

Sulphate Profile Examples

Ten examples of individual borehole sulphate profiles, and two examples of sites with one APEC profile and two background profiles are provided in this file. The data are from actual field profiles, mostly collected as part of general phase 2 ESA activities rather than being drilled specifically as Native Prairie Protocol (NPP) sulphate profiles.

The individual borehole profiles are classified into one of four possible types based on the information in Appendix A of the Native Prairie Protocol Scientific Rationale Document. The four types are:

- Definitive Downward;
- Probable Downward;
- Upward; and,
- Ambiguous.

See Appendix A of the NPP document for full details. Comments on each interpretation are provided below.

The Site examples are discussed in terms of the overall interpretation for the site.

Individual Borehole Sulphate Profiles

Definitive Downward Profile – Example 1. This profile meets all the requirements to be considered Definitive Downward. There is a decrease in sulphate from 1 m to near ground surface (passes Test A), the “sulphate maximum” is approximately 1.6 m (deeper than 1 m; passes Test B), and the sulphate concentration close to surface (14 mg/kg) is less than the deep concentration below the sulphate maximum (approximately 2,300 mg/kg; passes Test C).

Definitive Downward Profile – Example 2. This profile meets all the requirements to be considered Definitive Downward. There is a decrease in sulphate from 1 m to near ground surface (passes Test A), the “sulphate maximum” is approximately 1.1 m (deeper than 1 m; passes Test B), and the sulphate concentration close to surface (21 mg/kg) is less than the deep concentration below the sulphate maximum (approximately 2,000 mg/kg; passes Test C).

Definitive Downward Profile – Example 2. This profile meets all the requirements to be considered Definitive Downward. There is a decrease in sulphate from 1 m to near ground surface (passes Test A), the “sulphate maximum” is approximately 1.9 m (deeper than 1 m; passes Test B), and the sulphate concentration close to surface (21 mg/kg) is less than the deep concentration below the sulphate maximum (approximately 500 mg/kg; passes Test C).

Definitive Downward Profile – Example 4. This profile meets all the requirements to be considered Definitive Downward. There is a decrease in sulphate from 1 m to near ground surface (passes Test A), the “sulphate maximum” is approximately 3.3 m (deeper than 1 m; passes Test B), and the sulphate concentration close to surface (17 mg/kg) is less than the deep concentration below the sulphate maximum (approximately 2,500 mg/kg; passes Test C). The slight wiggle in the profile at around 1 m

depth is not considered significant in the overall interpretation of what the profile tells us about moisture flux, particularly given the unusually deep sulphate maximum at this site. It is felt that this profile provides sufficient determination for a Definitive Downward interpretation in spite of a uniform deep sulphate concentration not being established by the maximum depth of 6 m.

Probable Downward Profile – Example 1. This profile has relatively few points but passes Tests A and B (sulphate decrease in the top 1 m, and sulphate maximum (just) below 1 m depth. Test C fails, as the shallowest sulphate concentration (1,400 mg/kg) is greater than the deepest (950 mg/kg). Accordingly the conditions for Definitive Downward are not met. However, since sulphate has been flushed out of the top m of the profile, Test A passes, and the conditions for Probable Downward Profile are met.

Probable Downward Profile – Example 2. This profile has relatively few points but passes Tests A and C (sulphate decrease in the top m, and shallowest sulphate less than deepest sulphate. Test B fails, as the sulphate maximum is at 0.7 m, shallower than 1 m, and accordingly the conditions for Definitive Downward are not met. However, since Test A passes, the conditions for Probable Downward are met.

Probable Downward Profile – Example 3. This profile passes Tests A and B (sulphate decrease in the top m, and sulphate maximum below 1 m. Test C fails, as the shallowest sulphate concentration (3,100 mg/kg) is greater than the deepest (2,400 mg/kg). Accordingly the conditions for Definitive Downward are not met. However, since sulphate has been flushed out of the top m of the profile, Test A passes, and the conditions for Probable Downward are met.

Upward Profile – Example 1. Test A fails in this profile since there is an increase in sulphate from 1 m to surface (in fact sulphate increases all the way from 3 m to surface) and hence this is interpreted as an Upward Profile.

Upward Profile – Example 2. Test A fails in this profile since there is an increase in sulphate from 1 m to surface, which would classify this as an upward profile. However, note the expanded sulphate concentration scale in this profile and the very low overall sulphate concentrations (all less than 25 mg/kg), which would be unusual if there was in fact sulphate accumulating at surface. It might be necessary to look more carefully at the overall setting of this site (whether other nearby profiles showed much higher sulphate concentrations than this one, whether this location was particularly sandy, whether this location was situated in a discharge or recharge position etc.) to make a more definitive interpretation of the significance of this profile.

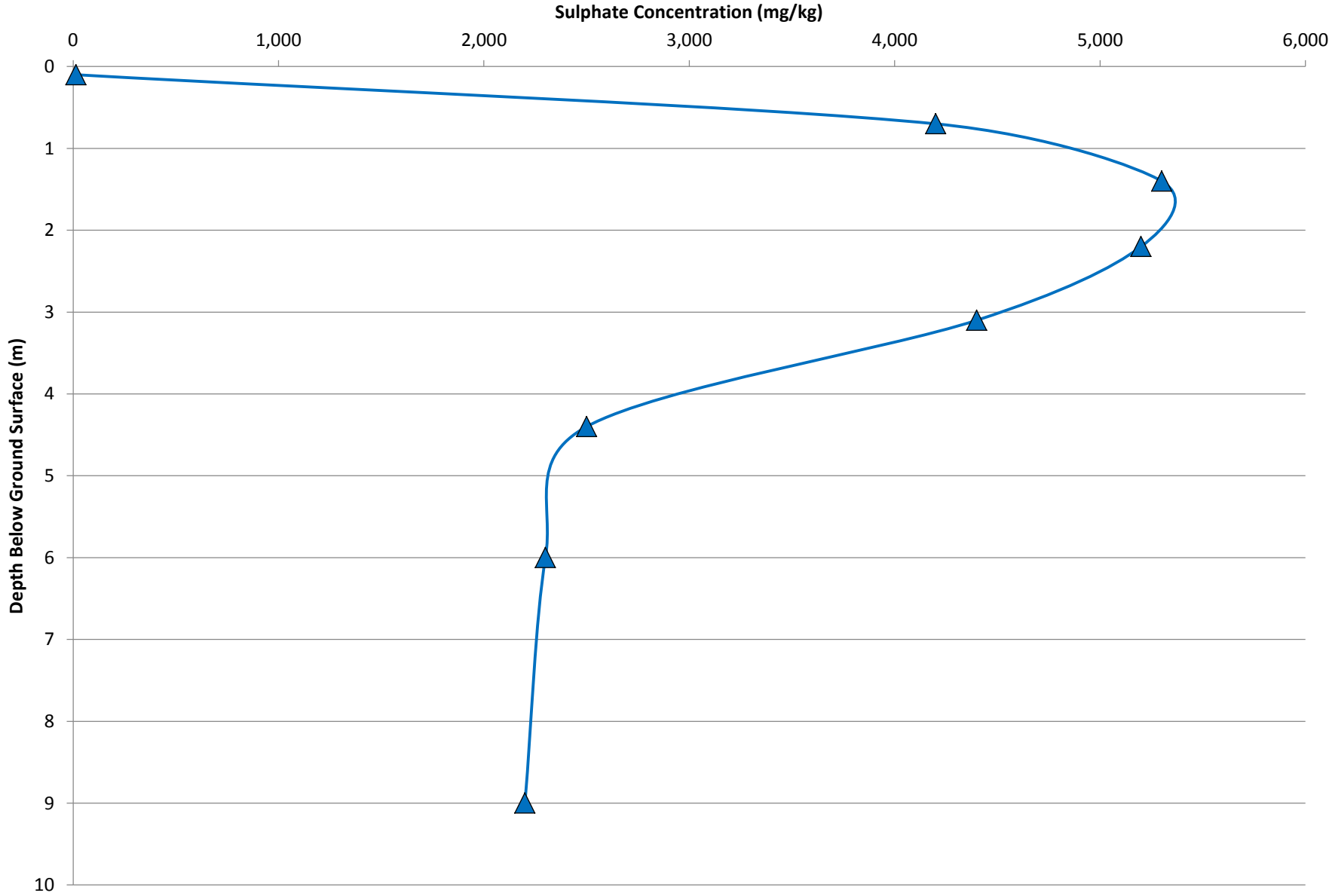
Ambiguous Profile – Example 1. The overall shape of this profile is not really consistent with the generic example provided in Appendix A of the NPP, and therefore it is classified as an Ambiguous Profile. It is possible that additional shallower and deeper samples at this location would allow a different interpretation. Note the expanded sulphate concentration scale on this profile and the low overall sulphate concentrations (relative to most of the other examples in this document).

Site Examples

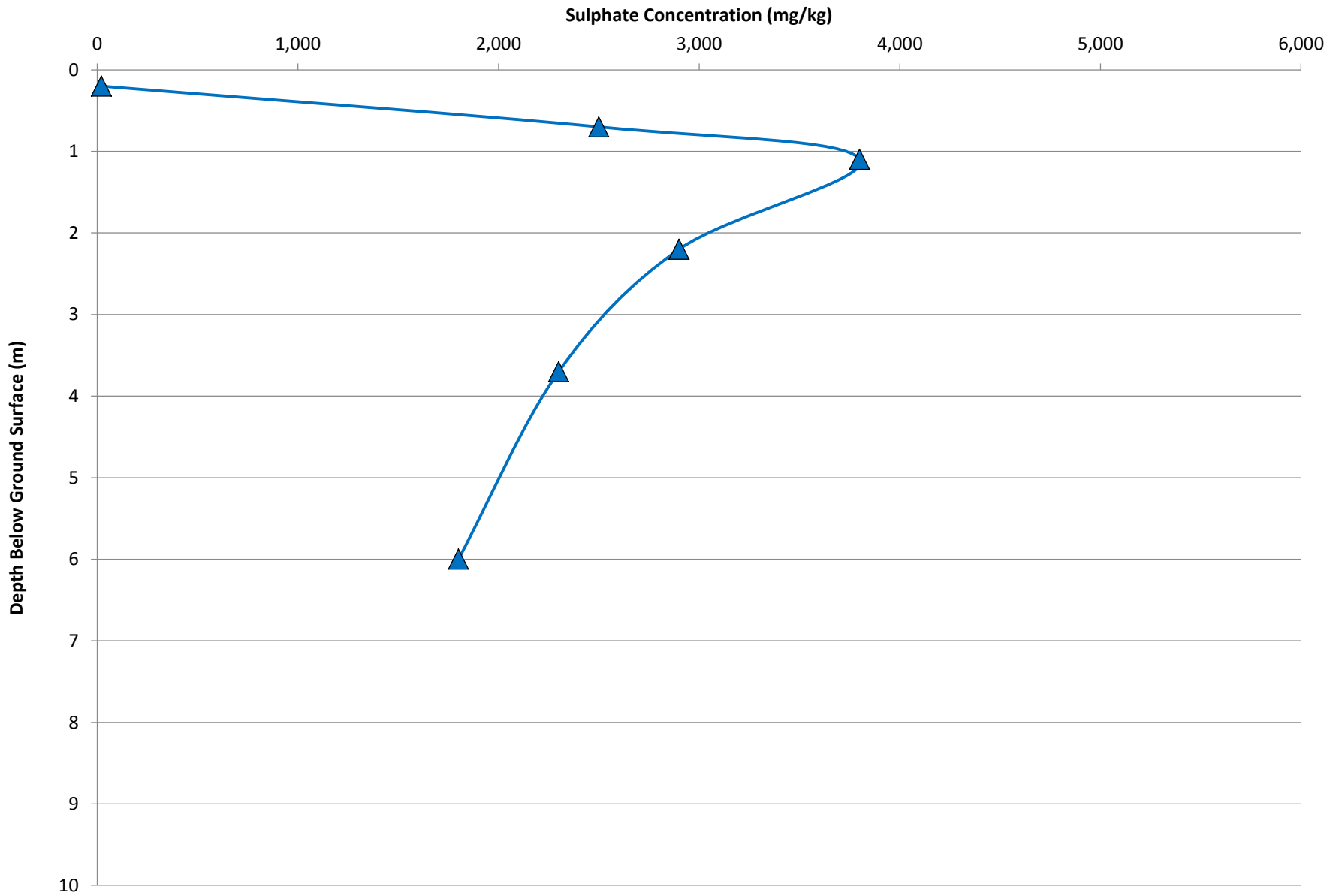
Site Example 1. For this example site, one profile adjacent to the APEC (in this case a delineation borehole for a drilling waste disposal area) and two profiles from background locations at the periphery of the wellsite lease are provided. All three profiles show a sulphate decrease in the top m (passes Test A). All three profiles show sulphate maximums deeper than 1 m (passes Test B). Background 2 and the APEC profile show the shallowest sulphate concentration less than the deepest (passes Test C), while Background 1 does not. Thus the APEC profile is interpreted as Definitive Downward, and the background profiles are interpreted as one Definitive Downward and one Probable Downward. The site therefore falls under Scenario 1 and the Native Prairie Protocol is applicable at the Site.

Site Example 2. For this example site, one profile adjacent to the APEC (again, a delineation borehole for a drilling waste disposal area) and two profiles from background locations at the periphery of the wellsite lease are provided. All three profiles show a sulphate decrease in the top m (passes Test A). All three profiles show sulphate maximums deeper than 1 m (passes Test B). Background 1 shows the shallowest sulphate concentration less than the deepest (passes Test C), while Background 2 and the APEC profile do not. Thus the APEC profile is interpreted as Probable Downward, and the background profiles are interpreted as one Definitive Downward and one Probable Downward. The site therefore falls under Scenario 2 and the Native Prairie Protocol would be applicable at the Site if and only if Step 3b (water table depth deeper than 2 m) passes. At this site the water table depth was interpreted as being greater than 6 m, and therefore the Native Prairie Protocol was applicable.

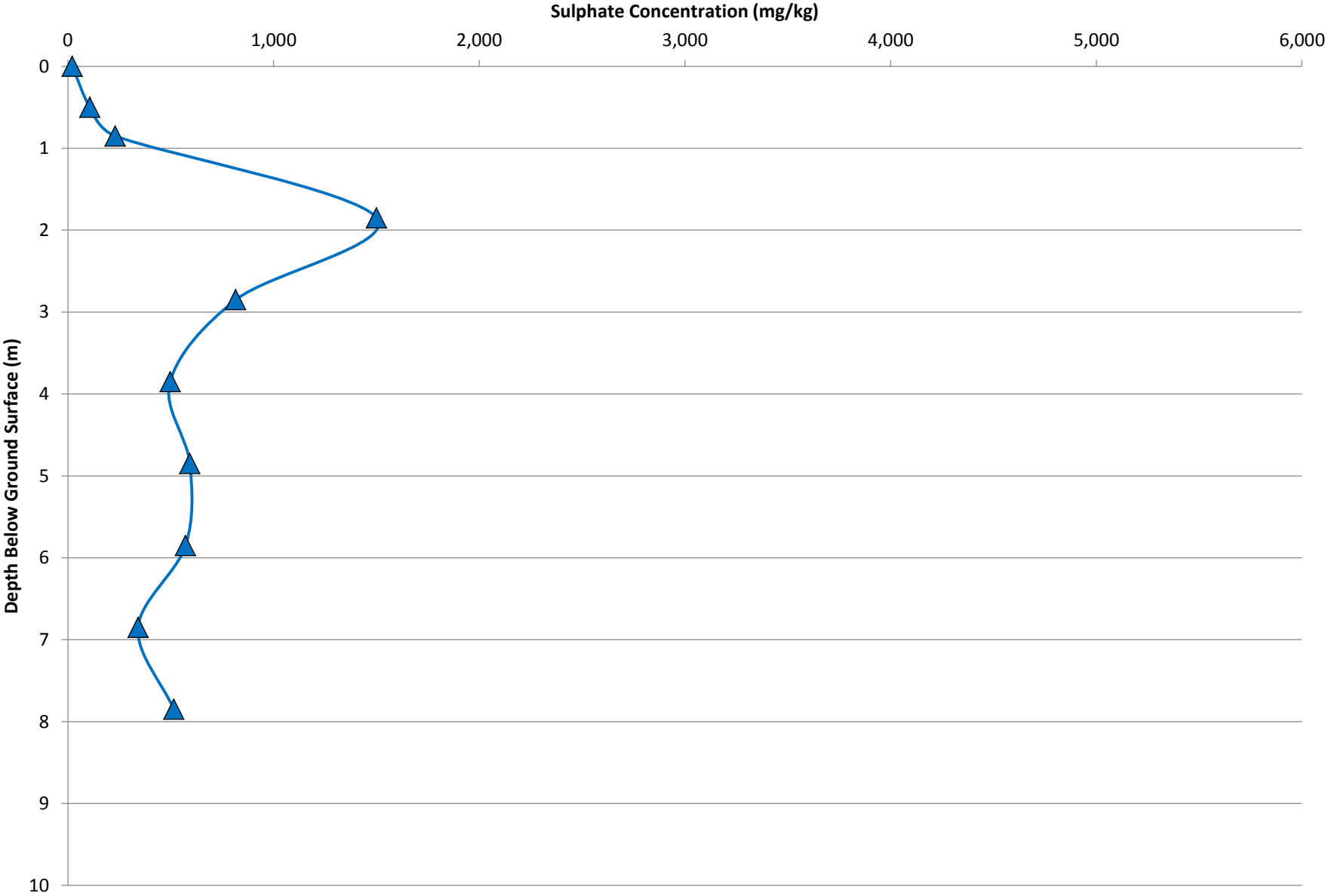
Definitive Downward Profile - Example 1



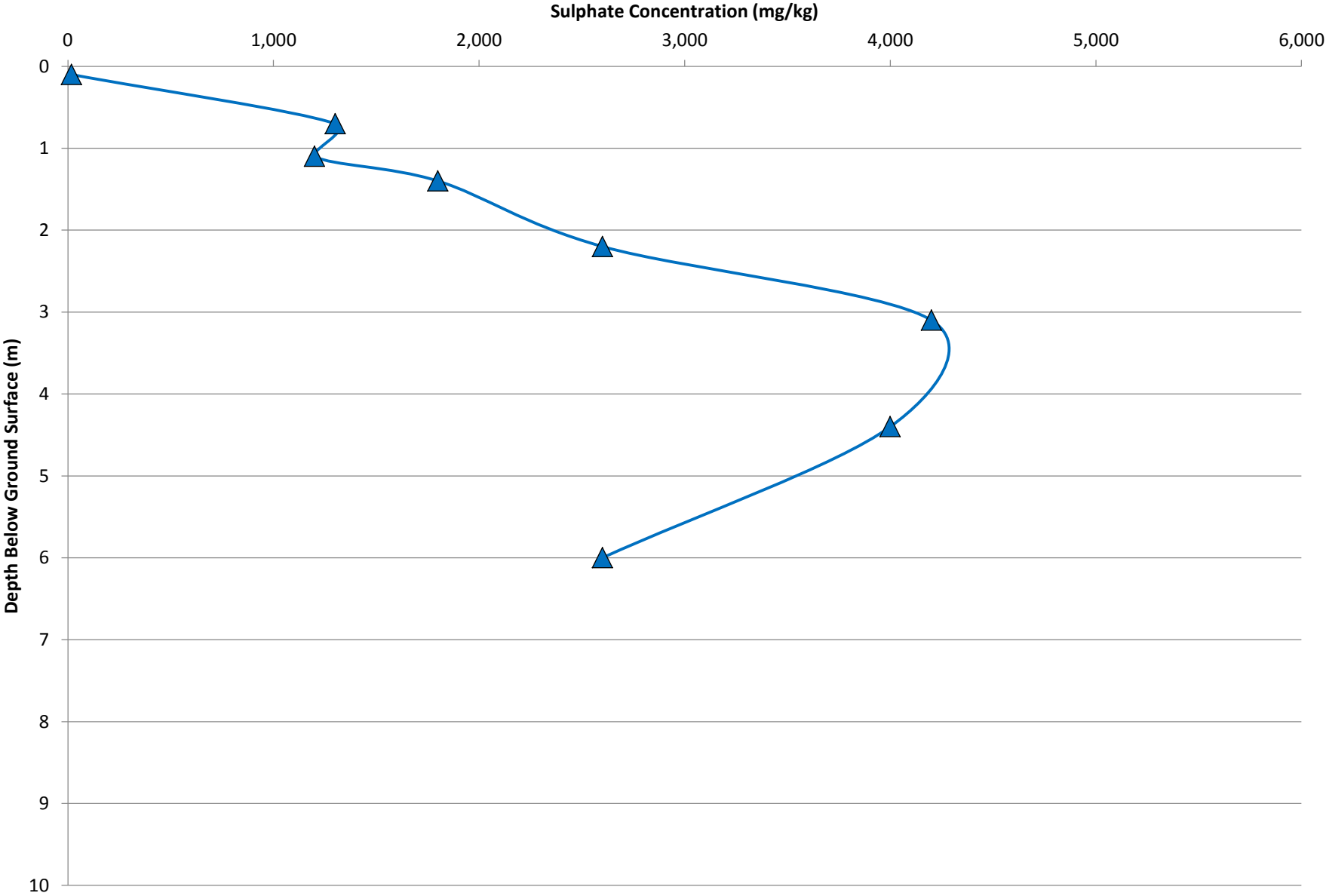
Definitive Downward Profile - Example 2



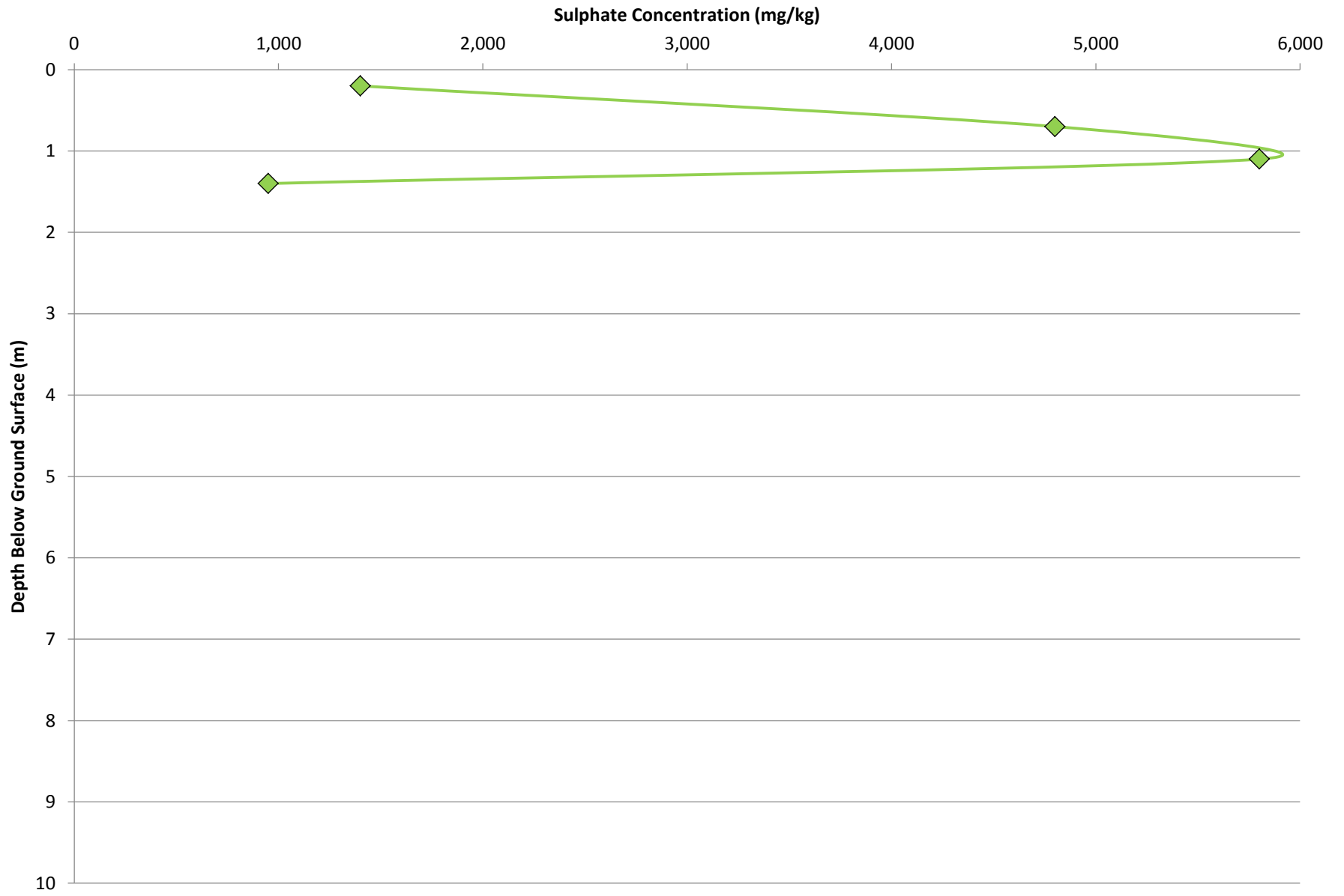
Definitive Downward Profile - Example 3



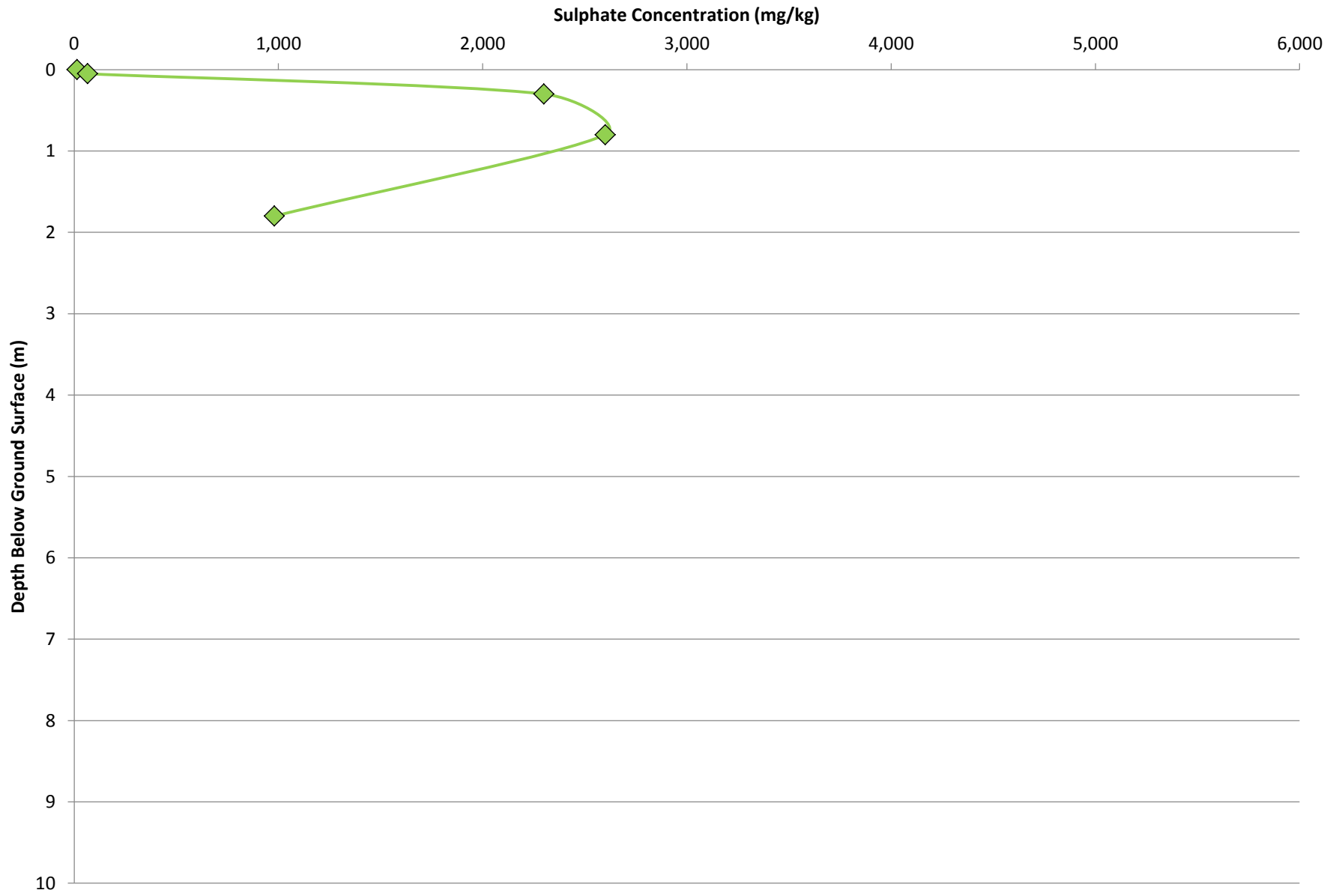
Definitive Downward Profile - Example 4



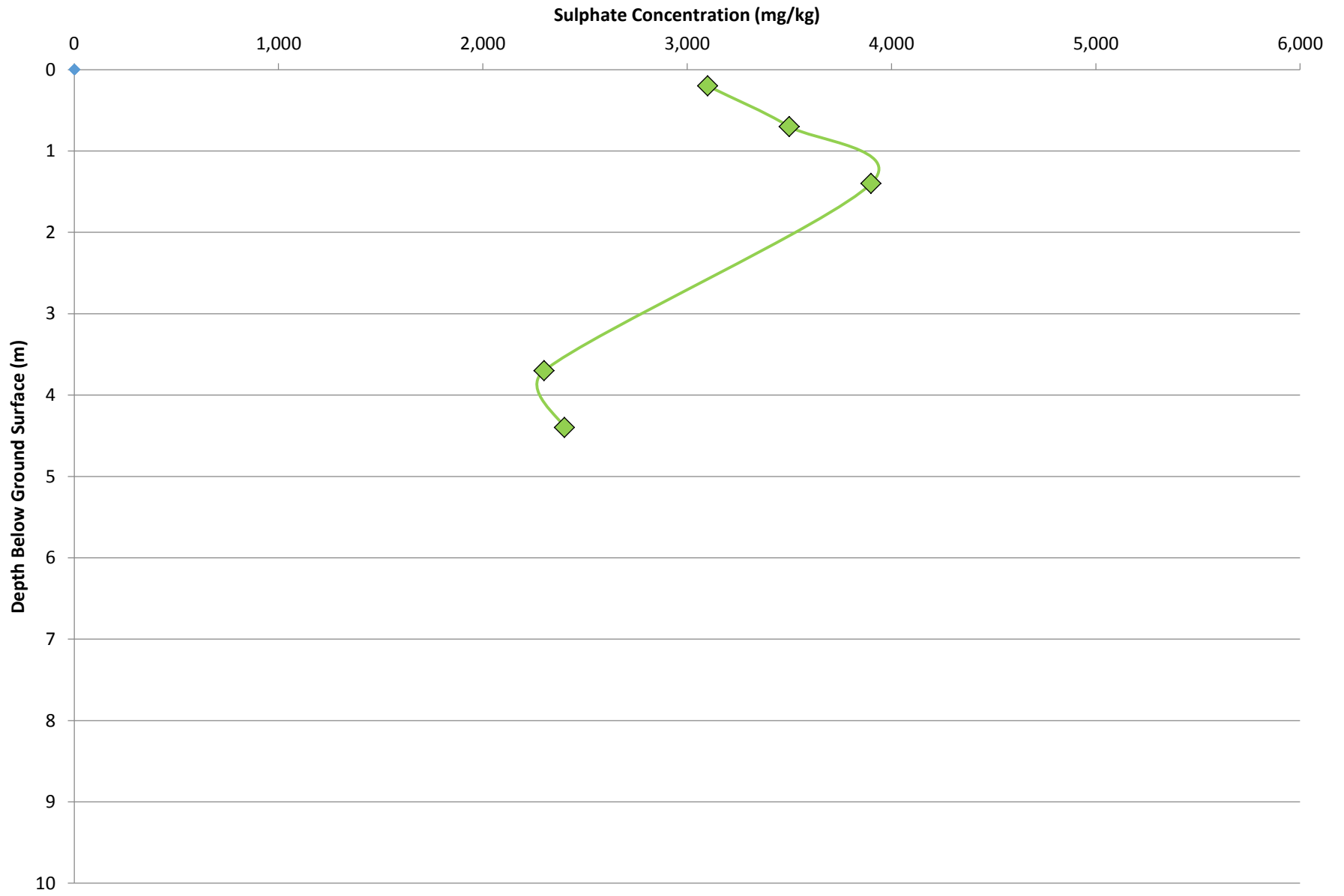
Probable Downward Profile - Example 1



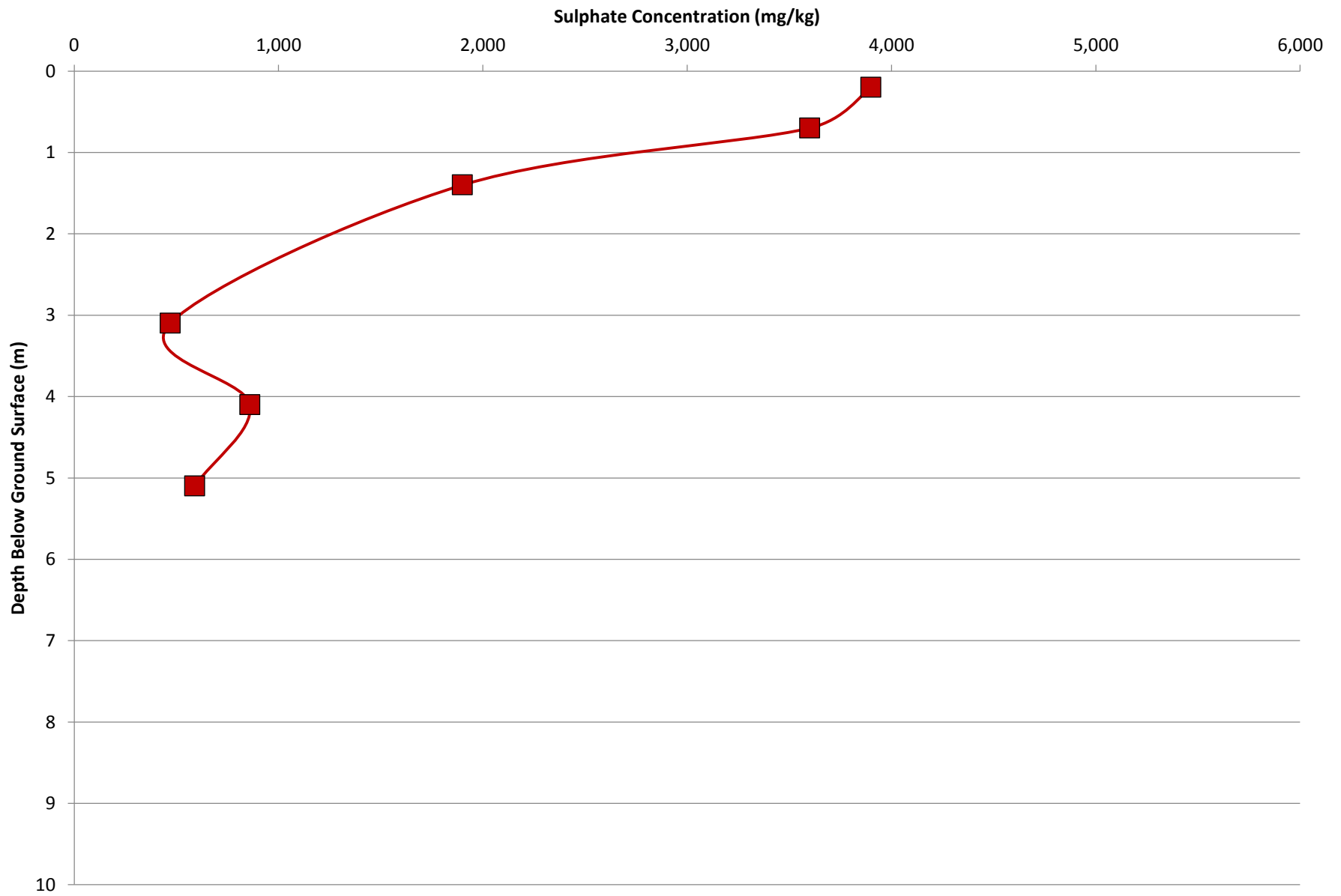
Probable Downward Profile - Example 2



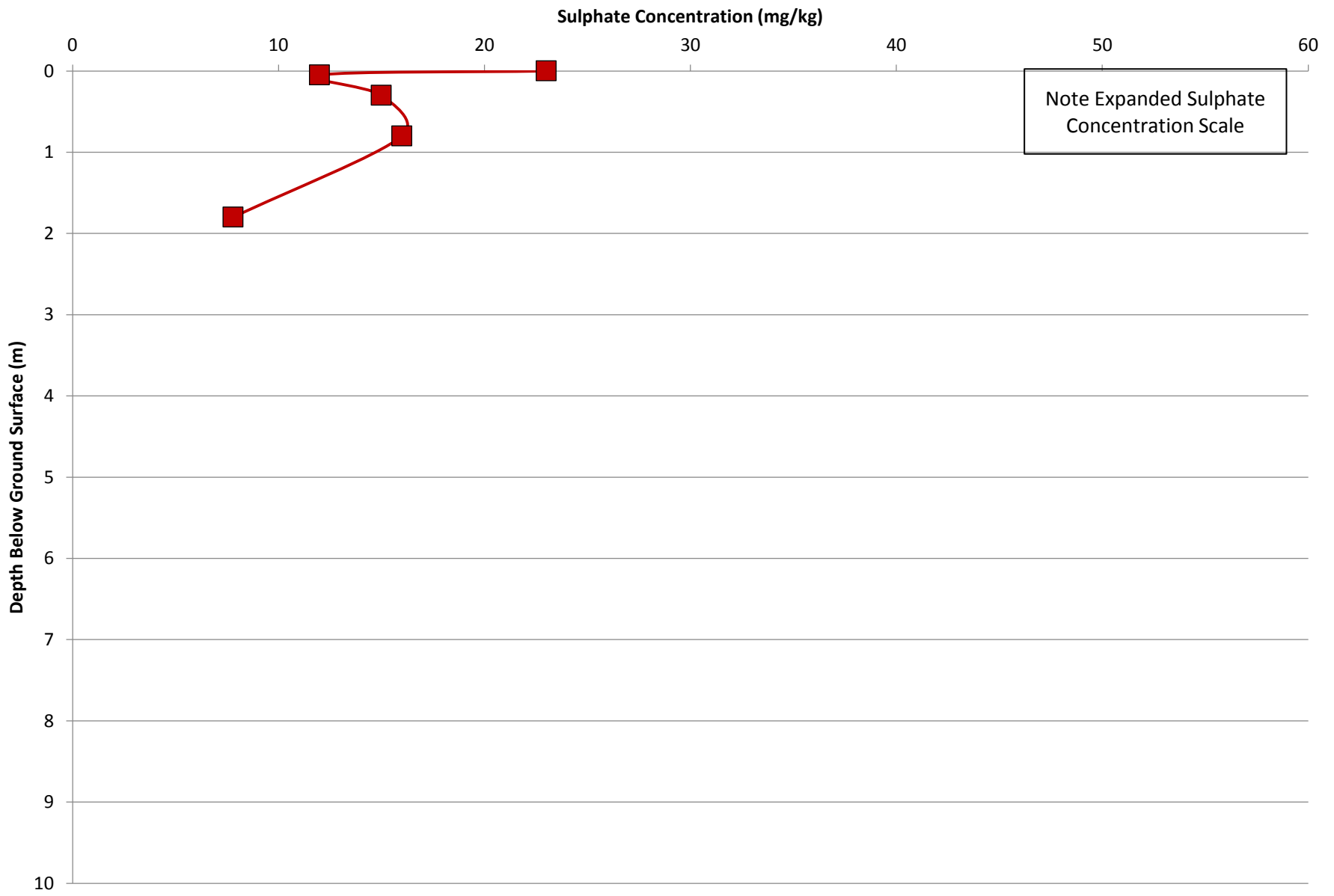
Probable Downward Profile - Example 3



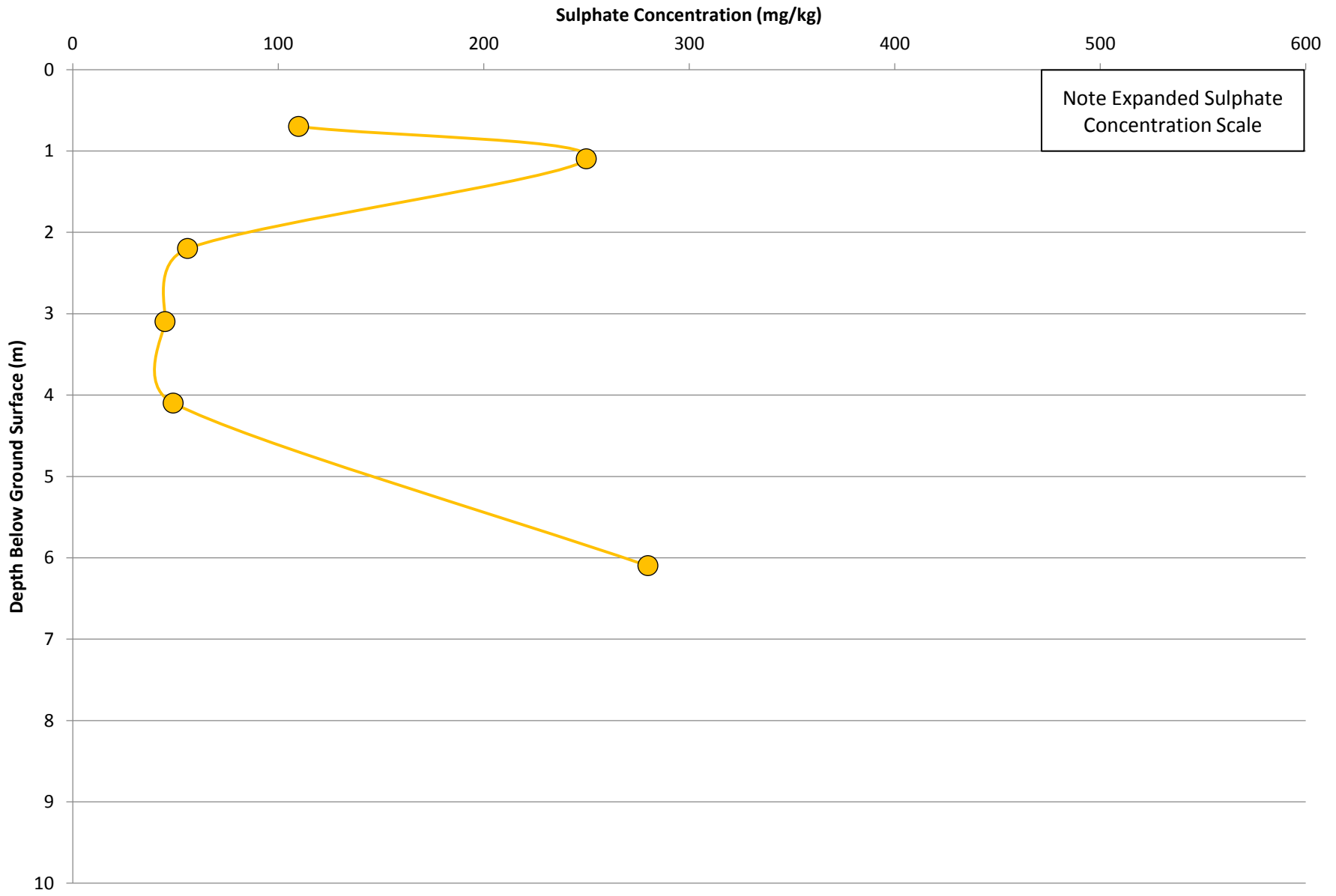
Upward Profile - Example 1



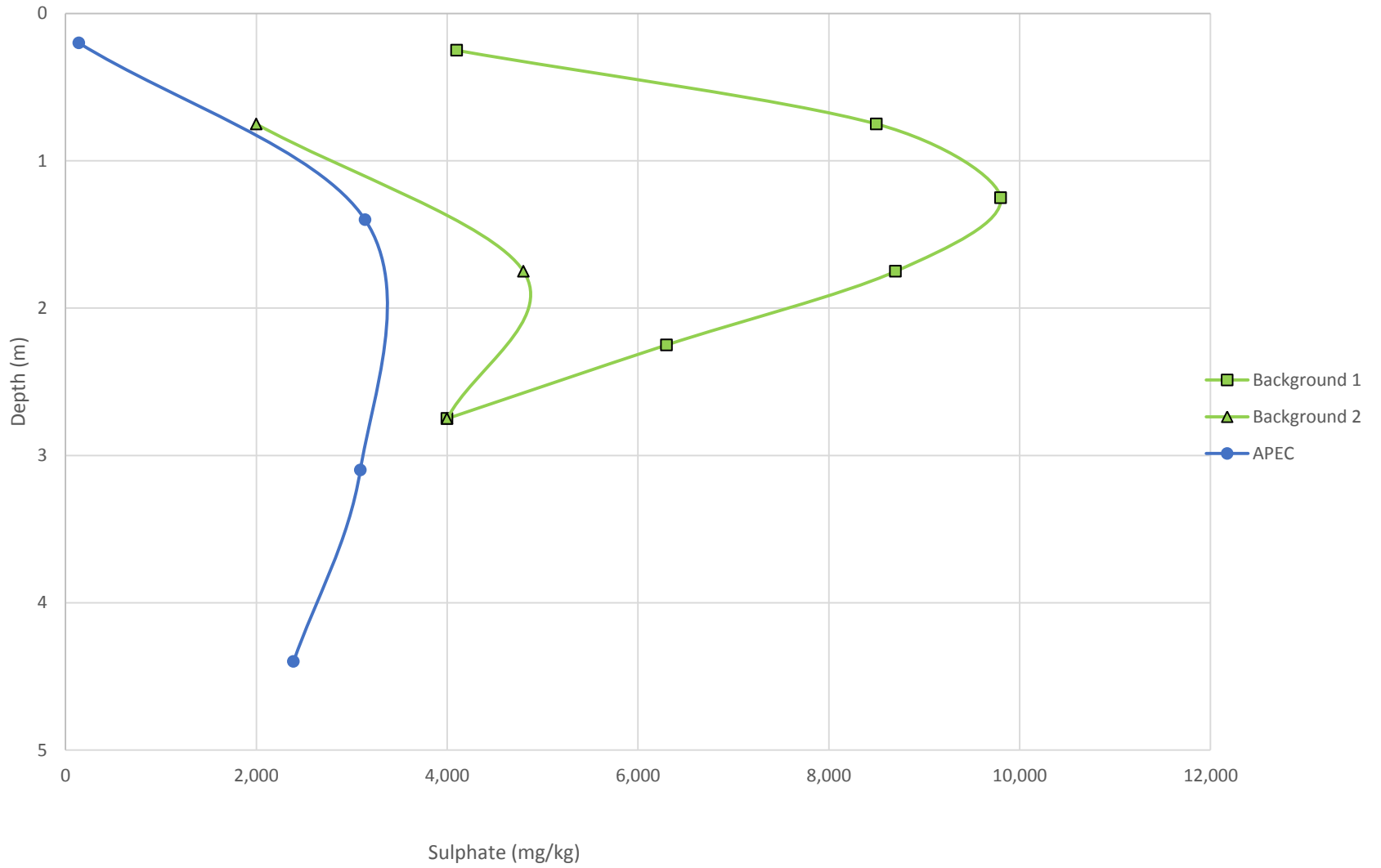
Upward Profile - Example 2



Ambiguous Profile - Example 1



Sulphate Profiles - Site Example 1



Sulphate Profiles - Site Example 2

