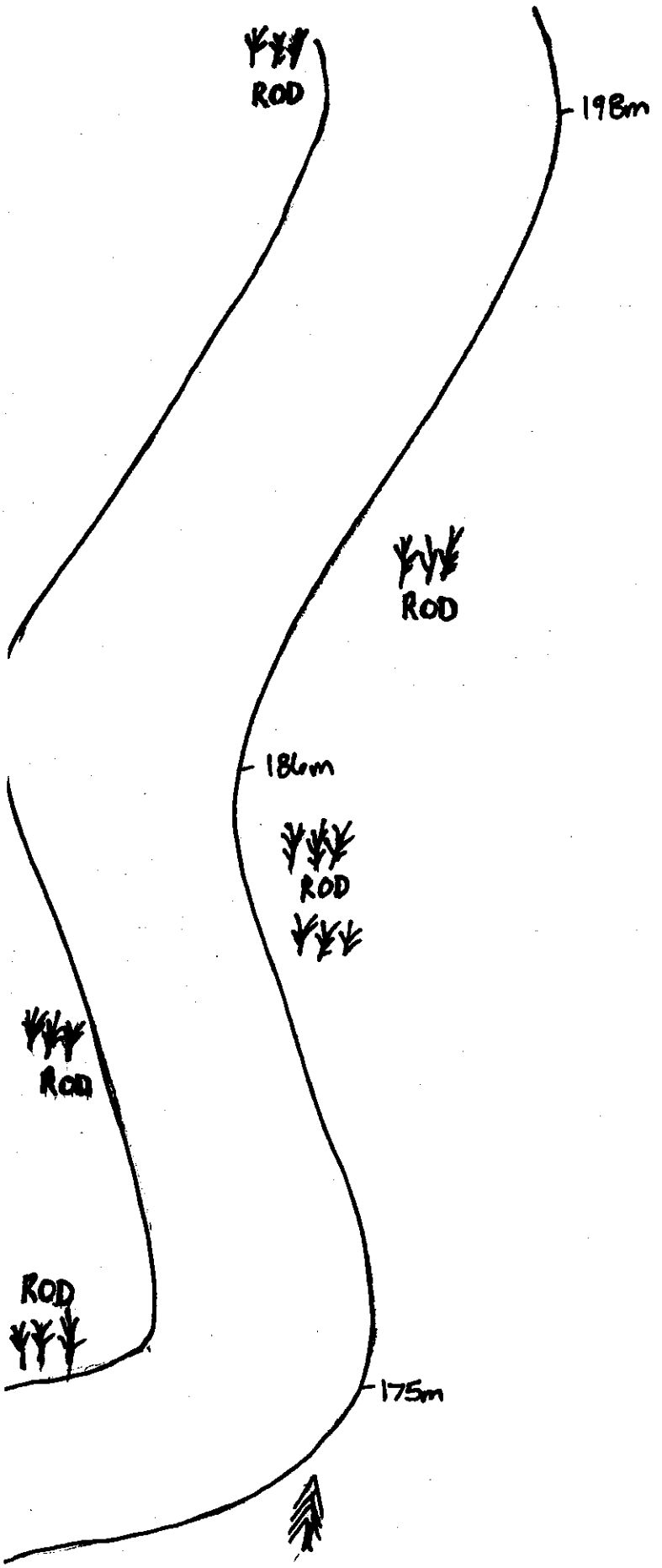

54m
ROD
tall grasses bordering 2m from stream
WC
ROD
ROD
30m

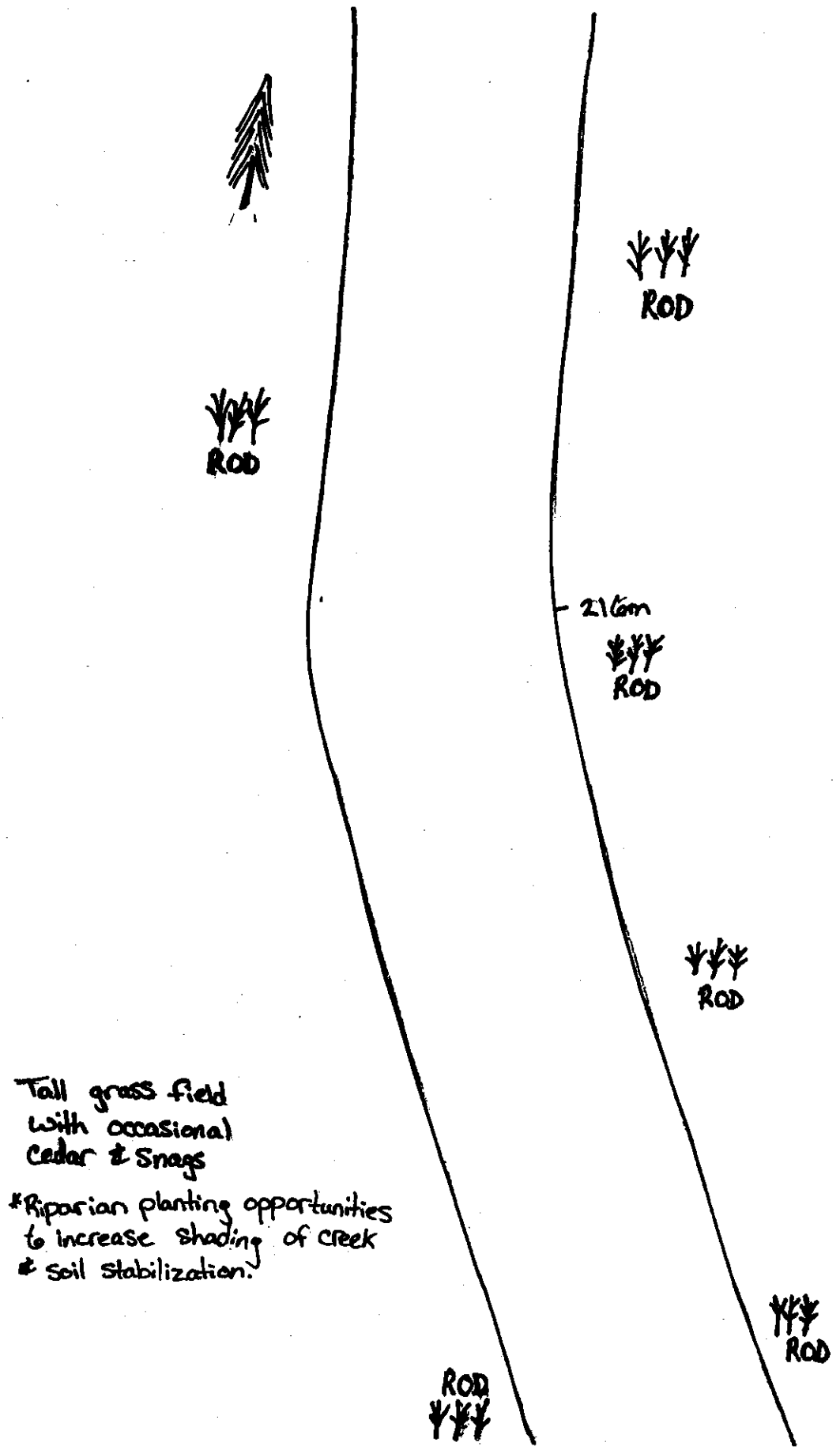

ROD
Submergent grasses
ephemeral Channel
Small flow
ROD
emergent grasses
Pool
Covered foot bridge
erosion
* plant/live stake bank
70m.
(hemlock)
Pool
(Shrub)
tall grasses
Open, ferns; trees further back
ROD
tall grasses
Cedar
ROD

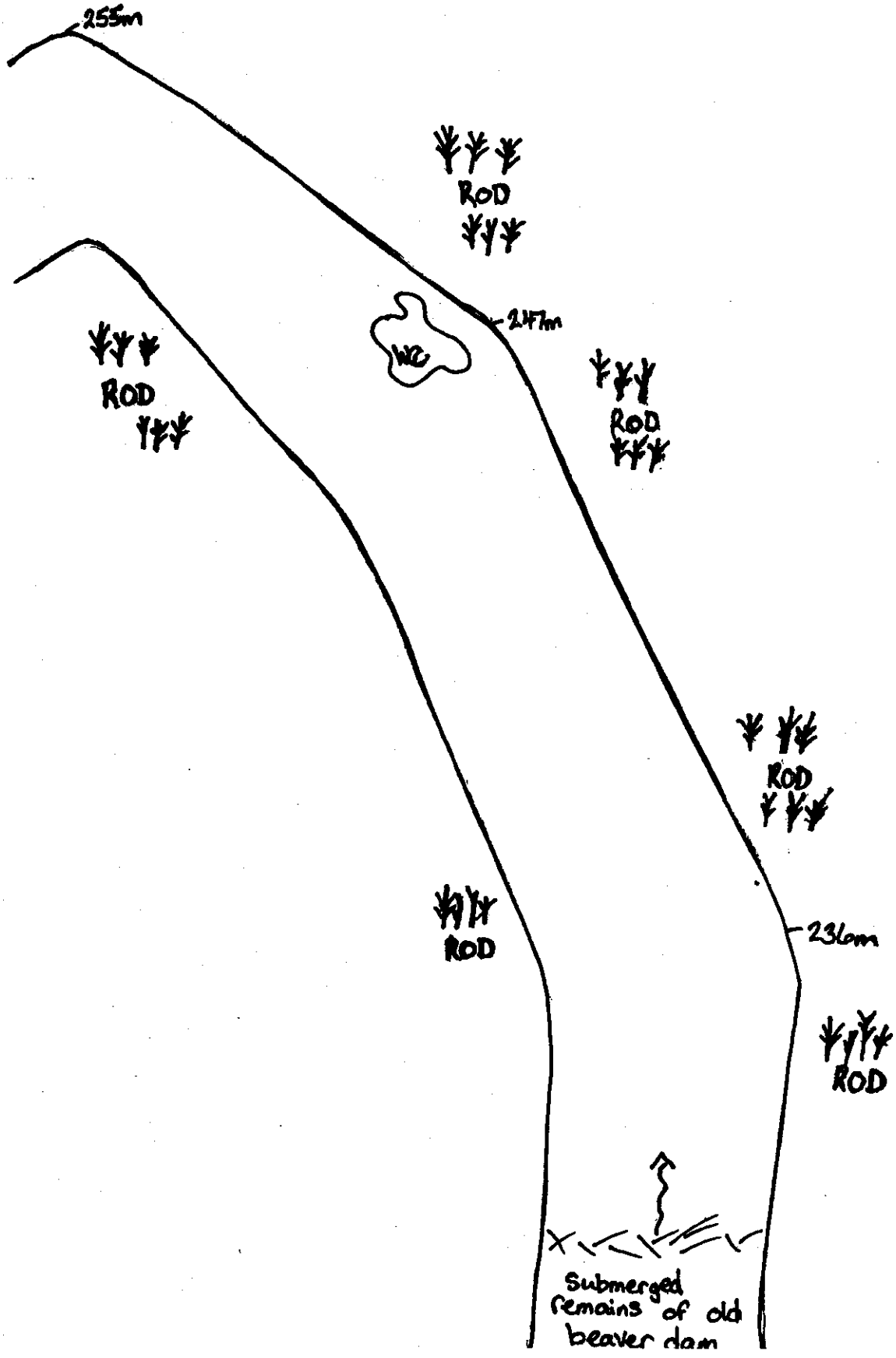

ROD
105m
ROD
ROD
ROD
Spruce, Cedars
&
red osier dogwood

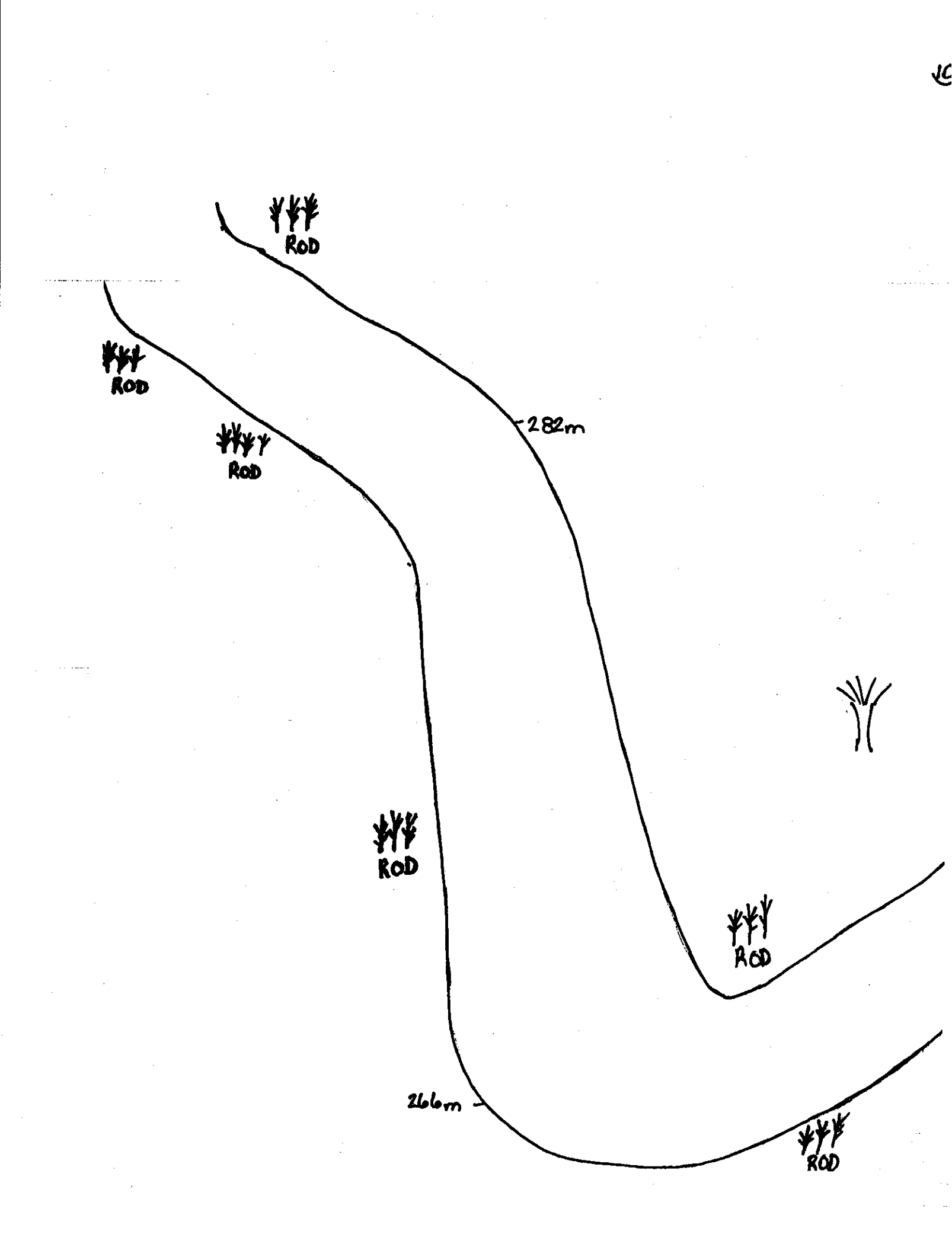

144m
ROD
ROD
elderberry
ROD
Deep Pool (7.5m)
WC
12hm
Long grass buffer extends ≥15m from stream edge
Shed, etc.
ROD
Ferns & Tall Grasses; Sandy Soil

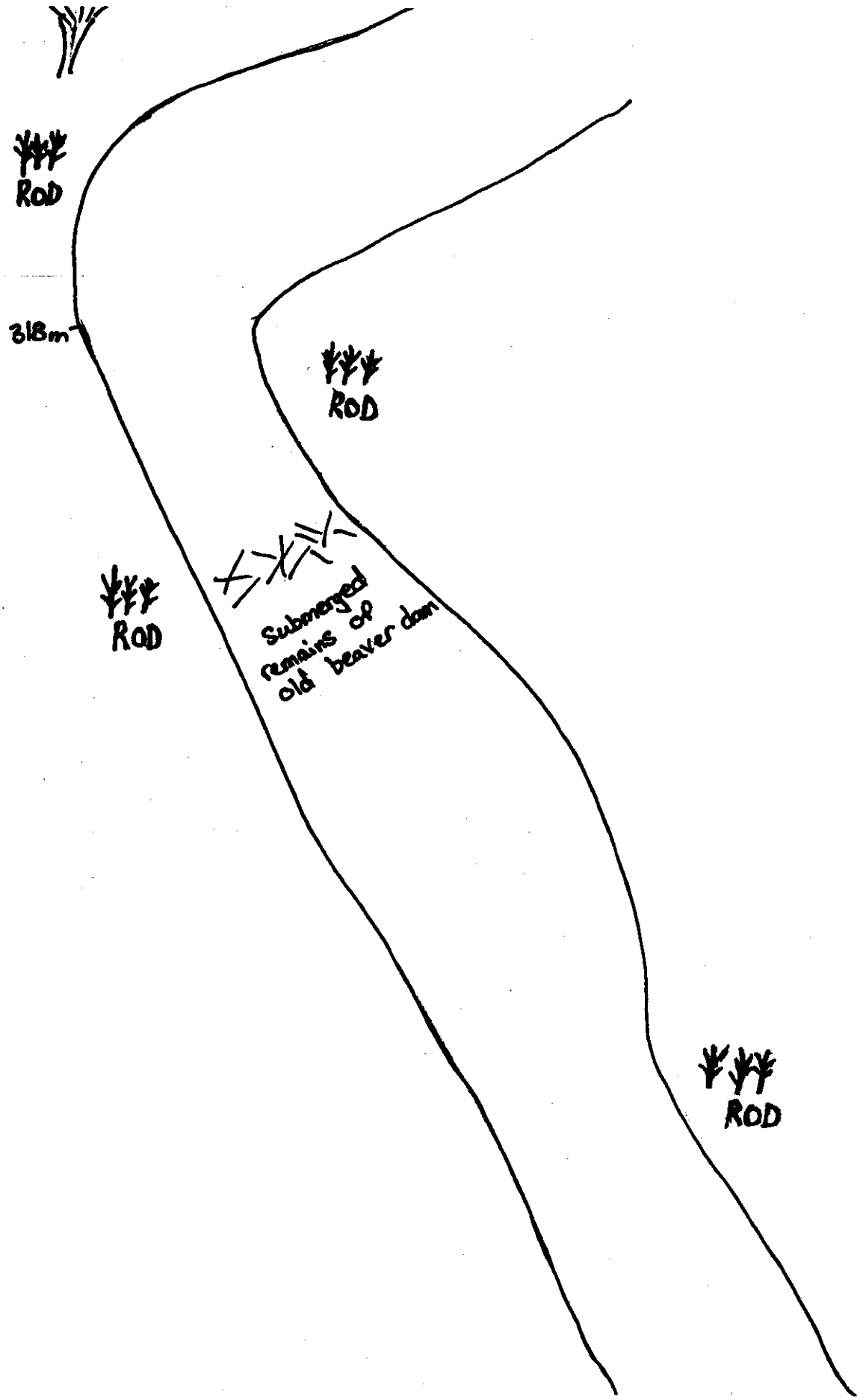

Gray dogwood
ROD
ROD
16th

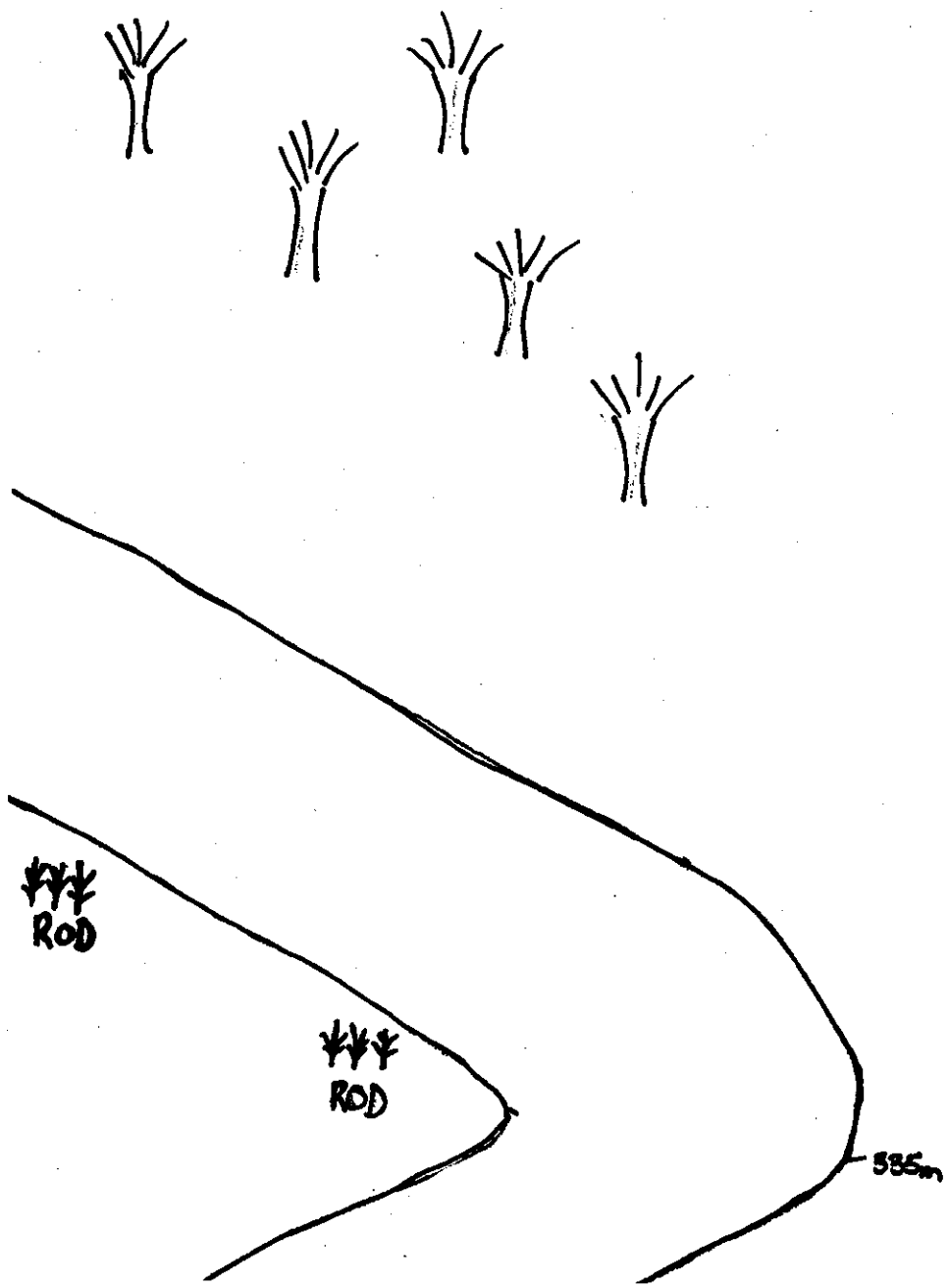

ROD
198m
ROD
186m
ROD
ROD
ROD
175m

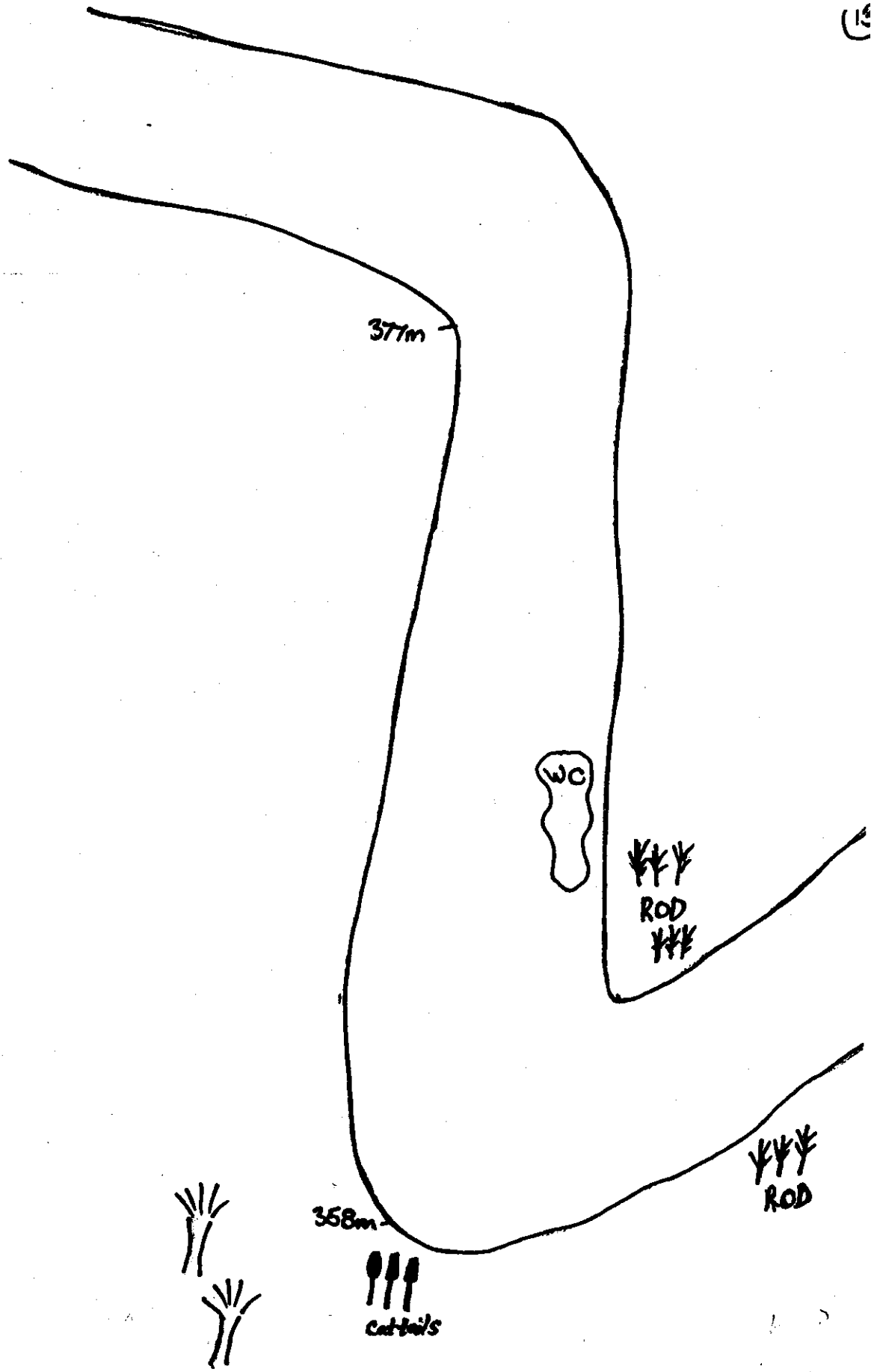

ROD
ROD
216m
ROD
ROD
ROD
ROD
Tall grass field with occasional cedar & snags
*Riparian planting opportunities to increase shading of creek & soil stabilization.

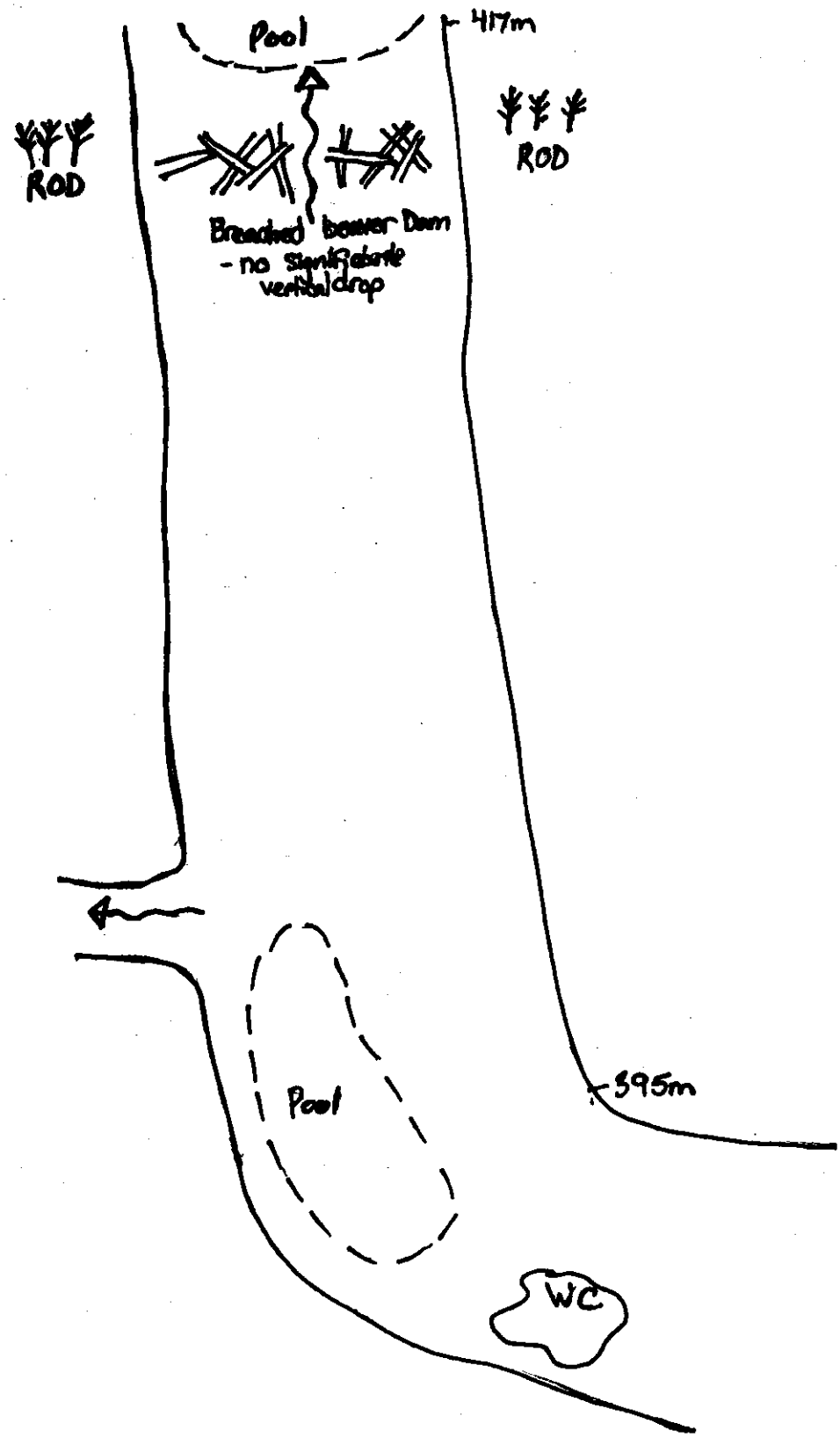

255m
ROD
247m
WC
ROD
ROD
ROD
ROD
236m
ROD
Submerged remains of old beaver dam

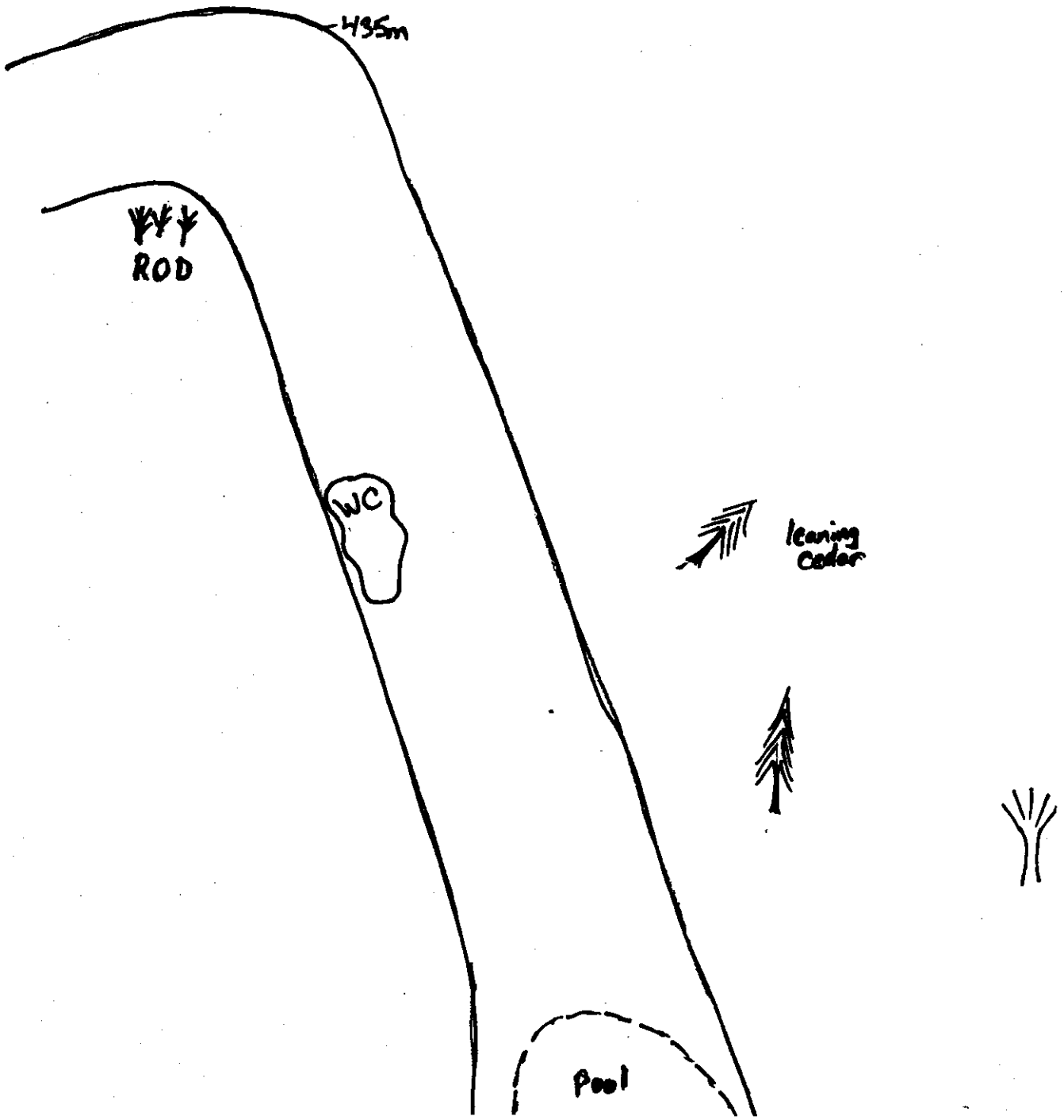

ROD
ROD
ROD
282m
ROD
ROD
266m
ROD

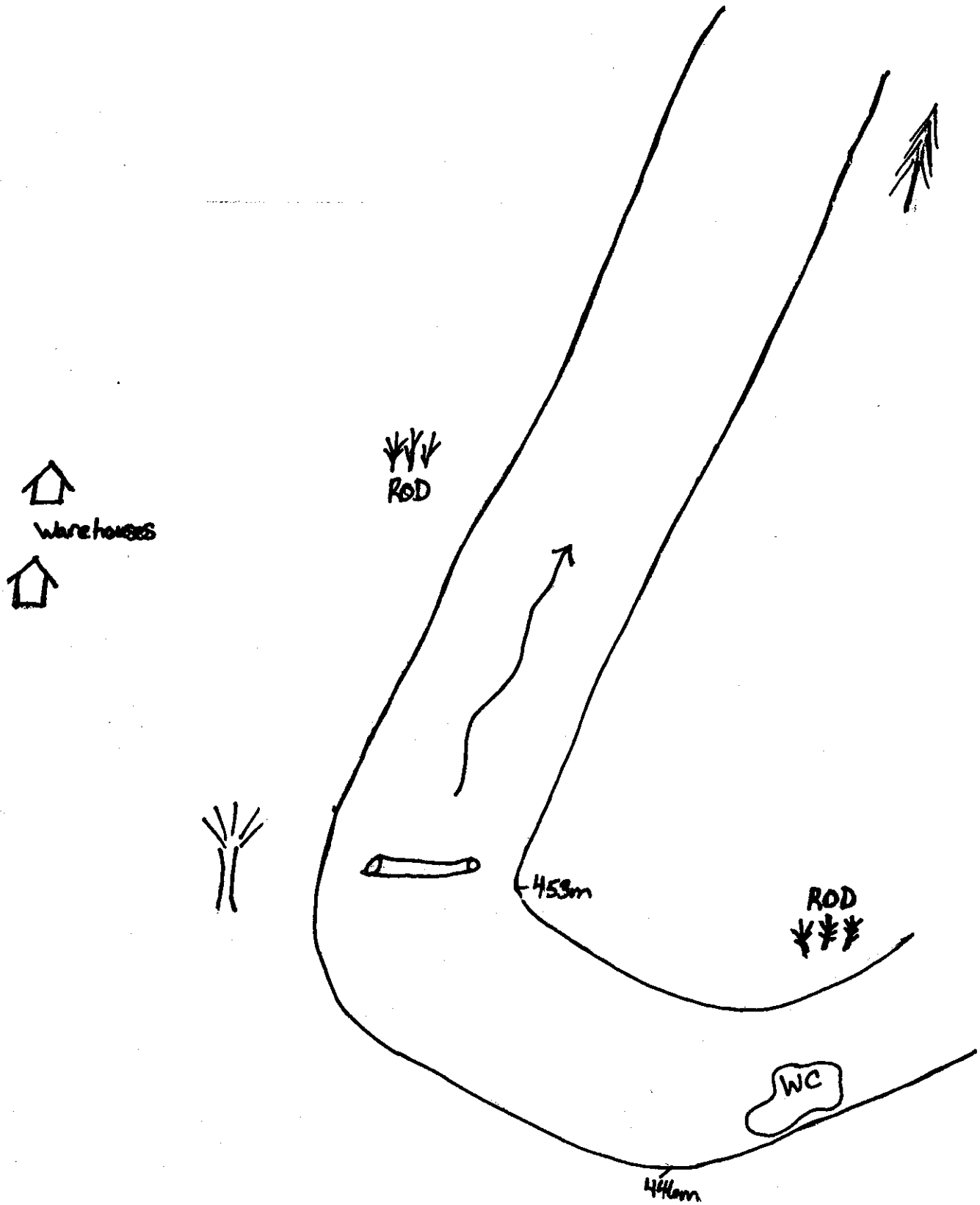

ROD
318m
ROD
ROD
Submerged remains of old beaver dam
ROD

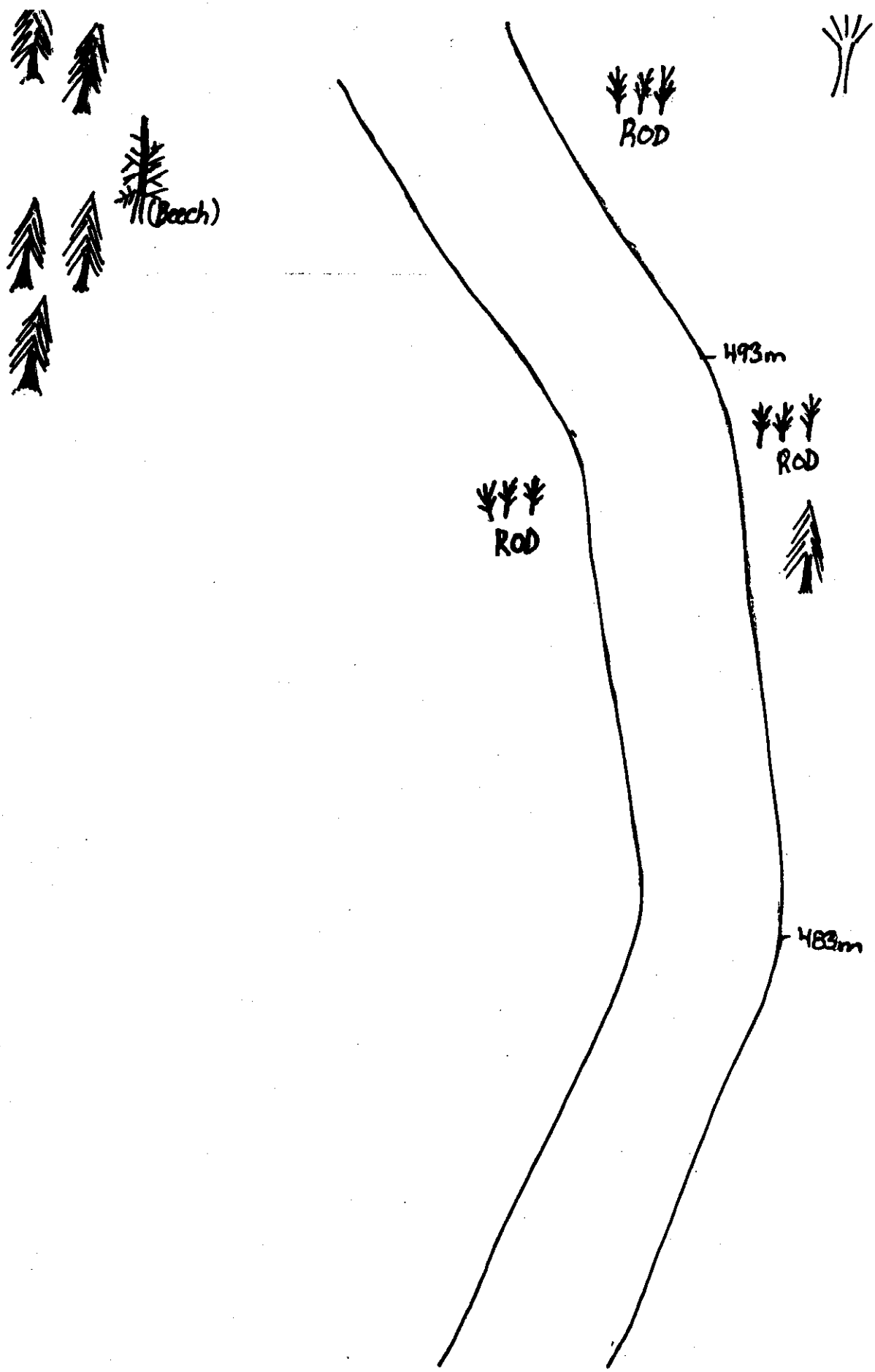

ROD
ROD
585m

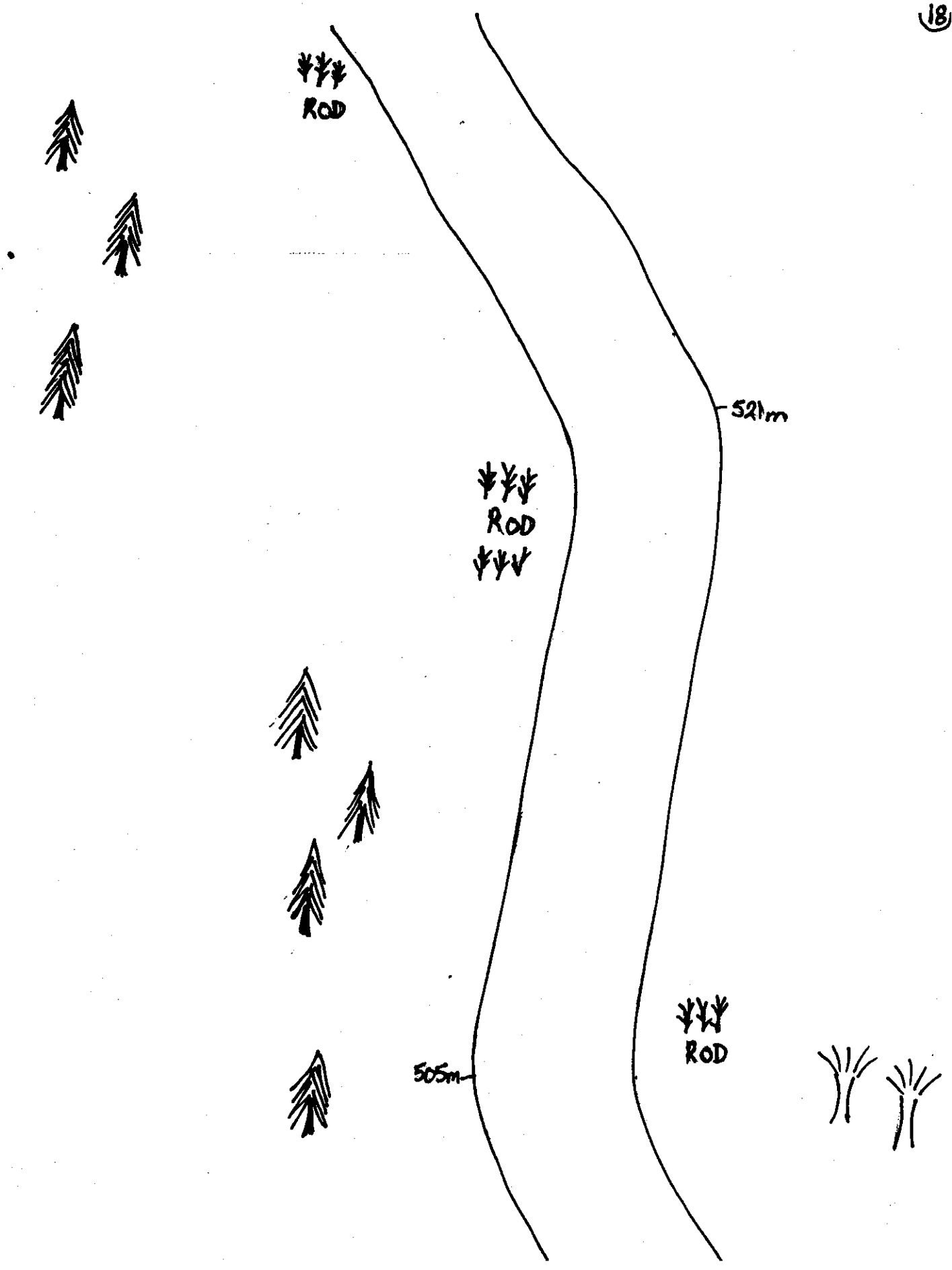

371m
WC
ROD
ROD
358m
cattails

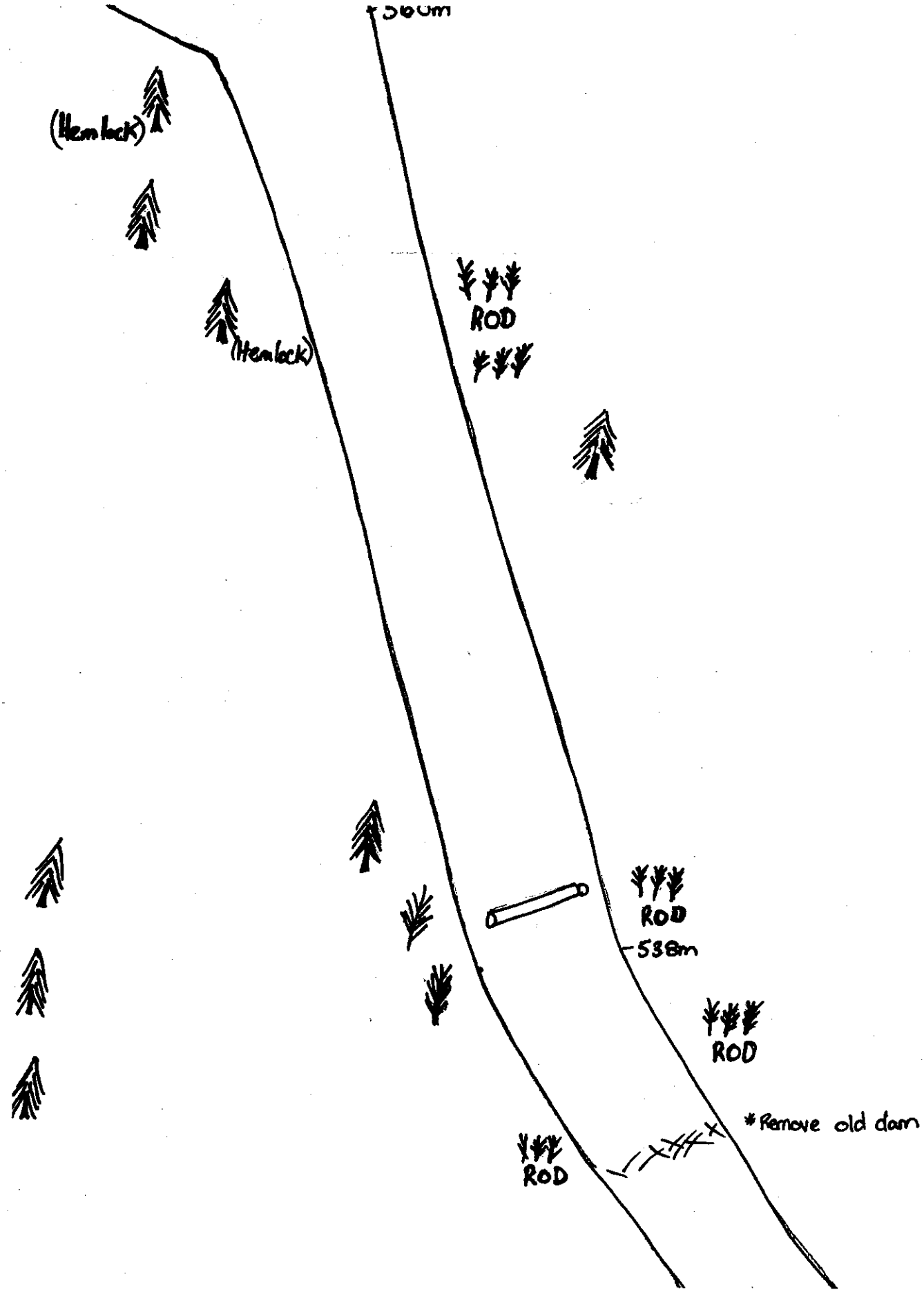

Pool
417m
ROD
ROD
Breached beaver Dam
- no significant
vertical drop
Pool
395m
WC

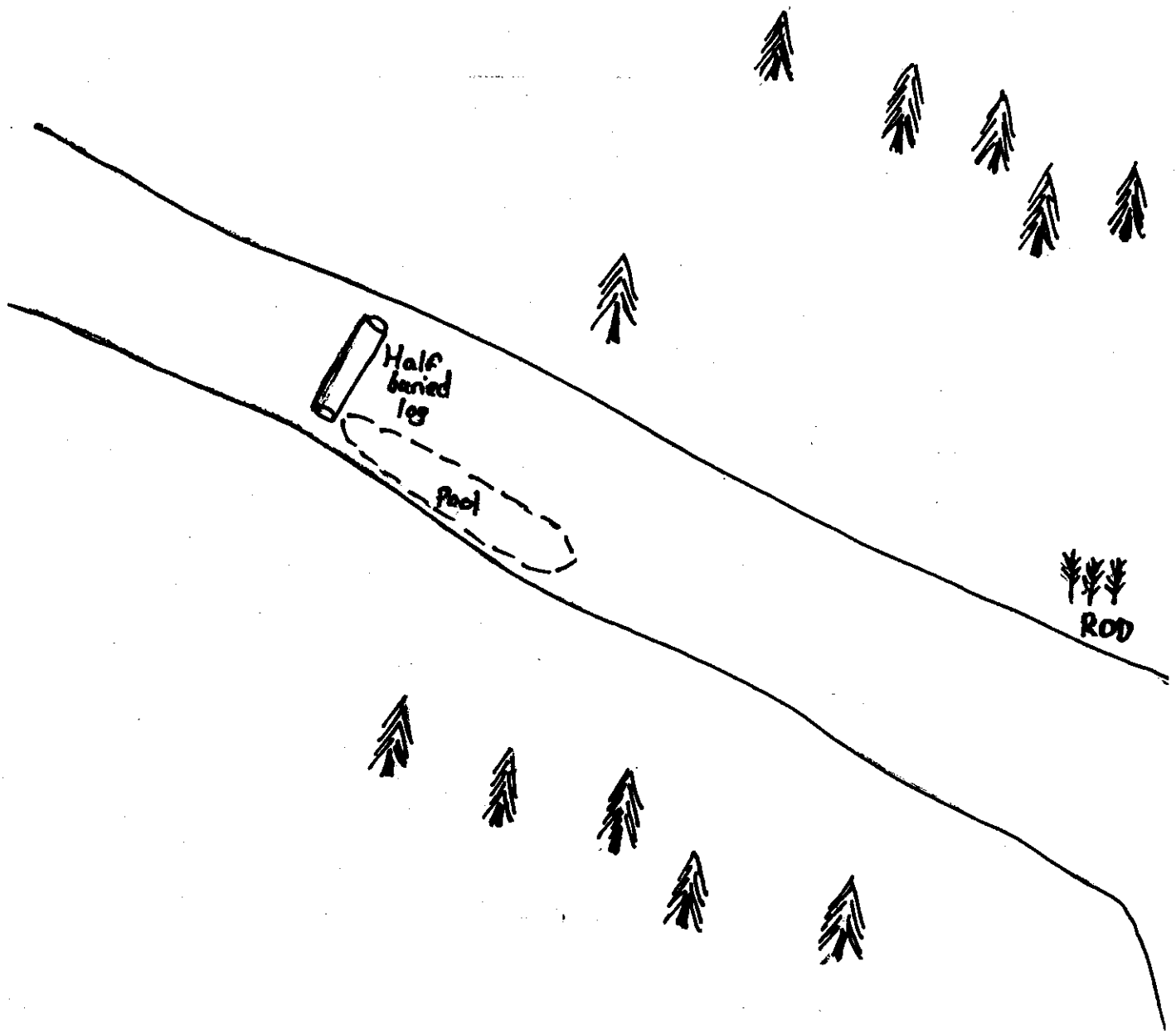

495m
ROD
WC
leaning cedar
Pool

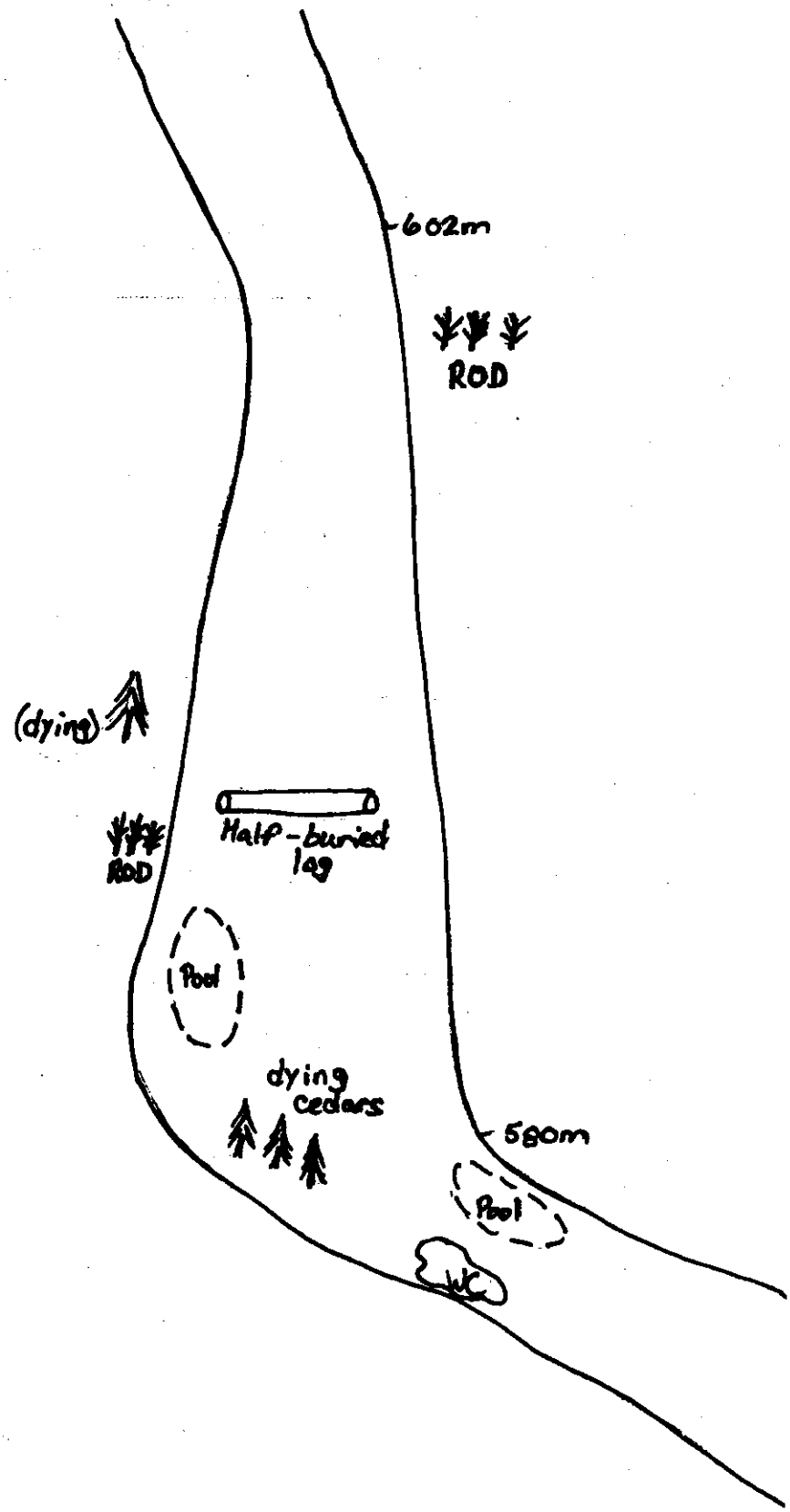

Warehouses
ROD
453m
ROD
WC
444m

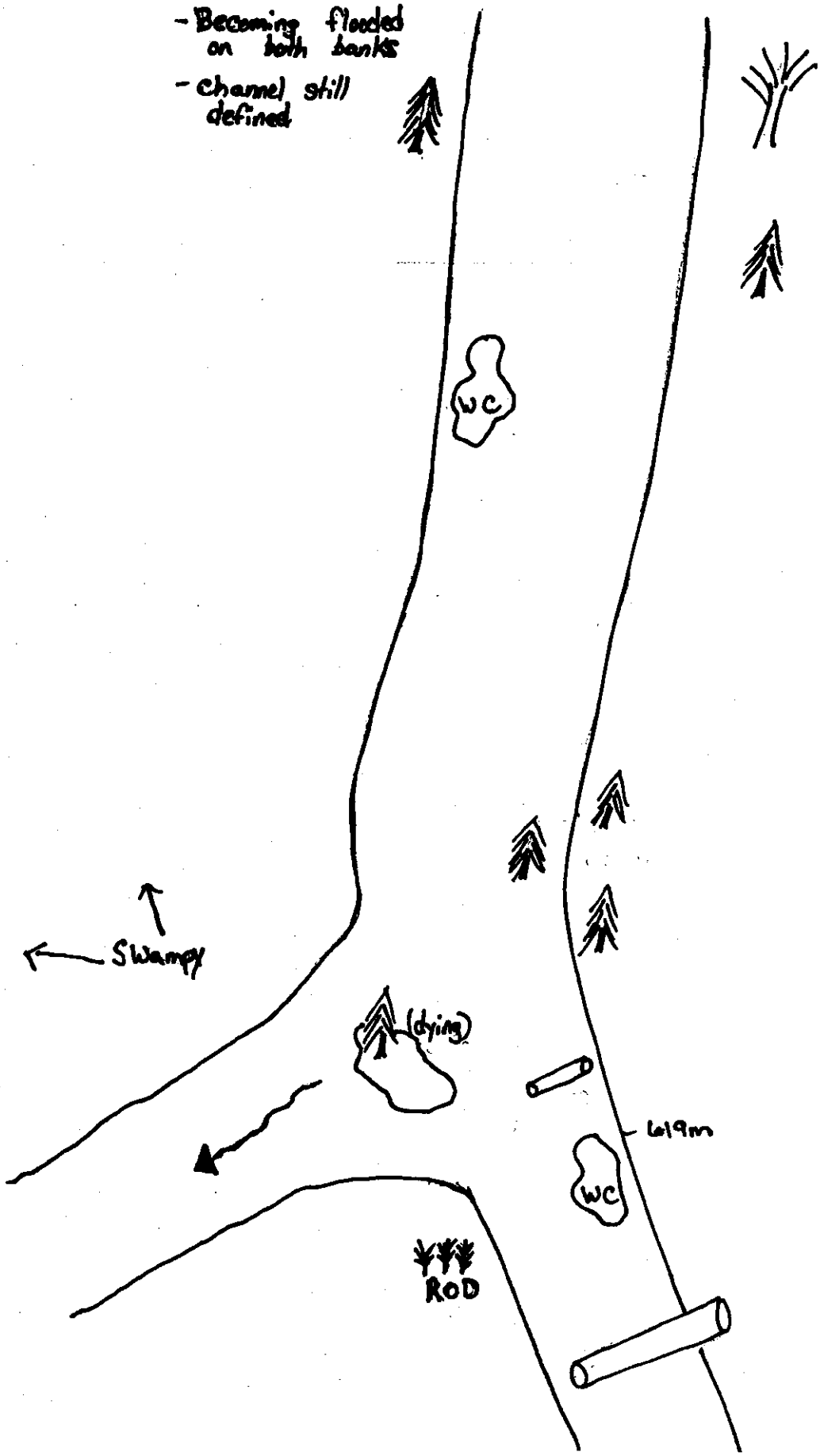

(Beech)
ROD
493m
ROD
ROD
489m

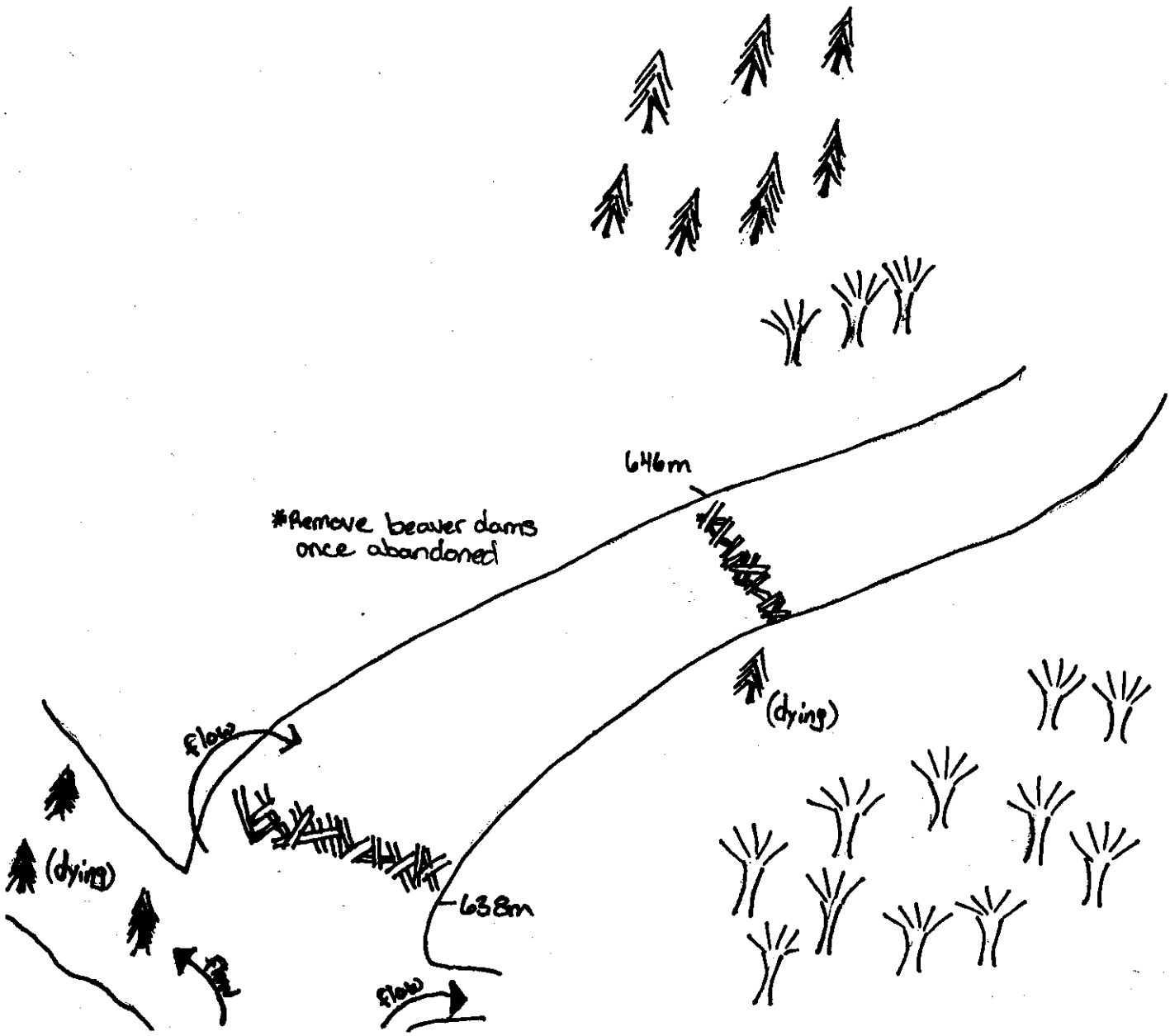

ROD
521m
ROD
ROD
505m


560m
(Hemlock)
(Hemlock)
ROD
ROD
538m
ROD
ROD
* Remove old dam

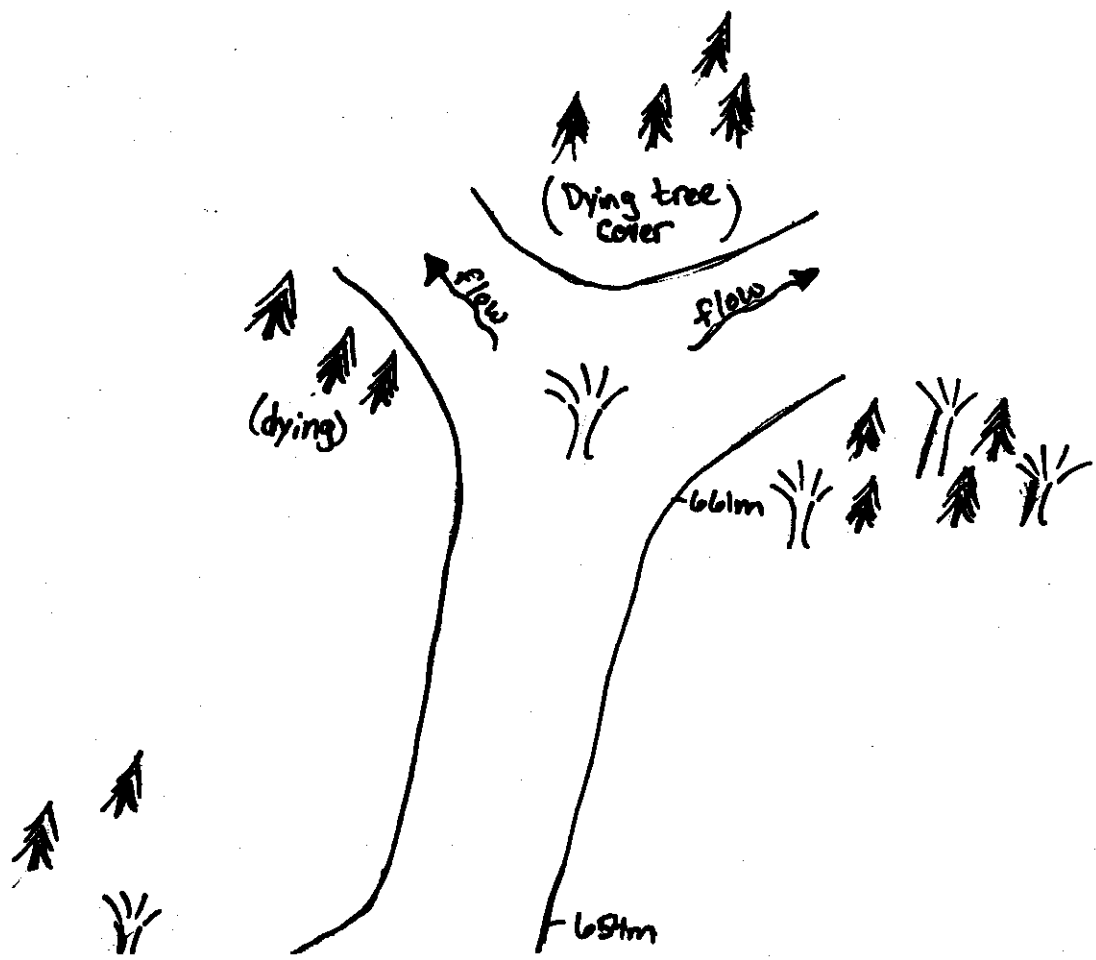

Half buried log
Pool
ROD


602m
ROD
(dying)
ROD
Half-buried log
Pool
dying cedars
580m
Pool
WC


- Becoming flooded on both banks
- Channel still defined
WC
Swampy
(dying)
6.19m
WC
ROD


646m
*Remove beaver dams once abandoned
(dying)
flow
(dying)
638m
flow

-Channel becomes increasingly branched due to downstream beaver activity.
Stop point: UTM 17T 0624458
4935522

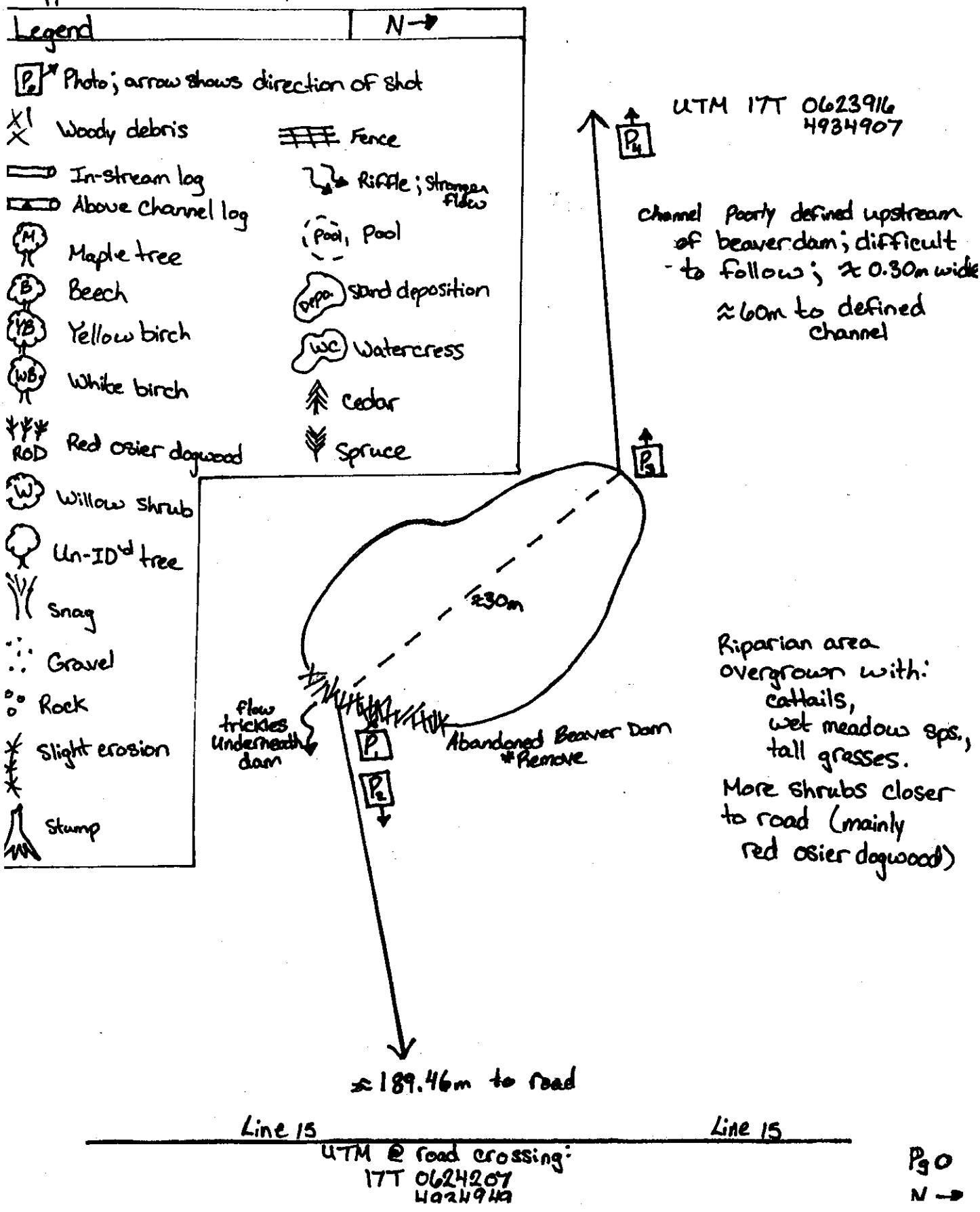


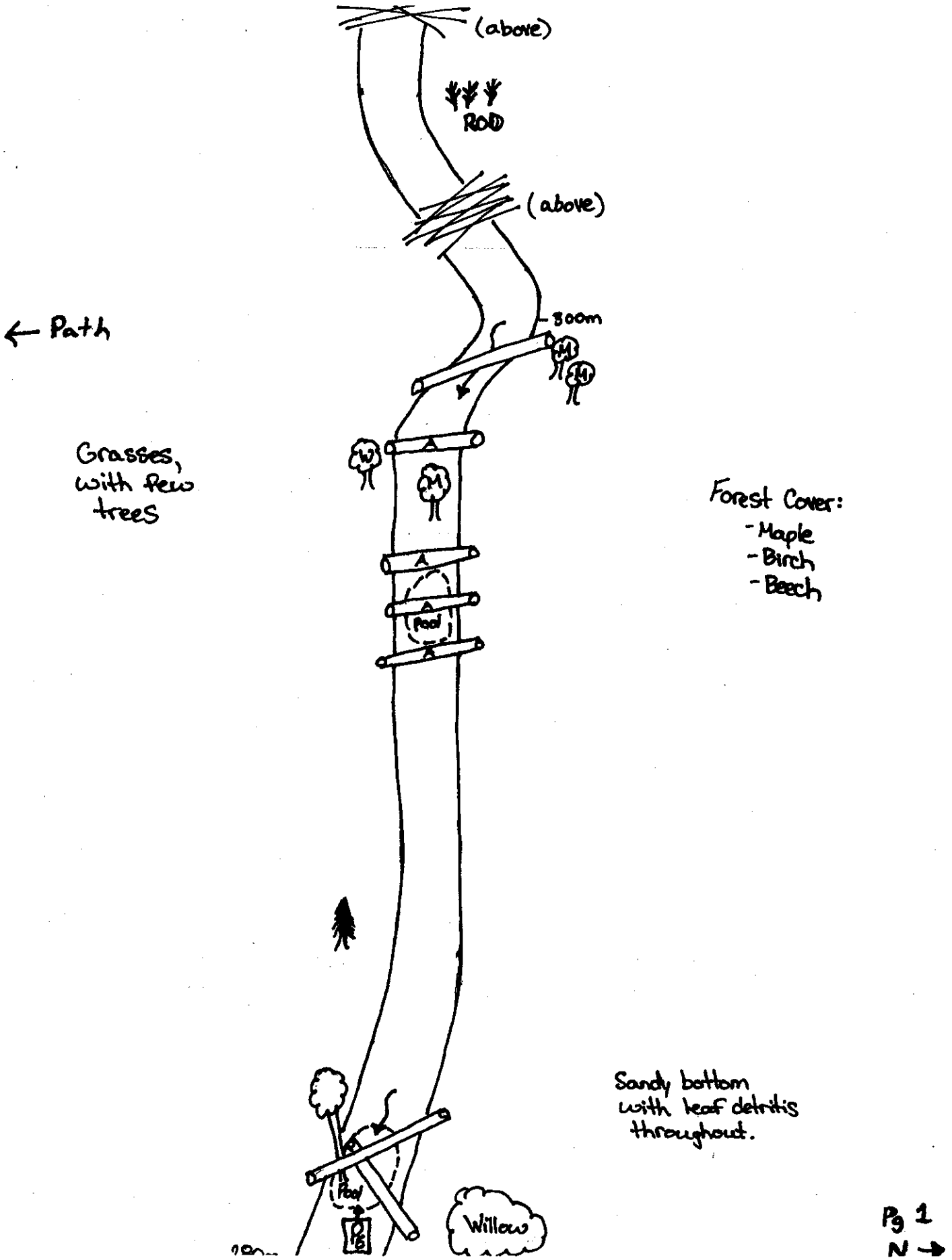
Appendix B - Goss Property Rehabilitation Plan Photographs

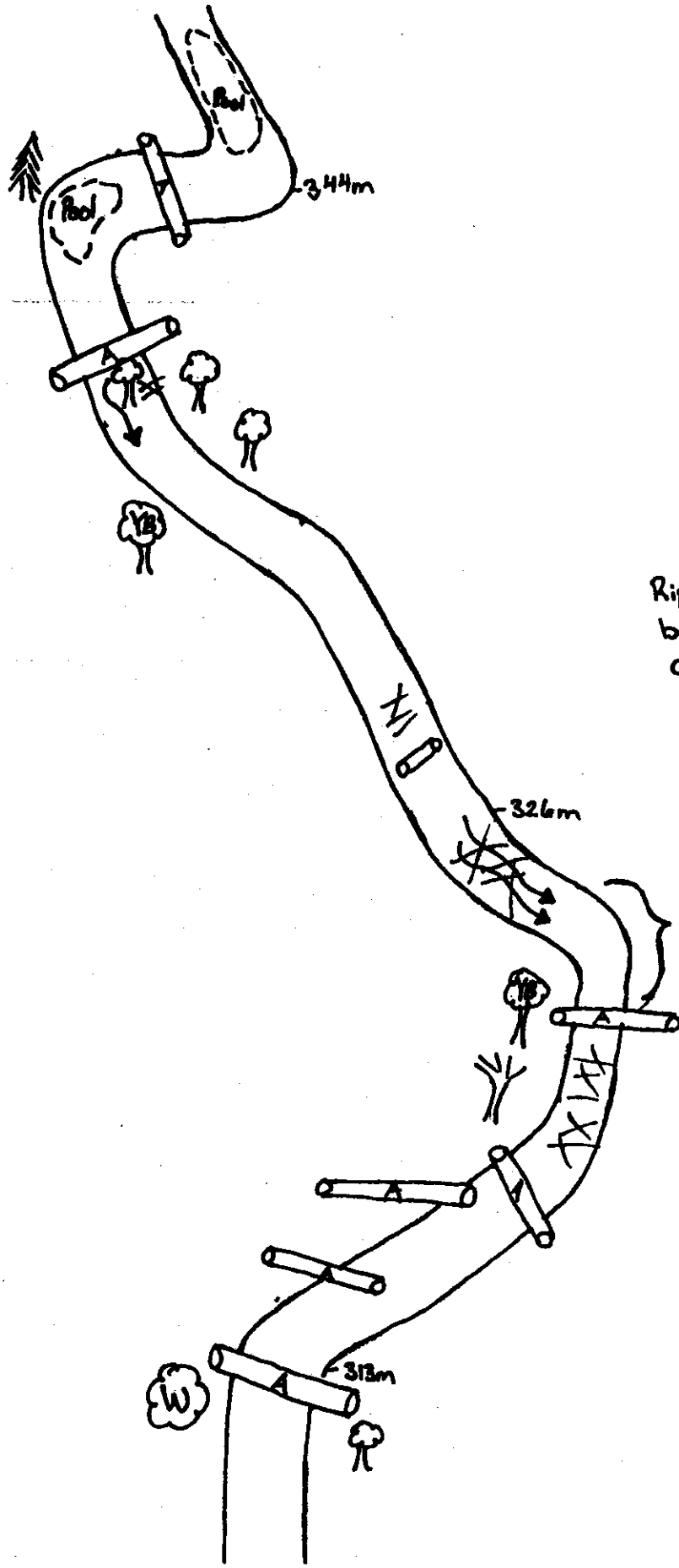
Photo 1: Bluff's Creek, looking downstream from Line 15.
Extent of riparian buffer on each bank visible.

Appendix C: Del Coin Property Rehabilitation Plan

Del Coin Property Rehabilitation Plan
Mapped November 3-4, 2008; Distance: 1034m



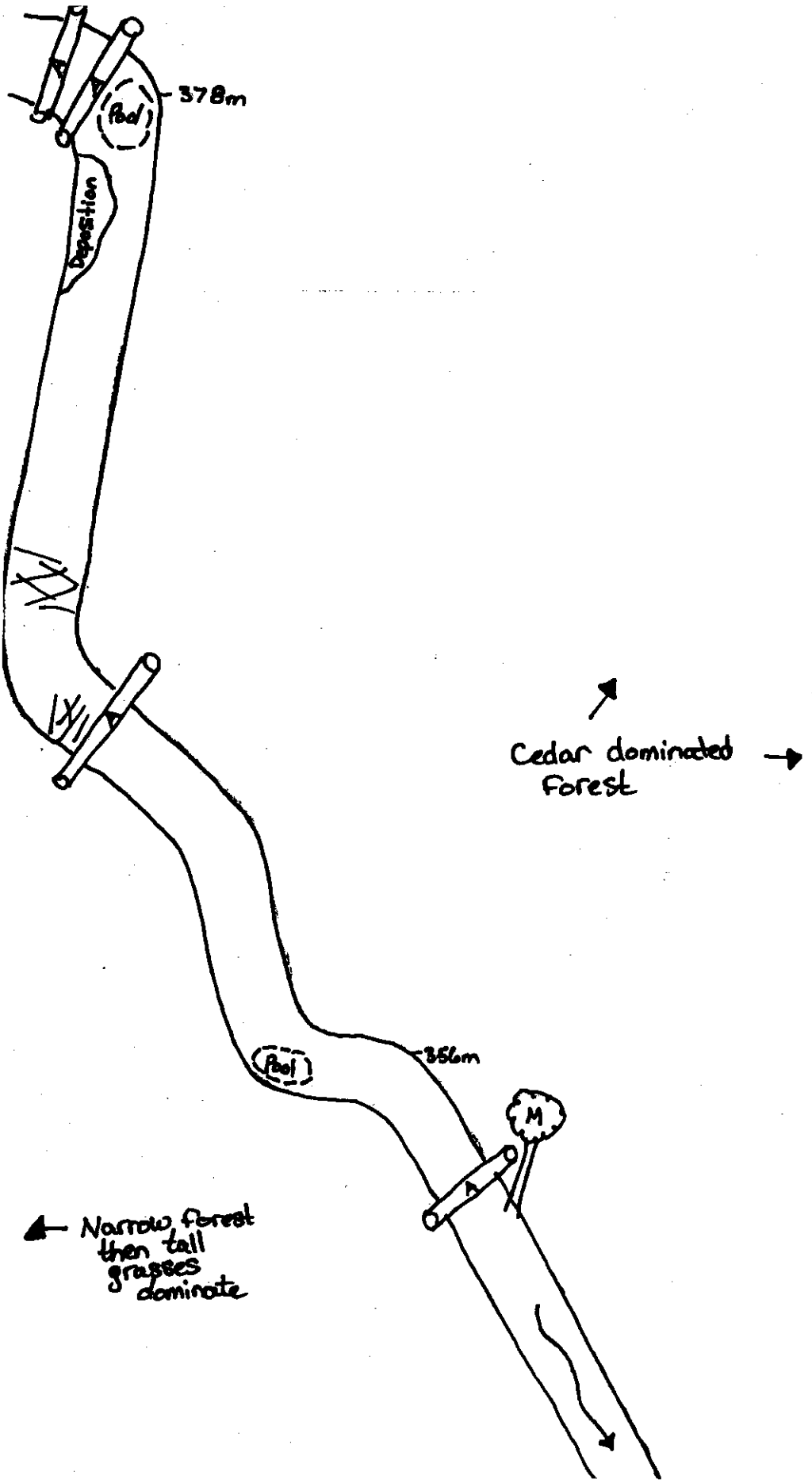

(above)
ROD
(above)
300m
← Path
Grasses, with few trees
Forest Cover:
- Maple
- Birch
- Beech
Pool
Pool
Willow
Sandy bottom with leaf detritis throughout.
Pg 1
N →



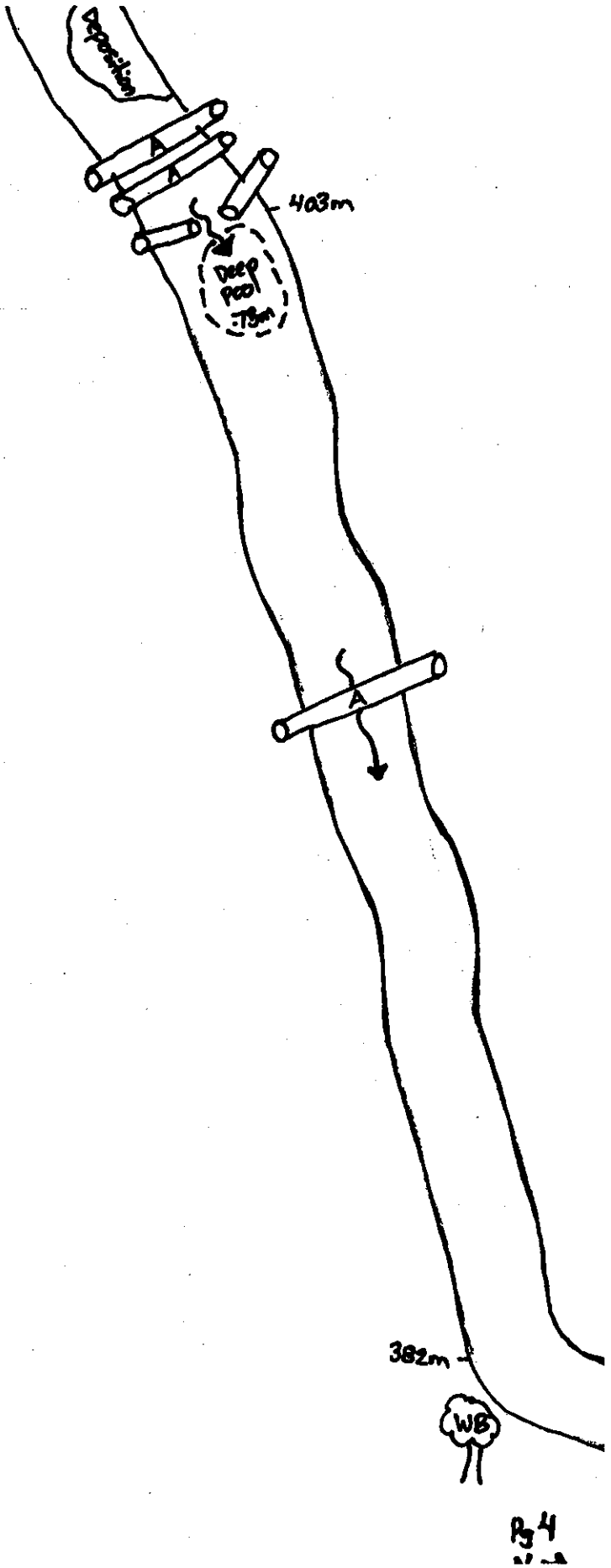
Riparian cover becoming more cedar dominated, both sides.

Pg 2

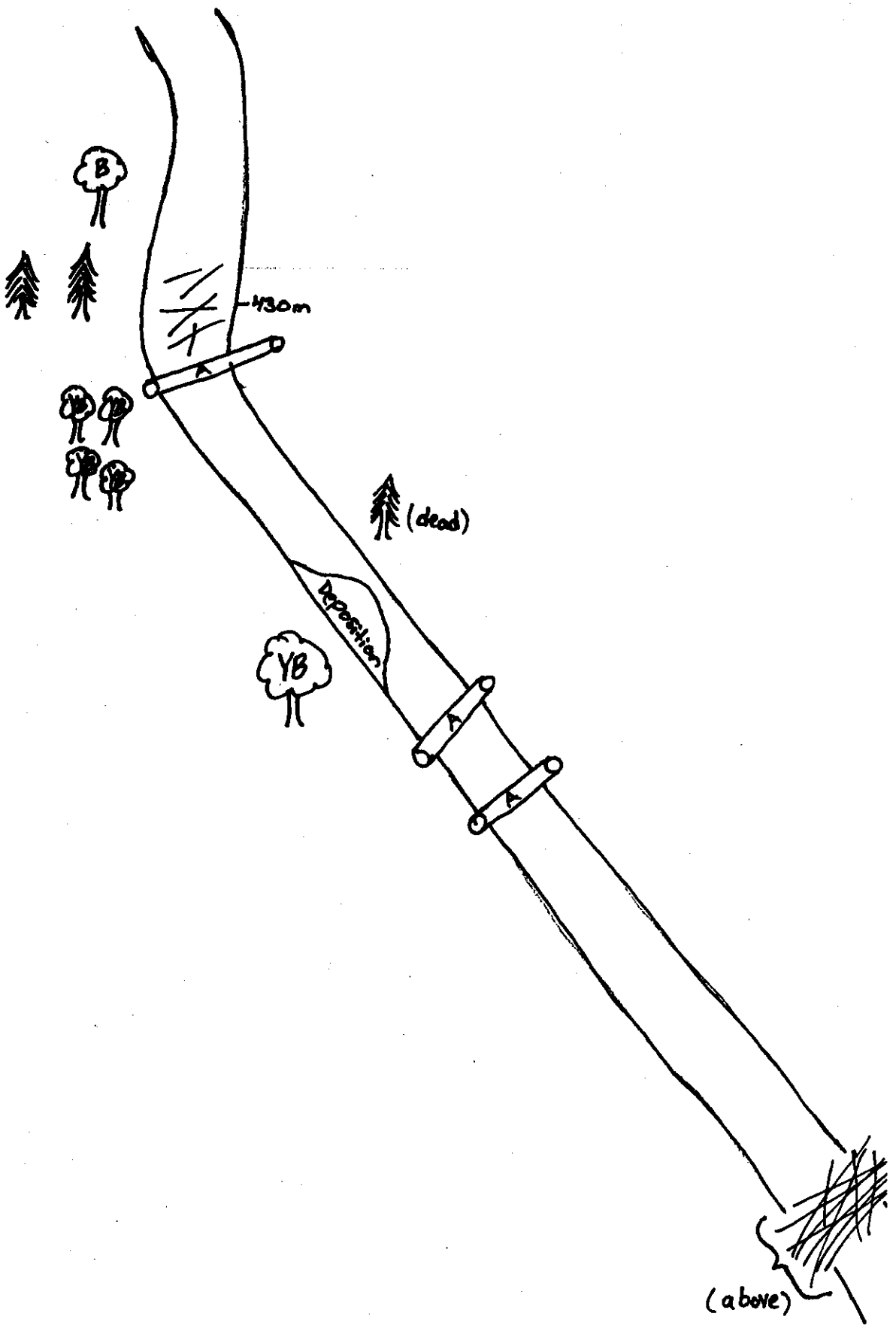
N →

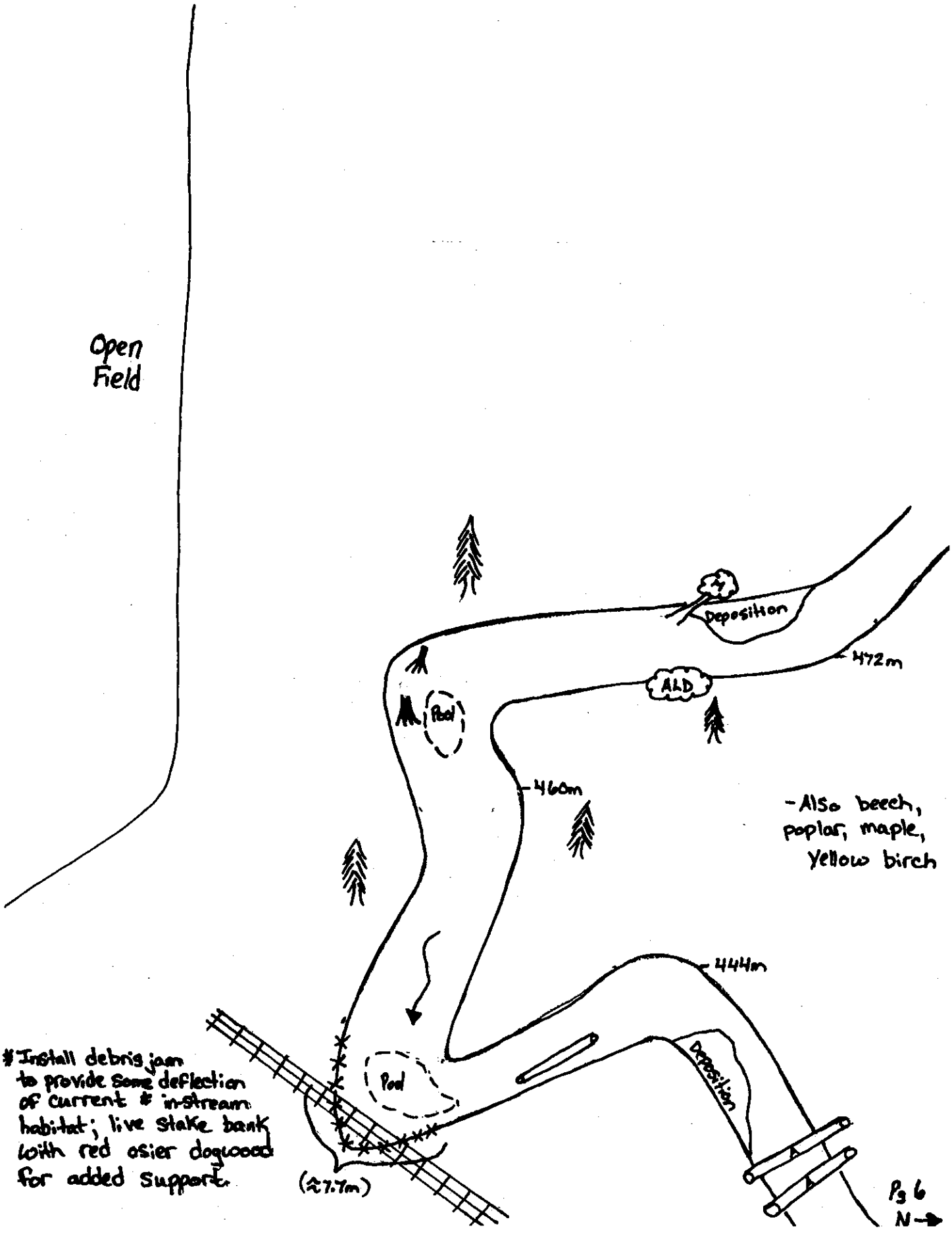

378m
Pool
Deposition
Cedar dominated Forest
Pool
356m
M
Narrow forest then tall grasses dominate

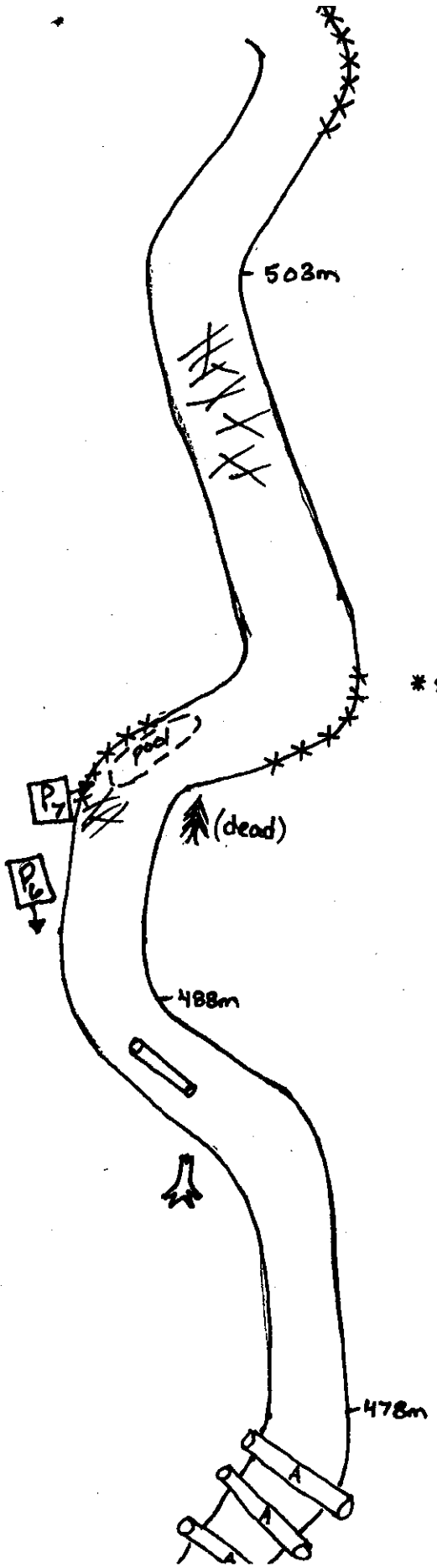
Pg 3
N →



Pg 4


B
430m
A
(dead)
Deposition
YB
A
A
(above)

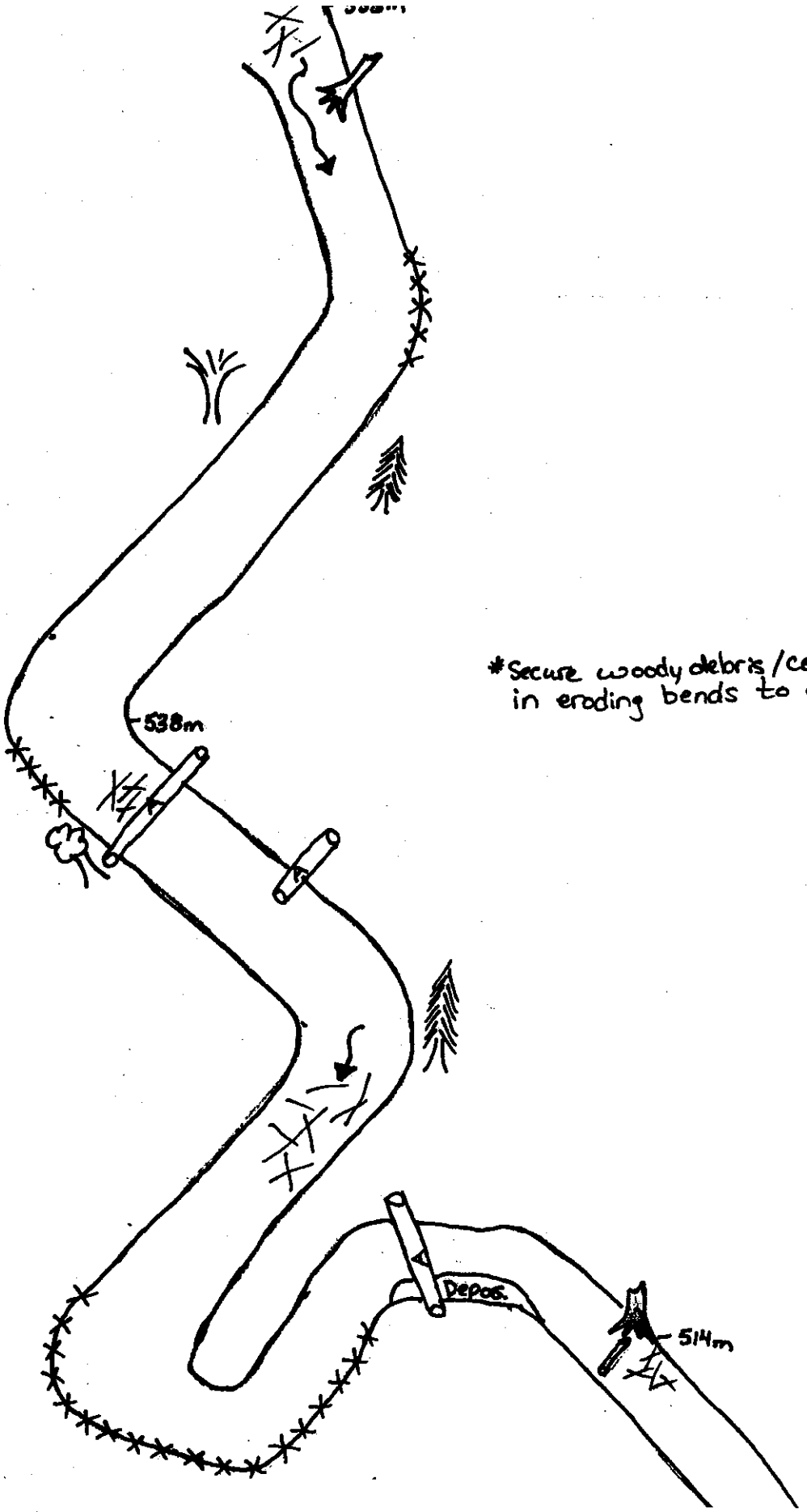

Open Field
Deposition
472m
ALD
Pool
460m
-Also beech, poplar, maple, yellow birch
444m
Deposition
Pool
(≈7.7m)
#Install debris jam to provide some deflection of current & in-stream habitat; live stake bank with red osier dogwood for added support.
Pg 6
N→



* Secure woody debris / cedar sweeps in eroding bends, against banks to deflect flow.

Forest cover, both sides; not much undercover

P7
N →

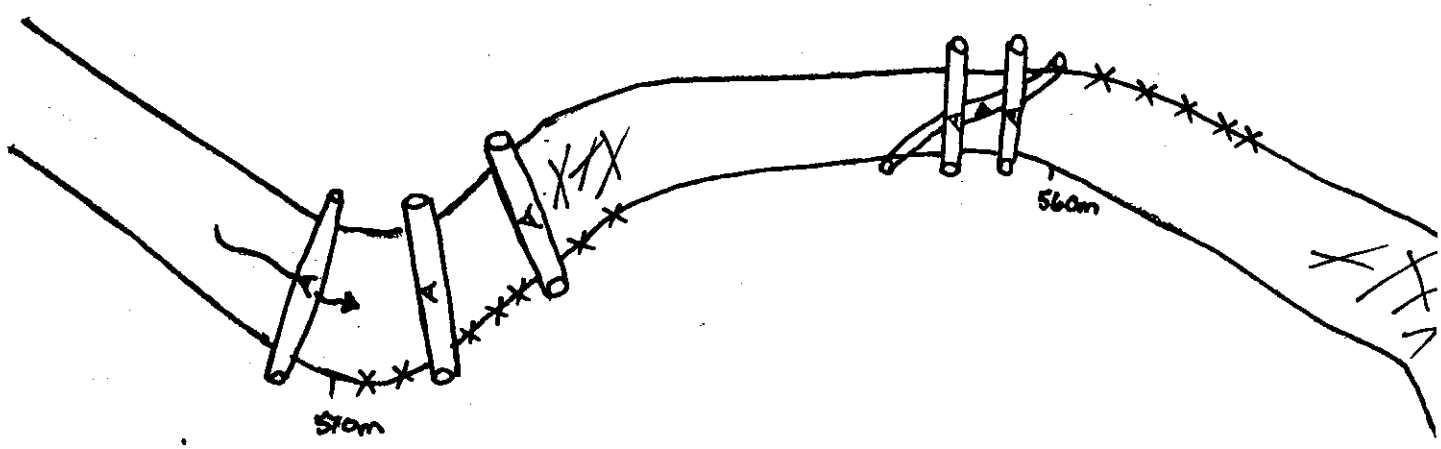


*Secure woody debris / cedar sweeps in eroding bends to deflect flow

Pg 8

N →

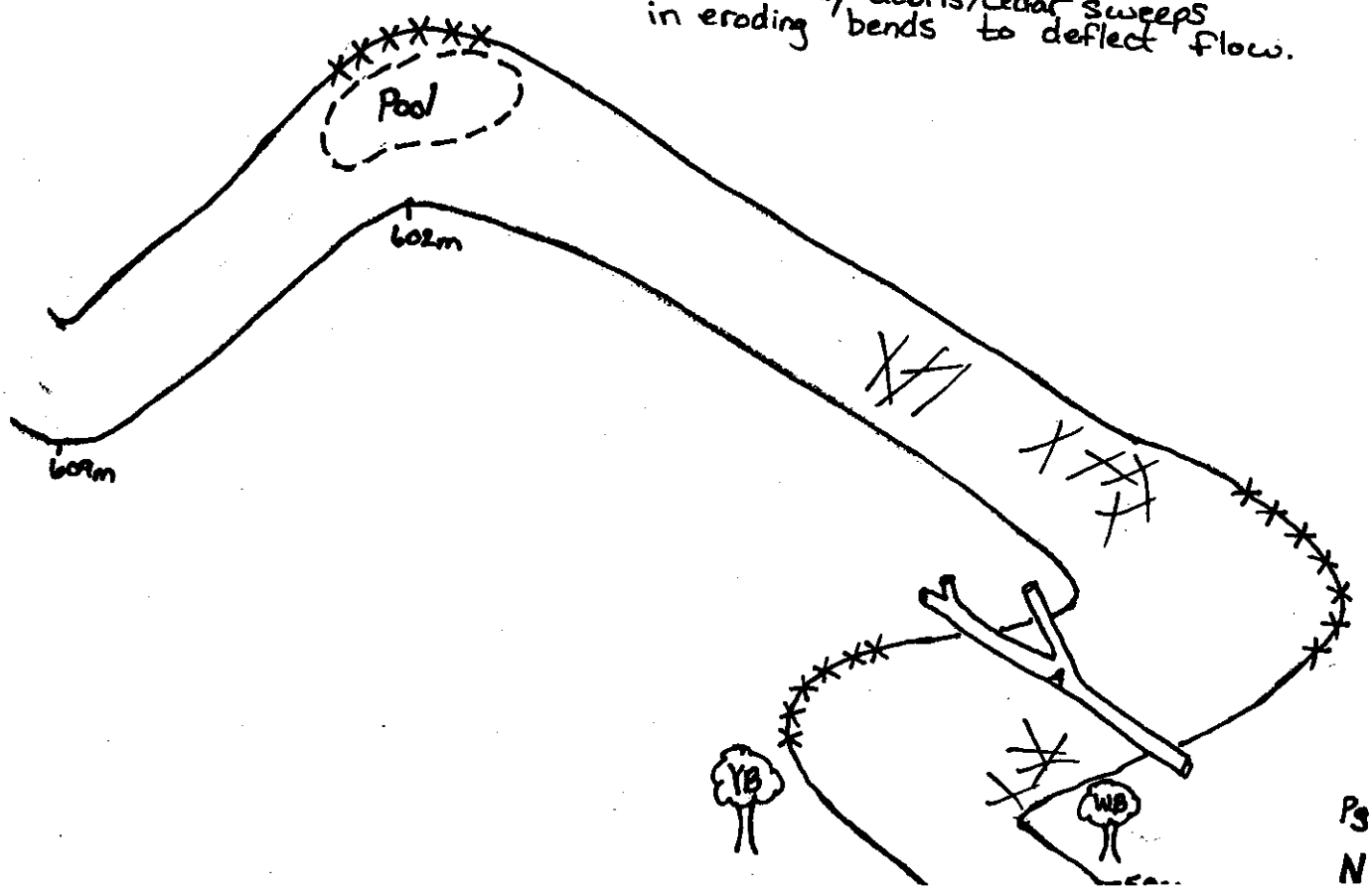
* Secure woody debris/cedar sweeps in eroding bends to deflect flow.



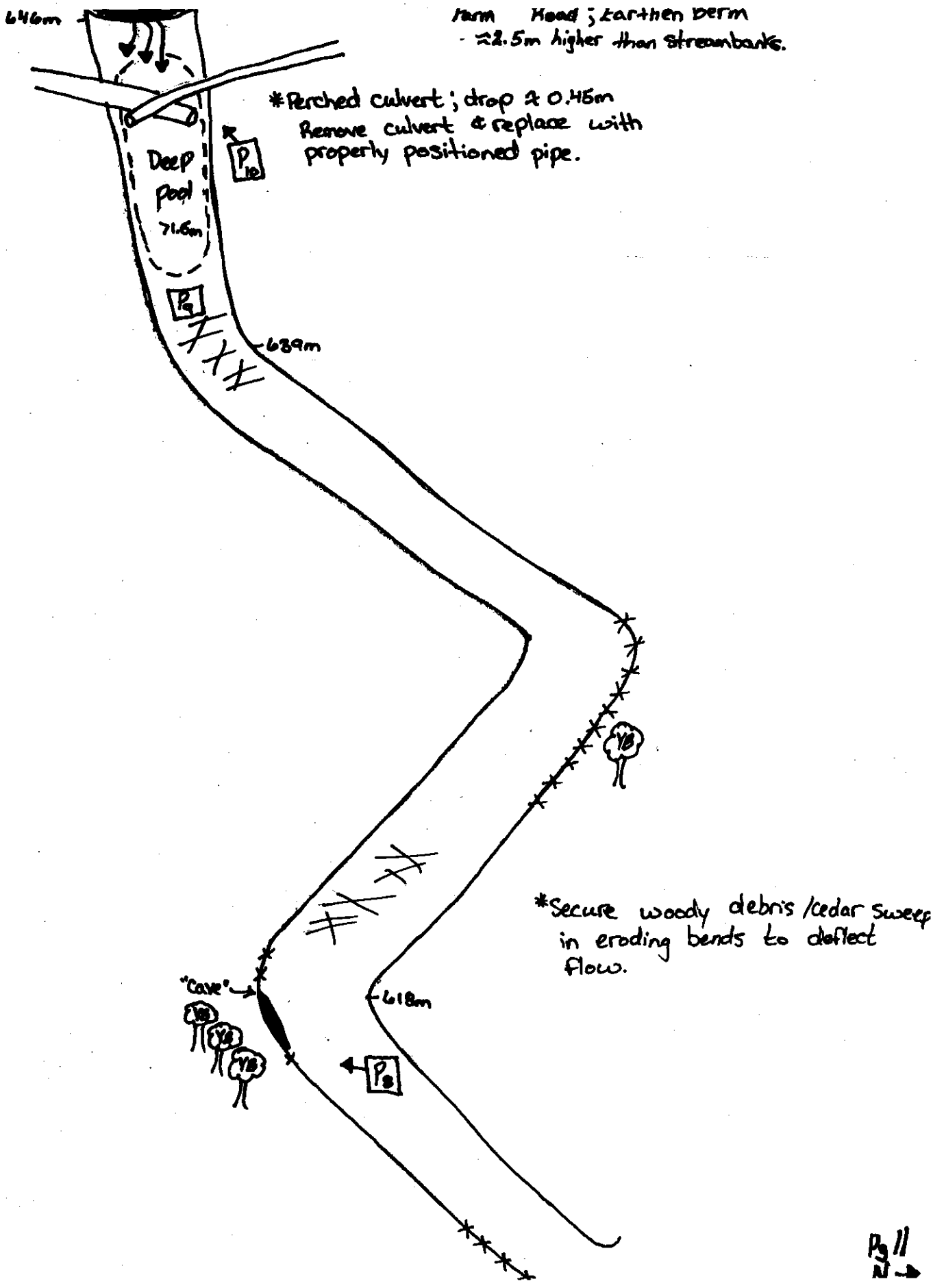
Pg 9

N →

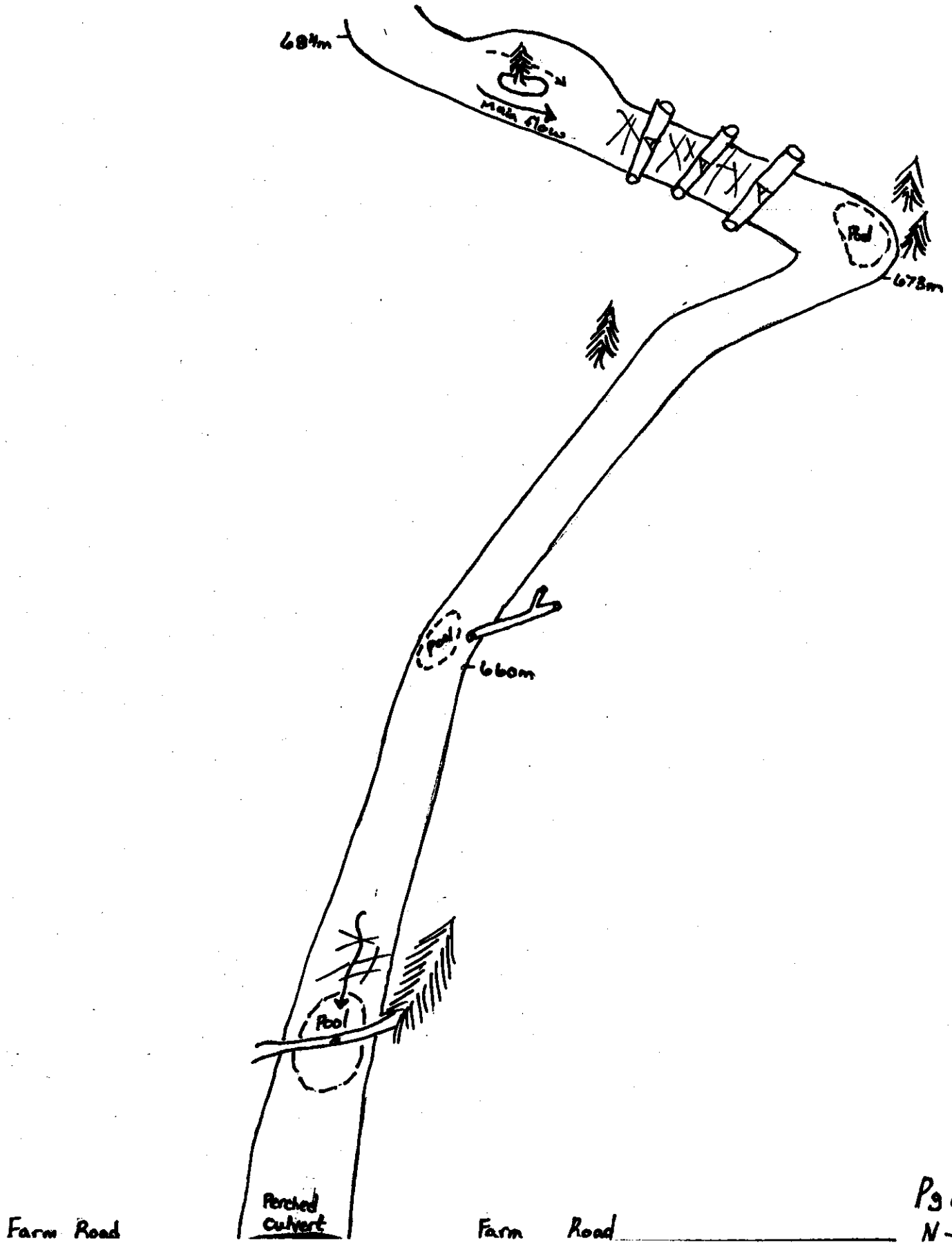
*Secure woody debris/cedar sweeps in eroding bends to deflect flow.

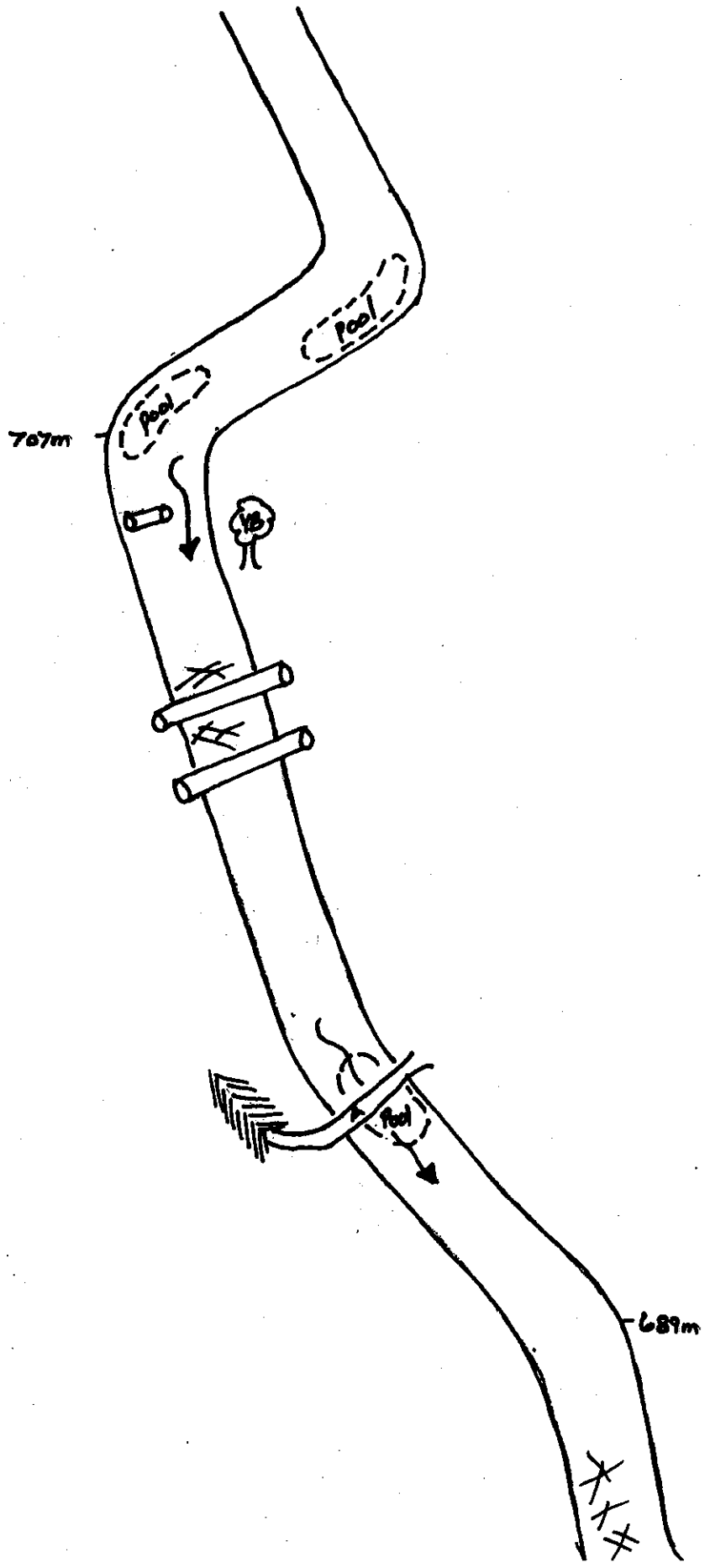


N →

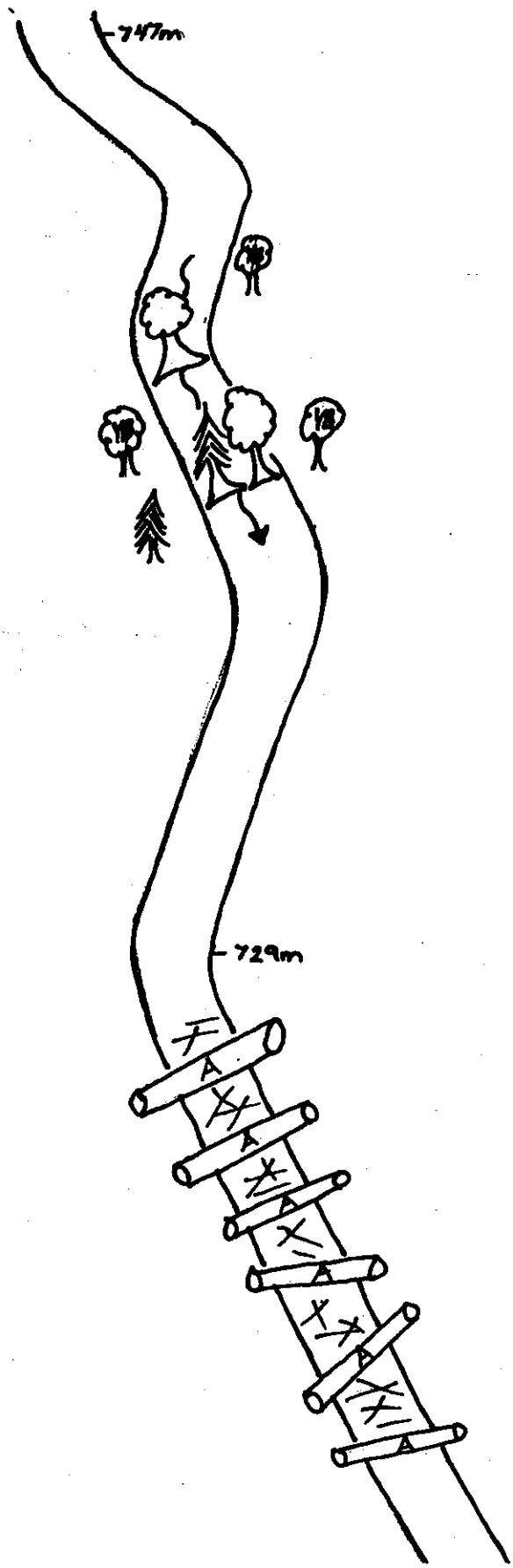

646m
Farm Road; Earthen berm
~2.5m higher than streambanks.
*Perched culvert; drop ± 0.45m
Remove culvert & replace with
properly positioned pipe.
Deep
Pool
~1.6m
P1e
P2
689m
YB
"Cave"
618m
YB
YB
YB
P3
*Secure woody debris/cedar sweep
in eroding bends to deflect
flow.

P3 11

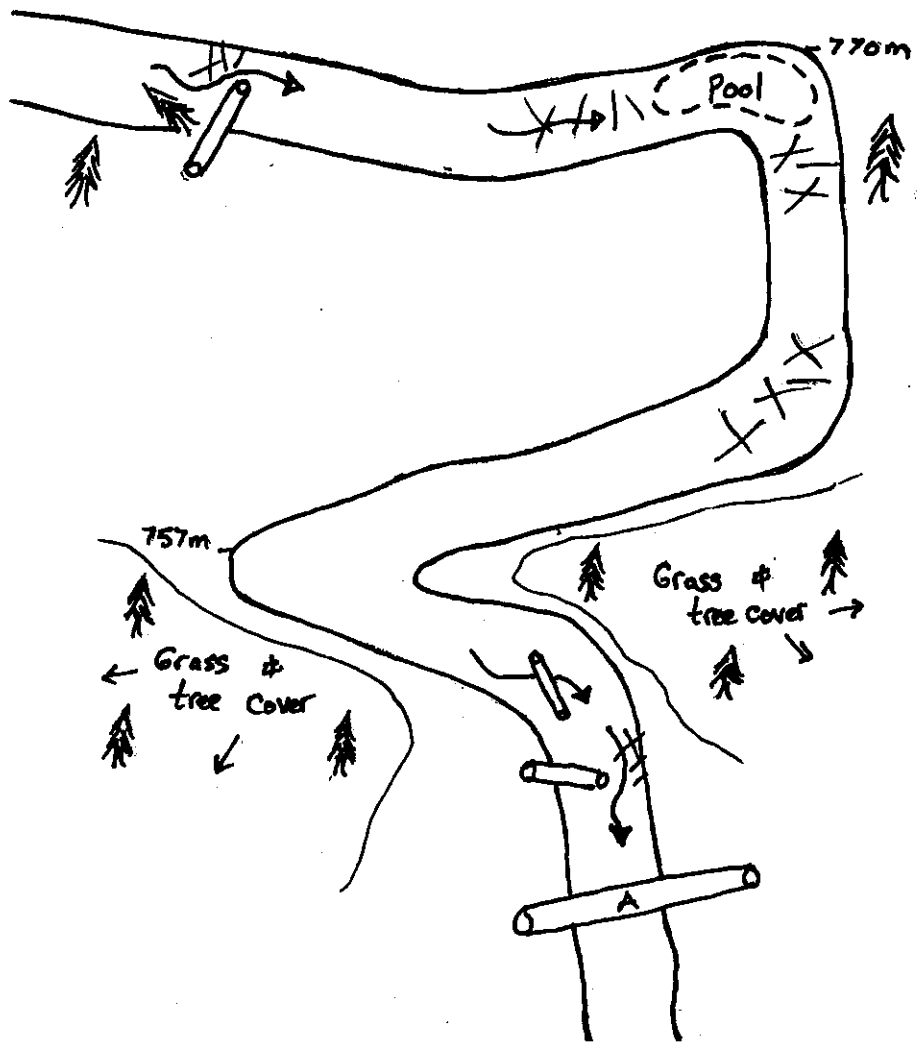

684m
Main flow
Pool
678m
Pool
660m
Pool
Perched Culvert
Farm Road
Farm Road
N



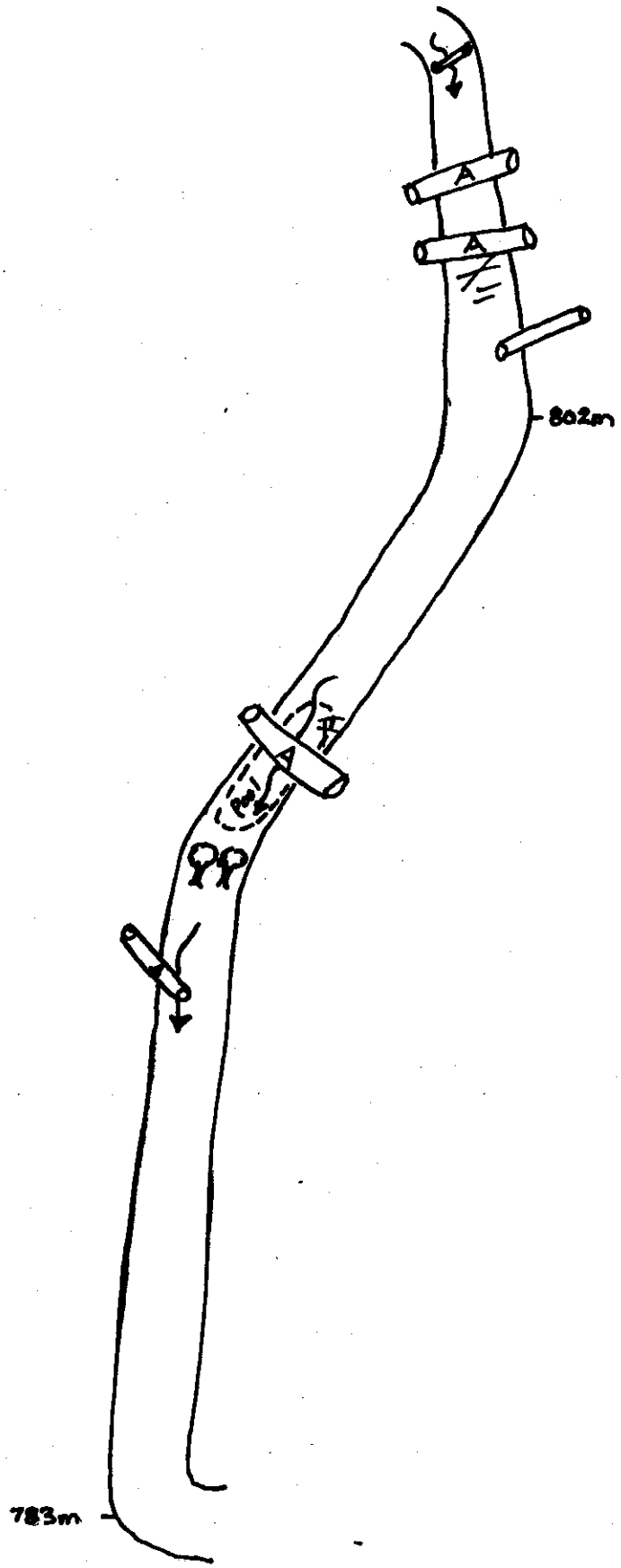
Pg 13
N →



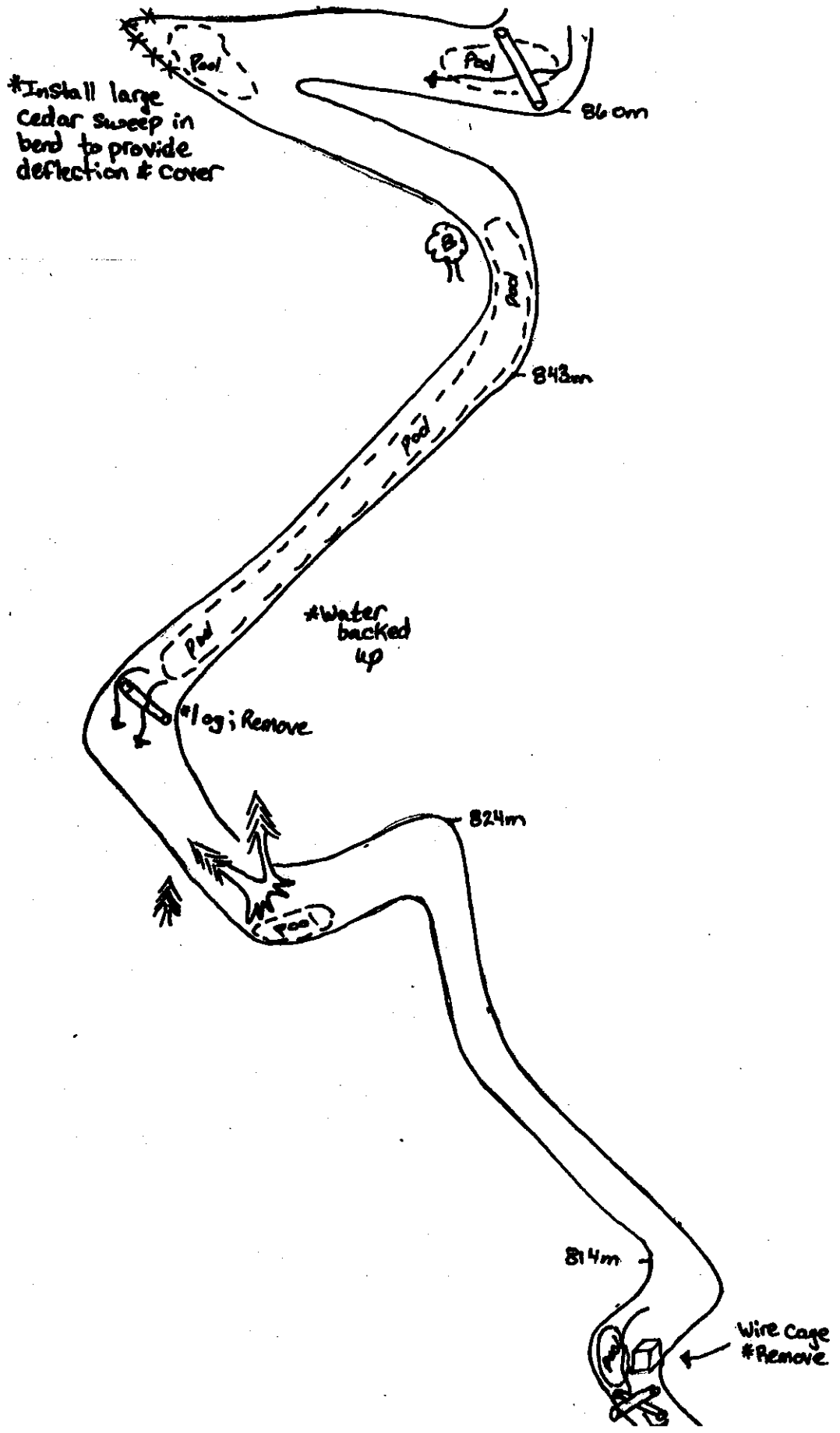
B 14
N→

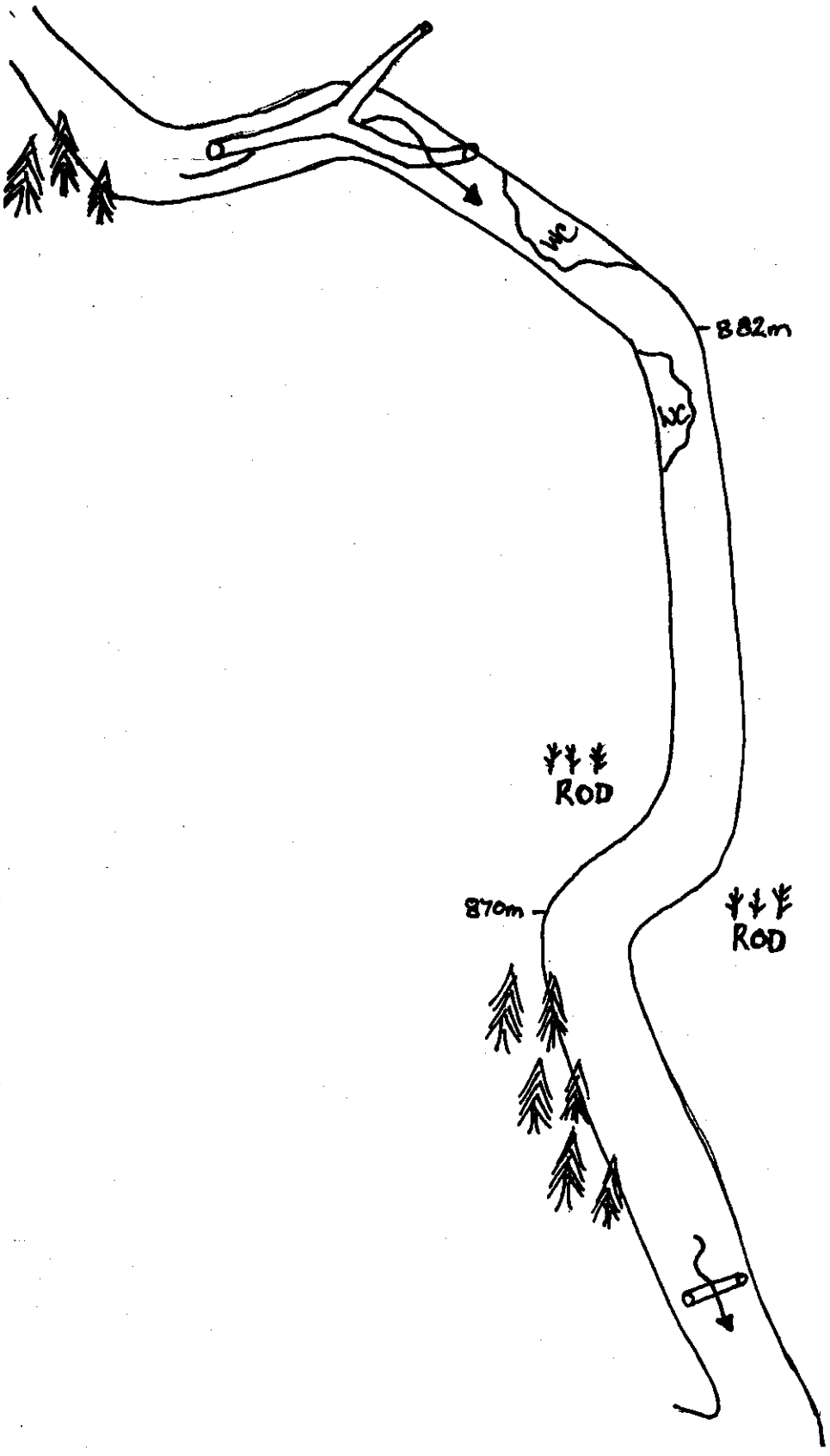


N→

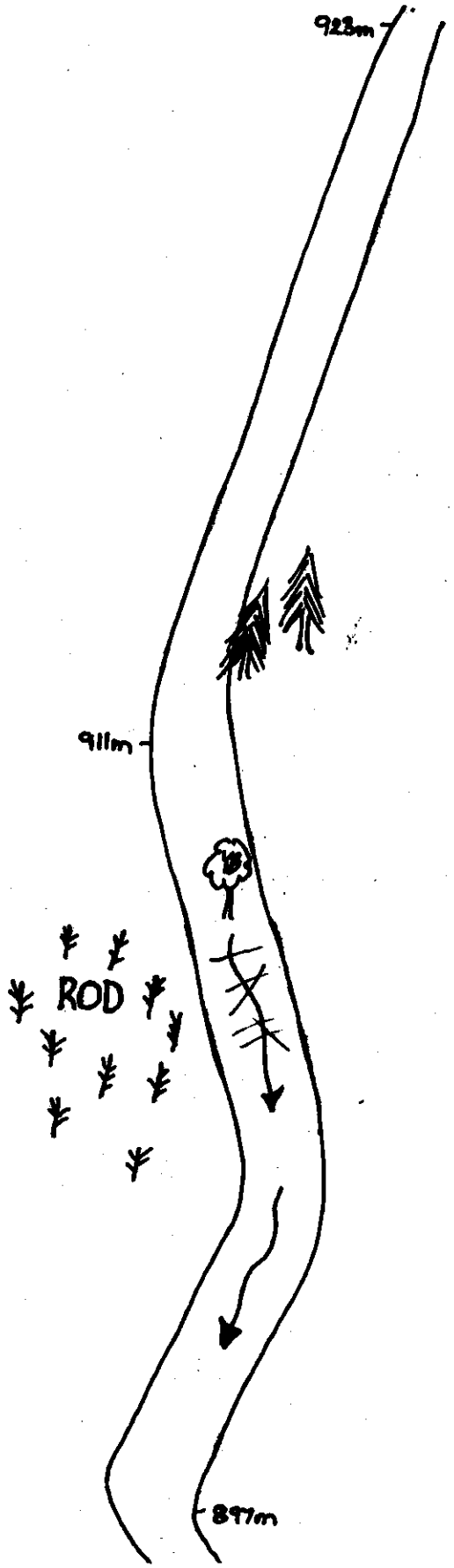


Pg 16
N →

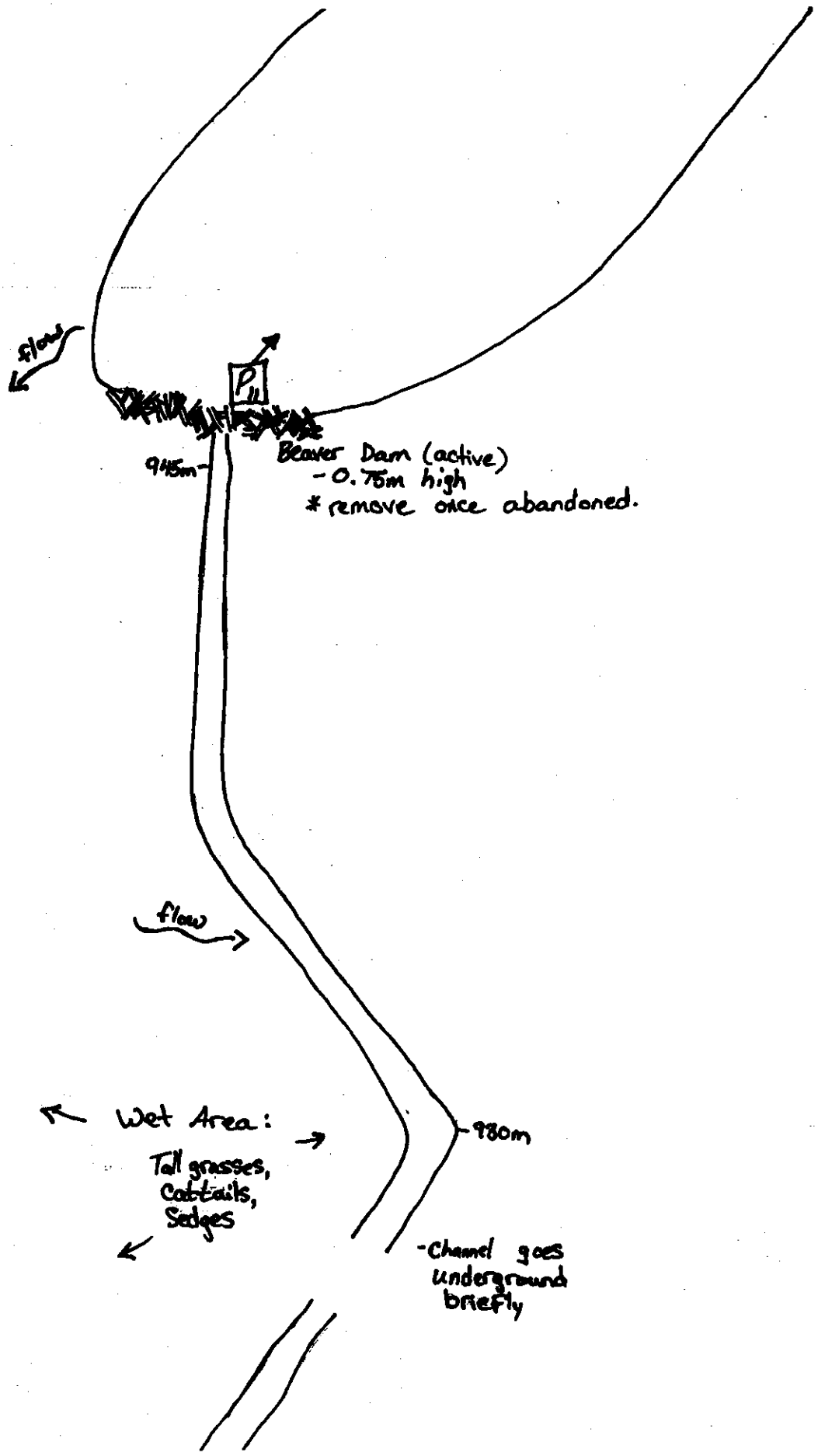

*Install large cedar sweep in bend to provide deflection & cover
Pool
Pool
86 cm
Pool
843m
pool
Pool
*Water backed up
*log; Remove
824m
Pool
814m
Wire cage
*Remove
N



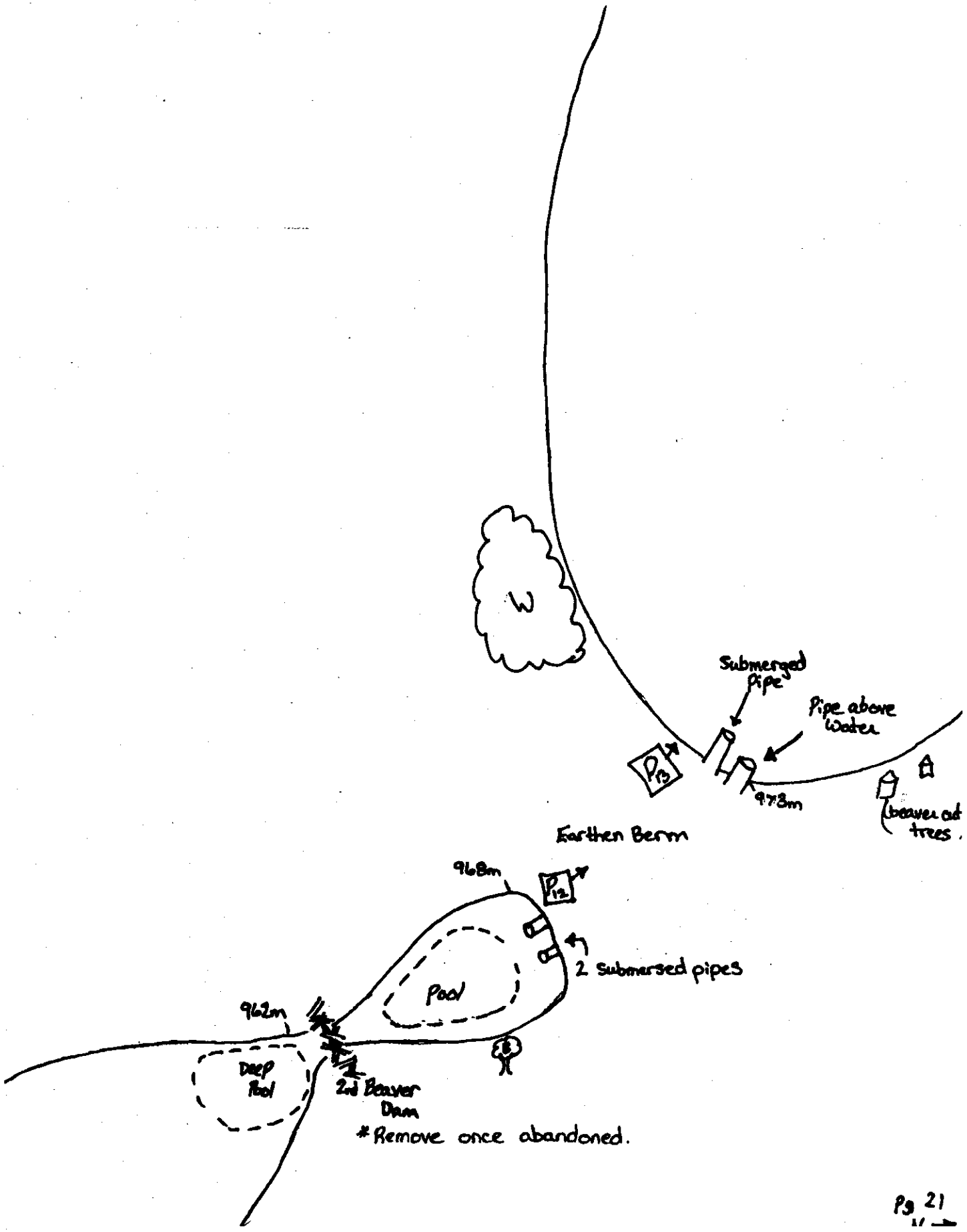
N →

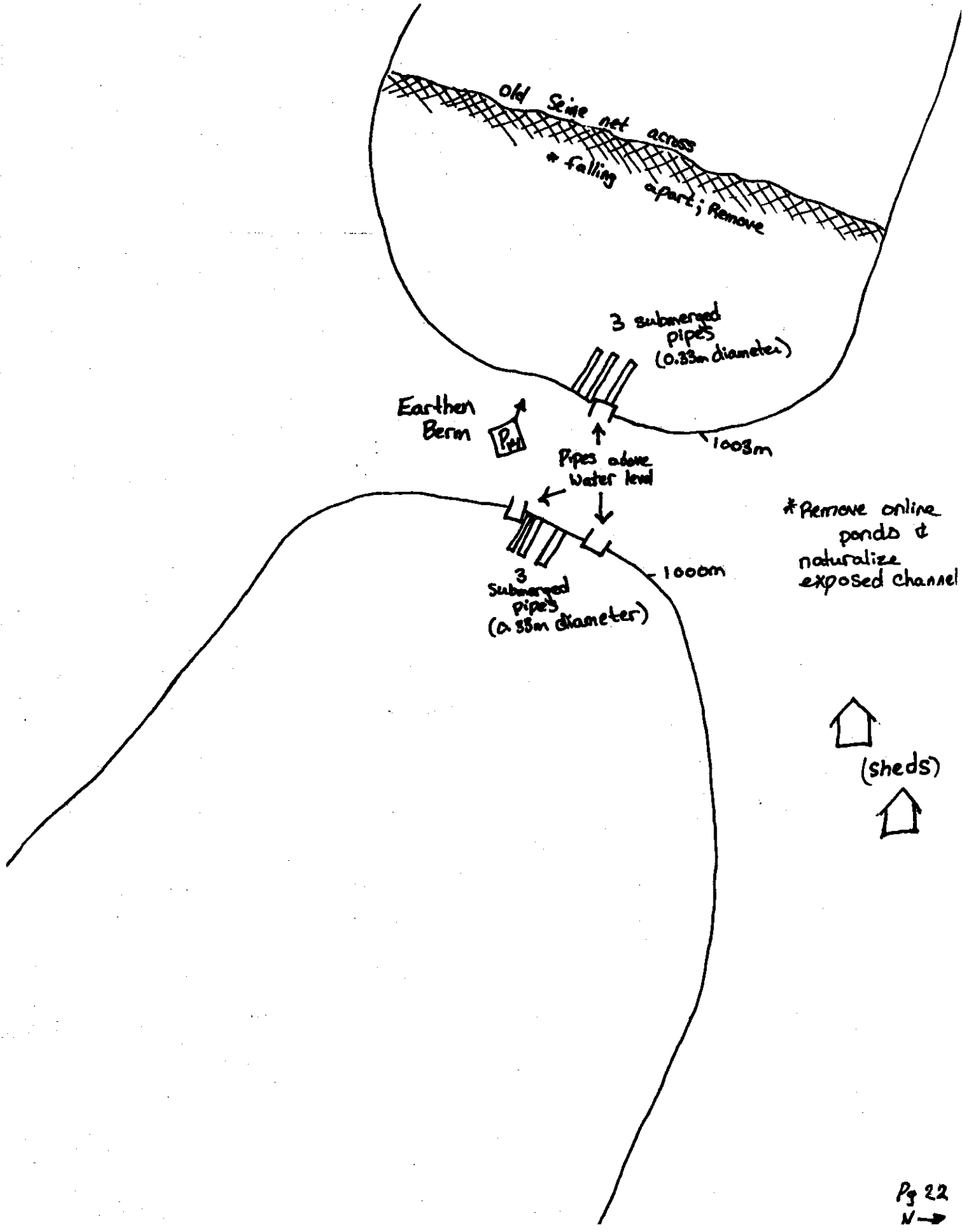


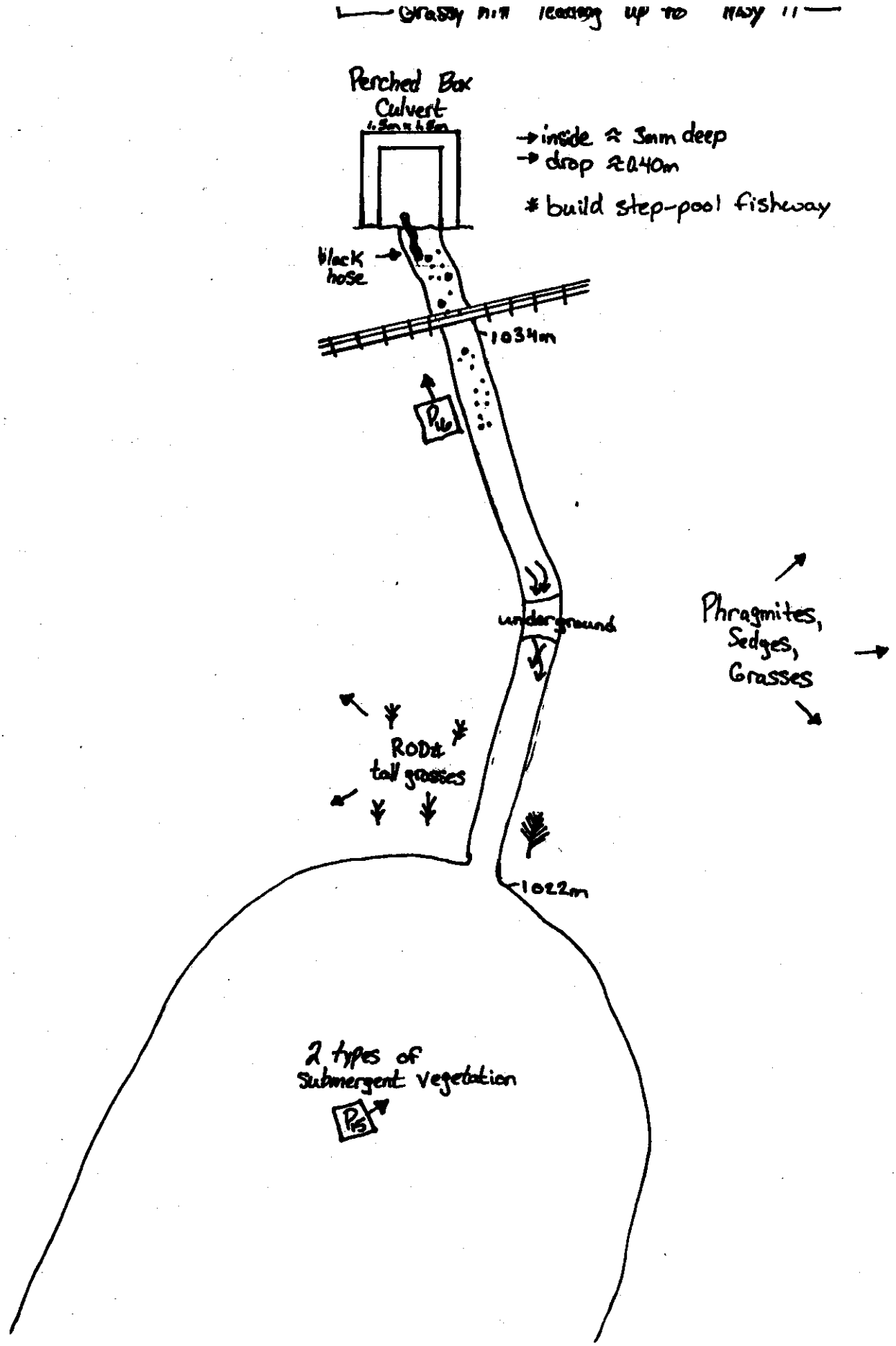
Pg 11
N→


flow
P11
945m
Beaver Dam (active)
-0.75m high
* remove once abandoned.
flow
Wet Area:
Tall grasses,
Cattails,
Sedges
980m
-Channel goes underground briefly

N →


W
Submerged pipe
Pipe above water
P13
973m
beaver cut trees
Earthen Berm
968m
P12
2 submersed pipes
Pool
962m
Deep Pool
2nd Beaver Dam
*Remove once abandoned.


Old Seine net across
* falling apart; Remove
3 submerged pipes (0.33m diameter)
Earthen Berm
Pipes above water level
100.3m
100.0m
3 Submerged pipes (0.33m diameter)
*Remove online ponds & naturalize exposed channel
(sheds)


Grassy hill leading up to Hwy 11
Perched Box Culvert
4.5m x 4.6m
→ inside ≈ 3mm deep
→ drop ≈ 0.40m
* build step-pool fishway
black hose
1034m
Pw
underground
Phragmites, Sedges, Grasses
RODd tall grasses
1022m
2 types of Submergent vegetation
Ps

Appendix C - Del Coin Property Rehabilitation Plan Photographs

Photo 1: Abandoned beaver dam

Photo 2: Wet meadow area between abandoned beaver dam and Line 15

Photo 3: Undefined channel upstream of beaver pond

Photo 4: Beginning of defined channel section

Benthic Invertebrate Studies

Bluffs Creek
1975

B2	Order	Family	*Genus/Species*	ti	si	(si*ti)/N	
1	Coleoptera	Elmidae	*Stenelmis sp.*		5	1	0.042735043
2	Diptera	Chironomiidae	Chironominae		6.4	13	0.711111111
3	Diptera	Chironomiidae	Orthocladiinae		5	25	1.068376068
4	Diptera	Chironomiidae	Tanypodinae		7	5	0.299145299
5	Ephemeroptera	Baetidae	*Centroptillum sp.*		2	2	0.034188034
6	Ephemeroptera	Ephemerellidae	*E. simplex*		2	20	0.341880342
7	Ephemeroptera	Heptageniidae	*E. vitrea*		0	5	0
8	Ephemeroptera	Heptageniidae	*S. canadense*		3	2	0.051282051
9	Ephemeroptera	Leptophlebiidae	*H. ameticana*		6	1	0.051282051
10	Ephemeroptera	Leptophlebiidae	*P. mollis*		1	1	0.008547009
11	Isopoda	Asellidae	*A. communis*		8	1	0.068376068
12	Neuroptera	Sialidae	*Sialis sp.*		4	1	0.034188034
13	Plecoptera	Leuctridae	*Leuctra sp.*		0	2	0
14	Plecoptera	Pteronacidae	*P. nobilis*		0	4	0
15	Trichoptera	Lepidostomatidae	*Lepidostoma sp.*		1	4	0.034188034
16	Trichoptera	Limnephilidae	*P. gulttif…*		0	17	0
17	Trichoptera	Psychonyiidae	*Neurelopsis sp.*		2	11	0.188034188
18	Trichoptera	Rhyacophilidae	*R. fuscula*		0	2	0
						117	2.933333333
							non-impacted

Taxon	# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera	31	26.4957265	40	13.5042735
Plecoptera	6	5.128205128	5	0.128205128
Trichoptera	34	29.05982906	10	19.05982906
Coleoptera	1	0.854700855	20	19.14529915
Chironomidae	43	36.75213675	10	26.75213675
Oligochaeta	0	0	5	5
Others	2	1.709401709	10	8.290598291
Total	117		100	91.88034188
				45.94017094
				54.05982906
				slightly impacted

B6	Order	Family	*Genus/Species*	ti	si	(si*ti)/N	
	Coleoptera	Dryopidae	*Helichus liphophilus*		5	1	0.047169811
	Amphipoda	Talitridae	*Hyalella azteca*		8	1	0.075471698
1	Coleoptera	Elmidae	*Stenelmis sp.*		5	7	0.330188679
2	Diptera	Chironomiidae	*Chironominae*		6.4	3	0.181132075
3	Diptera	Chironomiidae	Orthocladiinae		5	17	0.801886792
4	Diptera	Chironomiidae	Tanypodinae		7	11	0.726415094
5	Diptera	Simulidae	*Prosimulium sp.*		1.7	1	0.016037736
6	Diptera	Tabanidae	*Chrysops sp.*		5	1	0.047169811
7	Ephemeroptera	Baetidae	*Baetis sp.*		6	5	0.283018868
8	Ephemeroptera	Baetidae	*Baetis brunneicolor*		4	3	0.113207547
9	Ephemeroptera	Baetidae	*Centroptillum cemoexum*		2	2	0.037735849
10	Ephemeroptera	Ephemerellidae	*E. simplex*		2	8	0.150943396
11	Neuroptera	Sialidae	*Sialis sp.*		4	1	0.037735849
12	Odonata: Anisoptera	Aeshnidae	*Aeshna interrupta*		3	1	0.028301887
13	Odonata: Anisoptera	Cordulegastridae	*Cordulegaster ebligius*		3	4	0.113207547
14	Plecoptera	Chloroperlidae	*Chloroperla sp.*		0	2	0
15	Plecoptera	Peltoperlidae	*Peltoperla sp.*		0	5	0
16	Plecoptera	Perlodidae			2	1	0.018867925
17	Trichoptera	Hydropsychidae	*Diplectrona modesta*		0	1	0
18	Trichoptera	Hydropsychidae	*Hydropsyche betteni*		6	3	0.169811321
19	Trichoptera	Lepidostomatidae	*Lepidostoma sp.*		1	6	0.056603774
20	Trichoptera	Limnephilidae	*Limnephilus consoeius*		4	1	0.037735849
21	Trichoptera	Limnephilidae	*Limnephilus sericoeus*		4	1	0.037735849

Taxon	# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera	18	16.98113208	40	23.01886792
Plecoptera	8	7.547169811	5	2.547169811
Trichoptera	32	30.18867925	10	20.18867925
Coleoptera	8	7.547169811	20	12.45283019
Chironomidae	31	29.24528302	10	19.24528302
Oligochaeta	0	0	5	5
Others	9	8.490566038	10	1.509433962
Total	106		100	83.96226415
				41.98113208
				58.01886792
				slightly impacted

22	Trichoptera	Limnephilidae	*Neophylax ornatus*	3	1	0.028301887
23	Trichoptera	Limnephilidae	*Onocosmoecus quadanotatus*	4	1	0.037735849
24	Trichoptera	Limnephilidae	*Psychoglypha sp.*	0	2	0
25	Trichoptera	Limnephilidae	*Pycnopsyche gultifer?*	4	3	0.113207547
26	Trichoptera	Philopotamidae	*Trentonuis gentonius*	3	12	0.339622642
27	Trichoptera	Rhyacophilidae	*Rhyacophila fuscula*	0	1	0
					106	3.706603774
						non-impacted

B7	**Order**	**Family**	***Genus/Species***	**ti**	**si**	**(si*ti)/N**
	Amphipoda	Talitridae	*Hyalella azteca*		8	12	0.705882353
1	Coleoptera	Elmidae	*Stenelmis sp.*		5	6	0.220588235
2	Coleoptera	Hydrophilidae	Sperchopis sp.		5	1	0.036764706
3	Coleoptera	Psphenidae	*Psphenus sp.*		4	3	0.088235294
4	Decapoda	Astacidae	*Orconectes rusticus*		7	1	0.051470588
5	Diptera	Chironomiidae	Orthocladiinae		5	4	0.147058824
6	Diptera	Chironomiidae	Tanypodinae		7	1	0.051470588
7	Diptera	Tipulidae	*Tipula sp.*		4	1	0.029411765
8	Ephemeroptera	Heptageniidae	*Stenonema canadense*		3	9	0.198529412
9	Ephemeroptera	Heptageniidae	*Stenonema rubromaculatum*		3	1	0.022058824
10	Hemiptera	Corixidae			5	4	0.147058824
11	Hemiptera	Corixidae	*Sigara sp.*		5	1	0.036764706
12	Hirudinea	Glossiphonidae	*Glossiphonia complanata*		7	1	0.051470588
13	Mollusca: Gastropoda	Planorbidae	*Gyraulus sp.*		6	3	0.132352941
14	Odonata: Anisoptera	Aeshidae	Aeshna sp.		3	1	0.022058824
15	Odonata: Anisoptera	Aeshidae	*Aeshna cremita*		3	2	0.044117647
16	Zygoptera	Agriidae	*Agrion aequabile*		5	8	0.294117647
17	Trichoptera	Hydropsychidae	*Cheumatopsyche sp.*		5	47	1.727941176
18	Trichoptera	Hydropsychidae	*Hydropsyche recuvata*		4	7	0.205882353
19	Trichoptera	Hydropsychidae	*Hydropsyche slossonae*		4	3	0.088235294
20	Trichoptera	Limnephilidae	*Neophylax oligius*		3	5	0.110294118
21	Trichoptera	Limnephilidae	*Pycnopsyche guttifer??*		4	13	0.382352941
22	Trichoptera	Psychomyiidae	*Neureclepsis validus*		2	2	0.029411765
						136	4.117647059
							non-impacted

Taxon	# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera	10	7.352941176	40	32.64705882
Plecoptera	0	0	5	5
Trichoptera	77	56.61764706	10	46.61764706
Coleoptera	10	7.352941176	20	12.64705882
Chironomidae	5	3.676470588	10	6.323529412
Oligochaeta	0	0	5	5
Others	34	25	10	15
Total	136		100	123.2352941
				61.61764706
				38.38235294
				moderately impacted

Bluffs Creek
24-Jul-08

#	Phylum/Class	Order	Family	*Genus/Species*	ti	si	(si*ti)/N
1	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche sp.*		4	38	0.567164179
2	Insecta	Coleoptera	Elmidae	*Dubiraphia sp.*		6	83	1.858208955
3	Insecta	Diptera	Chironomidae			7	55	1.436567164
4	Insecta	Coleoptera	Gyrinidae	*Dineutus sp.*		4	14	0.208955224
5	Insecta	Trichoptera	Leptoceridae	*Oecetis sp.*		5	2	0.037313433
6	Insecta	Diptera	Simulidae	*Simulium sp.*		5	8	0.149253731
7	Insecta	Megaloptera	Corydalidae	*Chauliodes sp.*		4	1	0.014925373
8	Insecta	Hemiptera	Gerridae	*Gerris sp.*		5	1	0.018656716
9	Insecta	Ephemeroptera	Siphlonuridae	*Ameletus sp.*		0	66	0
							268	4.291044776
								non-impacted

Biotic Index Value	**Water Quality Assessment**
0 - 4.50	**non-impacted**
4.51 - 6.50	**slightly impacted**
6.51 - 8.50	**moderately impacted**
8.51 - 10.0	**severely impacted**

Taxon	# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera	66	24.62686567	40	15.37313
Plecoptera	0	0	5	5
Trichoptera	40	14.92537313	10	4.925373
Coleoptera	97	36.19402985	20	16.19403
Chironomidae	55	20.52238806	10	10.52239
Oligochaeta	0	0	5	5
Others	10	3.731343284	10	6.268657
Total	268		100	63.28358
				31.64179
				68.35821
				non-impacted

Kick and Sweep Benthic Results - Percent Model Affinity Metric

Upstream Riffle

Taxon		# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera		6	5.825242718	40	34.17475728
Plecoptera		3	2.912621359	5	2.087378641
Trichoptera		12	11.65048544	10	1.650485437
Coleoptera		4	3.883495146	20	16.11650485
Chironomidae		24	23.30097087	10	13.30097087
Oligochaeta		2	1.941747573	5	3.058252427
Others	Gastropoda	3		10	40.48543689
	Isopoda	16			
	Amphipoda	33	50.48543689		
Total		103	100	100	110.8737864
					55.4368932
					44.5631068
					moderately impacted

Downstream Riffle

Taxon		# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera		23	22.33009709	40	17.66990291
Plecoptera		8	7.766990291	5	2.766990291
Trichoptera		34	33.00970874	10	23.00970874
Coleoptera		0	0	20	20
Chironomidae		10	9.708737864	10	0.291262136
Oligochaeta		0	0	5	5
Others	Gastropoda	7		10	30.47619048
	Isopoda	14			
	Amphipoda	30	40.47619048		
Total		126	113.2917245	100	99.21405455
					49.60702728
					50.39297272
					slightly impacted

Pool

Taxon		# in sample	% in Sample	% in Model	Absolute Difference
Ephemeroptera		1	0.970873786	40	39.02912621
Plecoptera		11	10.67961165	5	5.67961165
Trichoptera		23	22.33009709	10	12.33009709
Coleoptera		3	2.912621359	20	17.08737864
Chironomidae		20	19.41747573	10	9.417475728
Oligochaeta		0	0	5	5
Others	Gastropoda	2		10	33.68932039
	Isopoda	12			
	Amphipoda	31	43.68932039		
Total		103	100	100	122.2330097
					61.11650485
					38.88349515
					moderately impacted