Klohn Crippen Berger

February 22, 2019

Resolution Copper Mining LLC
P.O. Box 1944
Superior, Arizona
85273

**Ms. Vicky Peacey**
**Senior Manager – Permitting and Approvals**

Dear Ms. Peacey:

**Resolution Copper Project**
**Summary of DEIS Tailings Alternatives Seepage Control Levels**
**Doc. # CCC.03-81600-EX-LTR-00001 – Rev. 0**

## 1 INTRODUCTION

The Tonto National Forest (the Forest) is assessing tailings storage facility (TSF) alternatives for detailed analysis as part of the Resolution Copper Mine Plan and Land Exchange Environmental Impact Statement (EIS). The Forest requested a summary of the TSF alternatives seepage control levels (description, schematics and estimated seepage rates) and general comparison to estimated seepage rates for other existing typical TSFs in the region. The Forest also requested a comment on the potential impacts of the varying degrees of seepage control measures have on the overall site water balance.

## 2 SEEPAGE CONTROL TECHNOLOGIES

A majority of TSFs in Arizona were constructed many decades ago before ADEQ[1] published the Arizona Mining Guidance Manual BADCT[2] (2005), which describes best practices for TSF seepage containment or collection control technologies. Seepage rates from some of these large facilities on high permeability foundation (e.g. alluvium basins) can be greater than 1,000 gpm (~1614 acre-ft/yr). In order to meet water quality guidelines, these facilities have installed seepage collection technologies, such as interceptor and pump-back well systems.

ADEQs Arizona Mining Guidance Manual includes the following potential design elements that could be used as part of discharge control systems to achieve BADCT for base metal TSFs, depending on project- and site-specific conditions:

[1] Arizona Department of Environmental Quality (ADEQ)
[2] Best Available Demonstrated Control Technology (BADCT)



Klohn Crippen Berger Ltd. • 500 - 2955 Virtual Way • Vancouver BC V5M 4X6 • CANADA
604.669.3800 t • 604.669.3835 f • www.klohn.com

- *Interception of storm run-off and groundwater flow in shallow aquifers to minimize water inflow.*
- *Natural geologic features functioning as liners.*
- *Localized lining with geosynthetic materials and/or clay.*
- *Slime sealing beneath the tailings pond. If properly done, this can produce an effective vertical hydraulic conductivity of $1x10^{-7}$ centimeters per second or less.*
- *Provision of sub-drainage beneath the impoundment to minimize hydraulic head and promote dewatering after closure.*
- *Leachate collection systems consisting of granular finger or blanket drains and corrugated perforated HDPE pipes can be used to supplement natural sub-drainage.*
- *Lining beneath the main underdrains is sometimes done to further minimize seepage.*
- *Centerline embankment construction to obtain a non-liquefiable stability zone.*
- *Drains and reclaim water pump back systems to lower or eliminate the phreatic surface in the embankment.*
- *High-strength, free draining rockfill zones in the embankment.*
- *Channels and dikes or berms to collect run-off from downstream slopes.*
- *Engineered hydraulic barriers downstream of the embankment and above the natural regional ground water table. These may include soil-bentonite slurry walls with upstream pump-back wells, reclaim wells and trench drains with downstream clay or geomembrane barriers.*

Furthermore, the following design considerations can also be used to achieve BADCT for seepage control:

- Tailings deposition strategies and management to control the rate of infiltration;
- TSF siting and configuration to control hydraulic gradient from TSF into the foundation (e.g. locating the pond in a low permeability area);
- Reduce the total footprint of TSF; and
- Thickening or dewatering tailings prior to placement.

Pump back wells are recognized as demonstrated seepage control technologies in ADEQ's Aquifer Protection Permit (APP) program, but not specifically listed as BADCT.

# 3 DEIS TAILINGS ALTERNATIVES SEEPAGE CONTROL LEVELS

Klohn Crippen Berger Ltd. (KCB), Golder Associates (Golder), and Montgomery & Associates (M&A) have completed the Draft EIS designs and estimates of uncaptured seepage, see Table 3.1.

A TSF design without incorporating seepage control features listed in Section 2 is expected to result in high (e.g., > 1,000 gpm) seepage rates. However, the Draft EIS designs incorporate additional BADCT seepage controls to achieve much lower modeled seepage rates, which are summarized in Table 3.2 to Table 3.7.

**Table 3.1 TSF Alternatives References**

| TSF Alternative | Seepage Control Design for Draft EIS | Uncaptured Seepage Estimate |
|---|---|---|
| 2<br>Near West ("wet") | KCB (2018a) | M&A (2018b, 2019) |
| 3<br>Near West ("dry") | KCB (2018b) | M&A (2018b, 2019) |
| 4<br>Silver King | KCB (2018c) | KCB (2019b) |
| 5<br>Peg Leg | Golder (2018a, 2018b) | Golder (2019) |
| 6<br>Skunk Camp | KCB (2018d) | KCB (2019a) |

The potential operational seepage control levels are schematically presented in Attachment 1.

## Table 3.2 Summary of TSF Alternatives Control Levels

| Seepage Control Measures | Alternative 2 Near West – "wet" | | | | Alternative 3 Near West – "dry" | | | | Alternative 4 Silver King Filtered | | Alternative 5 Peg Leg | | Alternative 6 Skunk Camp | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Seepage Control Level:** | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | **1** | **2** | **1** | **2** | **1** | **2** | **3** |
| **Discharge control systems to achieve BADCT for base metal TSFs (ADEQ 2005)** | | | | | | | | | | | | | | | |
| Storm water and shallow aquifer intercepts | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Natural geologic features functioning as liners | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | |
| Localized liners of geosynthetics and/or clay | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Slime Sealing | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Sub-drainage beneath the impoundment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Leachate collection systems (finger or blanket drains) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lining beneath main underdrains | | | | | | | | | | | | | ✓ | ✓ | ✓ |
| Centerline embankment construction | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Drains and reclaim water pump-back systems | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Free draining rockfill zones in the embankment | | | | | | | | | | | | | | | |
| Runoff water collection via channels and dikes or berms from embankment surface | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Engineered hydraulic barriers – grout curtains with pump-back wells | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ |
| Engineered hydraulic barriers – reclaim wells and trench drains with clay or geomembrane | | | | ✓ | | | | ✓ | | | | | ✓ | ✓ | ✓ |
| **Other seepage control measures** | | | | | | | | | | | | | | | |
| Tailings thickening | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| High-density thickening of tailings (and implementation of thin lift placement) | | | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | |
| Dewatering (filtering) | | | | | | | | | ✓ | ✓ | | | | | |
| Downgradient pump-back wells | | | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Extended engineered hydraulic barriers – grout curtains with pump-back wells | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ |
| Additional downgradient pump-back wells | | | | ✓ | | | | ✓ | | | | | | ✓ | ✓ |

**Table 3.3 Alternative 2 Near West Modified Proposed Action (Modified Centerline Embankment – "wet") Seepage Control Levels**

| Level of Seepage Control | Seepage Control Description (see KCB 2018a) | From M&A (2018b, 2019) | | | | |
|---|---|---|---|---|---|---|
| | | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Collection Pond Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
| 0 | Features required for stability and act as seepage control features include modified centerline-raised compacted cycloned sand embankments and an embankment underdrainage system. | *not explicitly modeled* | | | | |
| Between 0 and 1 (Note 2) | Seepage control measures represented in the 2018 Alternative 2/3 steady-state model report[2] (M&A 2018) include:<br>▪ features for stability described above;<br>▪ embankment underdrains extend into the impoundment under the entire scavenger beach; and<br>▪ seepage collection ponds with cut-offs walls and pump-back wells. | 91% | 1,912 | 220 | 8 | 194 |
| 1 | Seepage control measures as presented in the DEIS report (KCB 2018a) include:<br>▪ features for stability described above;<br>▪ embankment underdrains extend into the impoundment for 200 ft;<br>▪ foundation treatment or selective engineered low-permeability layers in areas that are not Gila Conglomerate;<br>▪ engineered low-permeability layers for the pyrite starter facility;<br>▪ encapsulation of pyrite tailings in the scavenger tailings slimes; and<br>▪ seepage collection ponds with cut-offs, grout curtains and pump-back wells. Grout curtain would extend from the ground surface to 100 ft below ground. | *not explicitly modeled* | | | | |
| 2 | To increase Level 1 seepage capture, Level 2 (as described in KCB 2018a) includes extending the grout curtain to target high-permeability zones and seepage pathways. | *not explicitly modeled* | | | | |
| 3 | To increase Level 2 seepage capture, Level 3 (as described in KCB 2018a) includes adding additional seepage collection ponds/facilities downstream. | *not explicitly modeled* | | | | |

| Level of Seepage Control | Seepage Control Description (see KCB 2018a) | From M&A (2018b, 2019) | | | | |
|---|---|---|---|---|---|---|
| | | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Collection Pond Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
| 4 | To increase Level 3 seepage capture, Level 4 (as described in KCB 2018a) includes additional pump-back wells and grout curtain/cut-off walls.<br><br>Seepage control measures represented in modified steady-state model report[2] (M&A 2019), in addition to the simulation described in M&A (2018), include:<br>▪ low-permeability liners in areas that are not Gila Conglomerate;<br>▪ engineered low-permeability liner for the entire pyrite cell;<br>▪ downgradient grout curtain extending from the ground surface to 100 ft below ground; and<br>▪ additional pump-back wells (see Note 3). | 99% | 1,910 | 223 | 0.6 | 21 |

Notes:

1. Seepage capture efficiency is calculated from the tailings seepage that enters the foundation, it does not account for dewatering (thickening/filtering) or climate effects.
2. Seepage control modeled by M&A were based on the seepage control measures described in KCB (2018a).
3. Pump back wells were added in the model by M&A in locations to maximize seepage capture.

**Table 3.4 Alternative 3 Near West Modified Proposed Action (High-density thickened NPAG Scavenger and Segregated PAG Pyrite Cell) - Seepage Control Levels**

| Level of Seepage Control | Seepage Control Description (see KCB 2018b) | From M&A (2018b, 2019) | | | | |
|---|---|---|---|---|---|---|
| | | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Collection Pond Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
| 0 | Features required for stability and act as seepage control features include modified centerline-raised compacted cycloned sand embankments and an embankment underdrainage system. | *not explicitly modeled* | | | | |
| Between 0 and 1 (Note 2) | Seepage control measures represented in the steady-state model report[2] (M&A 2018) include:<br>▪ embankment underdrains extend into the impoundment under the entire scavenger beach; and<br>▪ seepage collection ponds with cut-offs walls and pump-back wells. | 84% | 508 | 220 | 5 | 116 |
| 1 | Seepage control measures as presented in the DEIS report (KCB 2018a) include:<br>▪ features for stability described above;<br>▪ embankment underdrains extend into the impoundment under the entire scavenger beach;<br>▪ foundation treatment or selective engineered low-permeability layers in areas that are not Gila Conglomerate;<br>▪ engineered low-permeability layers for the entire pyrite cell; and<br>▪ seepage collection ponds with cut-offs, grout curtains and pump-back wells. Grout curtain would extend from the ground surface to 100 ft below ground. | *not explicitly modeled* | | | | |
| 2 | To increase Level 1 seepage capture, Level 2 (as described in KCB 2018b) includes extending the grout curtain to target high-permeability zones and seepage pathways. | *not explicitly modeled* | | | | |
| 3 | To increase Level 2 seepage capture, Level 3 (as described in KCB 2018b) includes adding additional seepage collection ponds/facilities downstream. | *not explicitly modeled* | | | | |

| Level of Seepage Control | Seepage Control Description (see KCB 2018b) | From M&A (2018b, 2019) | | | | |
|---|---|---|---|---|---|---|
| | | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Collection Pond Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
| 4 | To increase Level 3 seepage capture, Level 4 (as described in KCB 2018b) includes additional pump-back wells and grout curtain/cut-off walls.<br><br>Seepage control measures as represented in modified steady-state model report (M&A 2019), in addition to the simulation described in M&A (2018), include:<br>▪ selective engineered low-permeability liners in areas that are not Gila Conglomerate;<br>▪ engineered low-permeability liners for the entire pyrite cell;<br>▪ grout curtain would extend from the ground surface to 100 ft below ground, extending to target high-permeability zones and seepage pathways; and<br>▪ additional pump-back wells (see Note 3). | 99.5% | 630 | 130 | 15 | 3 |

Notes:

1. Seepage capture efficiency is calculated from the tailings seepage that enters the foundation, it does not account for dewatering (thickening/filtering) or climate effects.
2. Seepage control modeled by M&A were based on the seepage control measures described in KCB (2018b).
3. Pump back wells were added in the model by M&A in locations to maximize seepage capture.

**Table 3.5 Alternative 4 Silver King Seepage Control Levels**

| Level of Seepage Control | Seepage Control Description (see KCB 2018c, 2019b) | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Collection Pond Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
|---|---|---|---|---|---|---|
| 0 | Features required for stability and act as seepage control features include dewatered tailings, compacted structural zone with an underdrainage system. | n/a | 77.5 | 1.9 | 0.6 | n/a |
| 1 | In addition to the features for stability, seepage collection, as presented in the DEIS report (KCB 2018c), includes lined collection ditches and collection ponds that cut-off the alluvium. There is potential that a portion of the seepage would not be collected with this approach. A preliminary estimate of up to 80% capture is assumed because seepage can be collected in the underdrains and the alluvial channels will be cut-off. There is a remaining risk that a large portion of the flow paths would bypass seepage collection. | less than 80% | | | | greater than 17 acre-ft/yr |
| 2 | In addition to the features described for Level 1, additional seepage control measures would include targeted grouting of fractures (potential seepage pathways) in the foundation and pump-back wells for seepage return.<br>A preliminary estimate of up to 90% capture is assumed because of the uncertainty in the foundation conditions.<br>There is a remaining risk that a portion of the flow paths would bypass seepage collection. | up to 90% | | | | greater than 9 acre-ft/yr |

Notes:

1. Seepage capture efficiency is calculated from the tailings seepage that enters the foundation, it does not account for dewatering (thickening/filtering) or climate effects.

## Table 3.6 Alternative 5 Peg Leg Seepage Control Levels

| Level of Seepage Control | Seepage Control Description (see Golder 2018a, 2018b, 2019) | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Collection Pond Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
|---|---|---|---|---|---|---|
| 0 | Features required for stability and to act as seepage control features include modified centerline-raised compacted cycloned sand embankments and an embankment underdrainage system. Separate NPAG and PAG cells | n/a | 2,660 | 1,270 | <1 | 3,930 |
| 1 | Seepage control measures as presented in the DEIS report (Golder 2019) include:<br>▪ features for stability described above;<br>▪ surface water diversions around the NPAG and PAG facilities to minimize run-on surface water;<br>▪ lined Seepage collection ponds and ditches;<br>▪ finger drains extending from the embankment underdrains below the impoundment beach and along the existing drainages;<br>▪ HDPE lining of reclaim pond area (300 acres) where reclaim pond is in contact with native materials;<br>▪ engineered low-permeability layers for the entire pyrite cell; and<br>▪ pump-back wells to form a continuous cone of depression (cut off) and collect surface seepage below the NPAG embankment. | 65% | 2,537 | 1,211 | <1 | 1,317 |
| 2 | Seepage control measures, as described above with the addition of:<br>▪ complete synthetic lining of PAG cells base and embankment;<br>▪ removal of alluvium and pervious sediments above bedrock below PAG cells;<br>▪ utilization of thin-lift deposition beginning in year 7 when sufficient operating area becomes available; and<br>▪ adjusting pump back wells to allow 261 acre-ft/yr to bypass system (requires less pumping than level 1). | 84% | 1,640 | 25 | <1 | 261 |

Notes:

1. Seepage capture efficiency is calculated from the tailings seepage that enters the foundation, it does not account for dewatering (thickening/filtering) or climate effects.

**Table 3.7 Alternative 6 Skunk Camp Seepage Control Levels**

| Level of Seepage Control | Seepage Control Description (see KCB 2018d, 2019a) | Average Seepage Capture Efficiency (%) (Note 1) | Average Scavenger (NPAG) Seepage (acre-ft/yr) | Average Pyrite (PAG) Seepage (acre-ft/yr) | Average Uncaptured Seepage (acre-ft/yr) |
|---|---|---|---|---|---|
| 0 | Features required for stability and also act as seepage control features include centerline-raised compacted cycloned sand embankments and an embankment underdrainage system. | n/a | 1,820 | 50 | n/a |
| 1 | Seepage control measures as presented in the DEIS report (KCB 2018d) include:<br>▪ features for stability described above;<br>▪ embankment underdrains extend into the impoundment for 100 ft to 200 ft;<br>▪ engineered low-permeability layers for the pyrite cells;<br>▪ seepage collection ponds with cut-offs, grout curtains and pump-back wells. Grout curtain would extend from the ground surface to 70 ft below ground and the seepage pump-back wells at 20 ft below ground level (estimated to be the base of the alluvium). | 64%[1] | 1,820 | 50 | 580-660 |
| 2 | To increase Level 1 seepage capture, Level 2 (as described in KCB 2019) includes an extension of the grout curtain to 100 ft and the seepage pump-back wells installed at 70 ft below ground (estimated to be the base of the weathered Gila Conglomerate layer). | 80%[1] | 1,840 | 50 | 270-370 |
| 3 | To increase Level 2 seepage capture, Level 3 (as described in KCB 2019) includes an installation of the seepage pump-back wells at 100 ft below ground, at the depth of the grout curtain. | 90%[1] | 1,840 | 50 | 70-180 |

Notes:
1. Seepage capture efficiency is calculated from the tailings seepage that enters the foundation, it does not account for dewatering (thickening/filtering) or climate effects.

# 4 IMPACTS OF SEEPAGE CONTROL LEVELS ON MINE WATER BALANCE

The mine water balances (Westland 2018) were prepared for the TSF alternatives, but for only level 1 seepage control design. The Forest recognized that the addition of engineered seepage controls would result in higher seepage collection rates and lead to minor differences in the mine site-wide water balances.

During peak production years, average water inflows into the TSF's are approximately between 20,000 acre-ft/yr to 30,000 acre-ft/yr, depending on the TSF alternative. Inflows into the entire mine water balance are over 200,000 acre-ft/yr (M&A 2018a).

The difference in captured seepage rates between the seepage control levels for the TSF alternatives range from ~150 acre-ft/yr to ~1,100 acre-ft/yr. These are relatively minor flows in the overall mine water balance, resulting in <5% of the total TSF water balance inflows and <1% of the total mine water balance inflows. These minor differences are within the potential climate variability and error margins of the water balance.

# 5 CONCLUSIONS

The TSF Alternatives have multiple BADCT seepage controls that can be incorporated into design/construction to lower modeled seepage rates than other facilities in the region where the same level of controls have not been incorporated.

The additional seepage control measures above level 1 are not expected to have a large impact on the overall mine water balance and prediction of water demand.

# 6 CLOSING

This letter is an instrument of service of Klohn Crippen Berger Ltd. The letter has been prepared for the exclusive use of Resolution Copper Mining LLC (Client) for the specific application to the Resolution Copper Project. The letter's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this letter, Klohn Crippen Berger has endeavored to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

Yours truly,

**KLOHN CRIPPEN BERGER LTD.**

Kate Patterson, P.E., P.Eng., M.Eng.
Associate, Project Manager

KP:dl

Attachment: 1 - Potential Operational Seepage Control Levels

## REFERENCES

Arizona Department of Environmental Quality (ADEQ). 2005. Arizona Mining BADCT (Best Available Demonstrated Control Technology) Guidance Manual. August. https://legacy.azdeq.gov/environ/water/wastewater/download/badctmanual.pdf.

Golder Associates Ltd. (Golder). 2018a. Draft DEIS Design, PEG Leg Alternative 5 – Golder project 1688500-1000-1600-16-R-0. Prepared for Resolution Copper Mining LLC. June 20.

Golder Associates Ltd. (Golder). 2018b. Order of Magnitude Design, Peg Leg Alternative 5 – Golder project 1688500-1000-1600-16-R-0. Prepared for Resolution Copper Mining LLC. September 20.

Golder Associates Ltd. (Golder). 2019. Resolution Copper Mining – Alternative 5, Peg Leg Water Balance – Additional BADCT Technologies to Reduce Seepage. Prepared for Resolution Copper Mining LLC. January 28.

Klohn Crippen Berger Ltd. (KCB). 2018a. DEIS Design for Alternative 3A – Near West Modified Proposed Action (Modified Centerline Embankment - "wet"). Prepared for Resolution Copper Mining LLC. June 8.

Klohn Crippen Berger Ltd. (KCB). 2018b. DEIS Design for Alternative 3B – Near West Modified Proposed Action (High-density Thickened NPAG Scavenger and Segregated PAG Pyrite Cell) – Doc. #CCC.03-26000-EX-REP-00002 - Rev.0. Prepared for Resolution Copper Mining LLC. June 8.

Klohn Crippen Berger Ltd. (KCB). 2018c. DEIS Design for Alternative 4 – Silver King Filtered – Doc. #CC.03-26000-EX-REP-00006 - Rev. 0. Prepared for the Resolution Copper Project. June 4.

Klohn Crippen Berger Ltd. (KCB). 2018d. DEIS Design for Alternative 6 – Skunk Camp – Doc. #CCC.03-81600-EX-REP-00006 - Rev. 2. Prepared for Resolution Copper Mining LLC. September 7.

Klohn Crippen Berger Ltd. (KCB). 2019a. DEIS Design for Alternative 6 – Skunk Camp – Doc. #CCC.03-81600-EX-MMO-00024 - Rev. 3 – Appendix IV Seepage Estimate Amendment. Prepared for Resolution Copper Mining LLC. January 30.

Klohn Crippen Berger Ltd. (KCB). 2019b. DEIS Design for Alternative 4 – Silver King Filtered – Doc. #CCC.03-81600-EX-REP-00010 - Rev. 1 – Appendix IV Seepage Estimate Amendment. Prepared for Resolution Copper Mining LLC. January 23.

Montgomery & Associates. (M&A). 2018a. System-wide Hydrologic Water Flow Budget for Resolution Copper, Pinal County, Arizona. June 6.

Montgomery & Associates. (M&A). 2018b Alternatives 2 and 3 Steady-State Modeling – Near West Tailings Facility Technical Memorandum. Prepared for the United States Forest Service. December 21.

Montgomery & Associates. (M&A). 2019. Revised Near West TSF Alternatives 2 and 3 Steady-State Modeling Incorporating Additional Seepage Collection Measures – Near West Tailings Facility Technical Memorandum. Prepared for the Resolution Copper Project. January 25.

Westland Resources Inc. (Westland). 2018. Resolution Copper Water Balance Tailings Alternatives 2, 3, 4, 5 and 6. September 4.

# ATTACHMENT 1

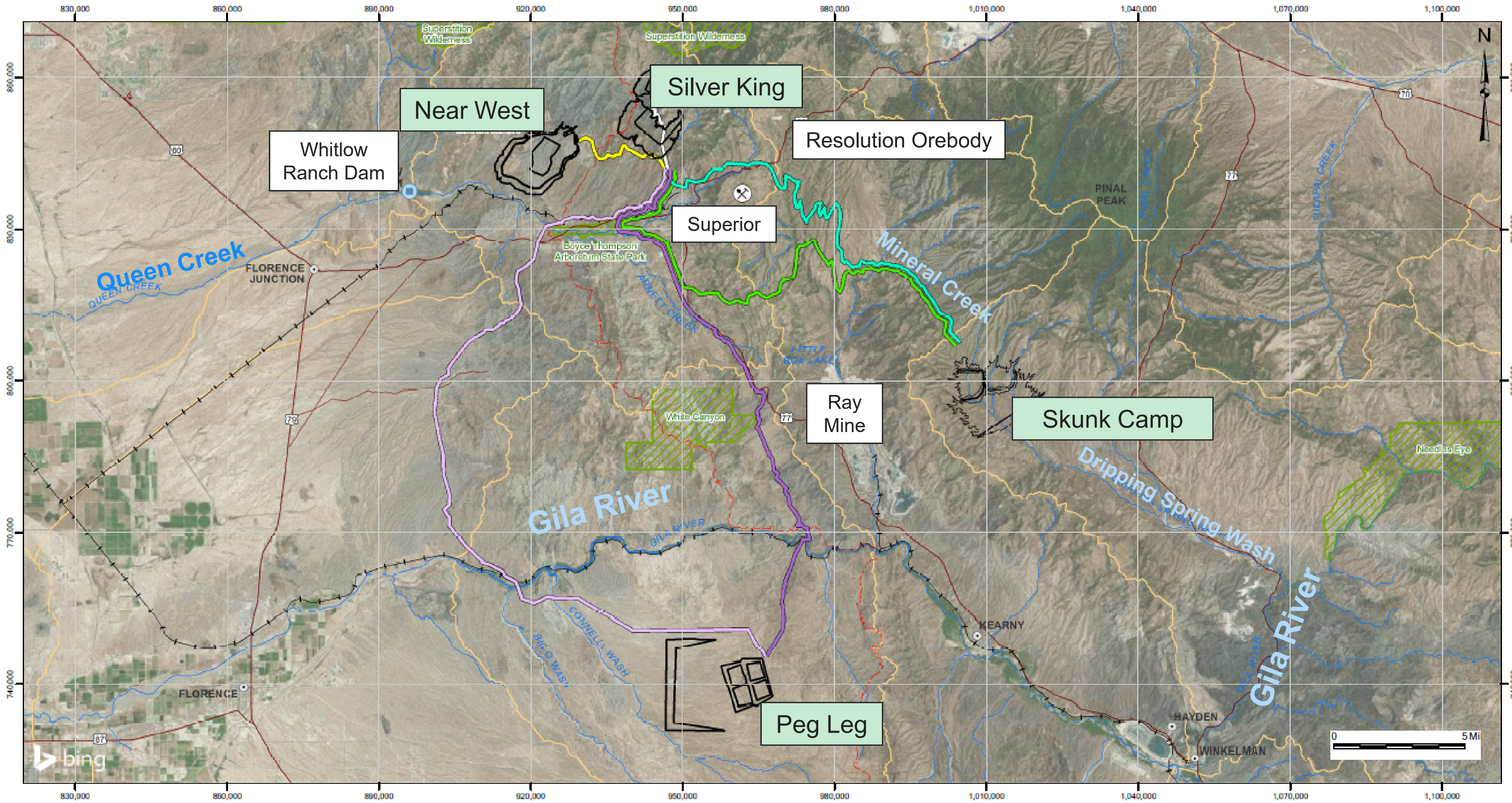
## Potential Operational Seepage Control Levels

RESOLUTION COPPER

February 2019 EIS Tailings Alternatives – Seepage Control Levels

Klohn Crippen Berger

# ALTERNATIVES

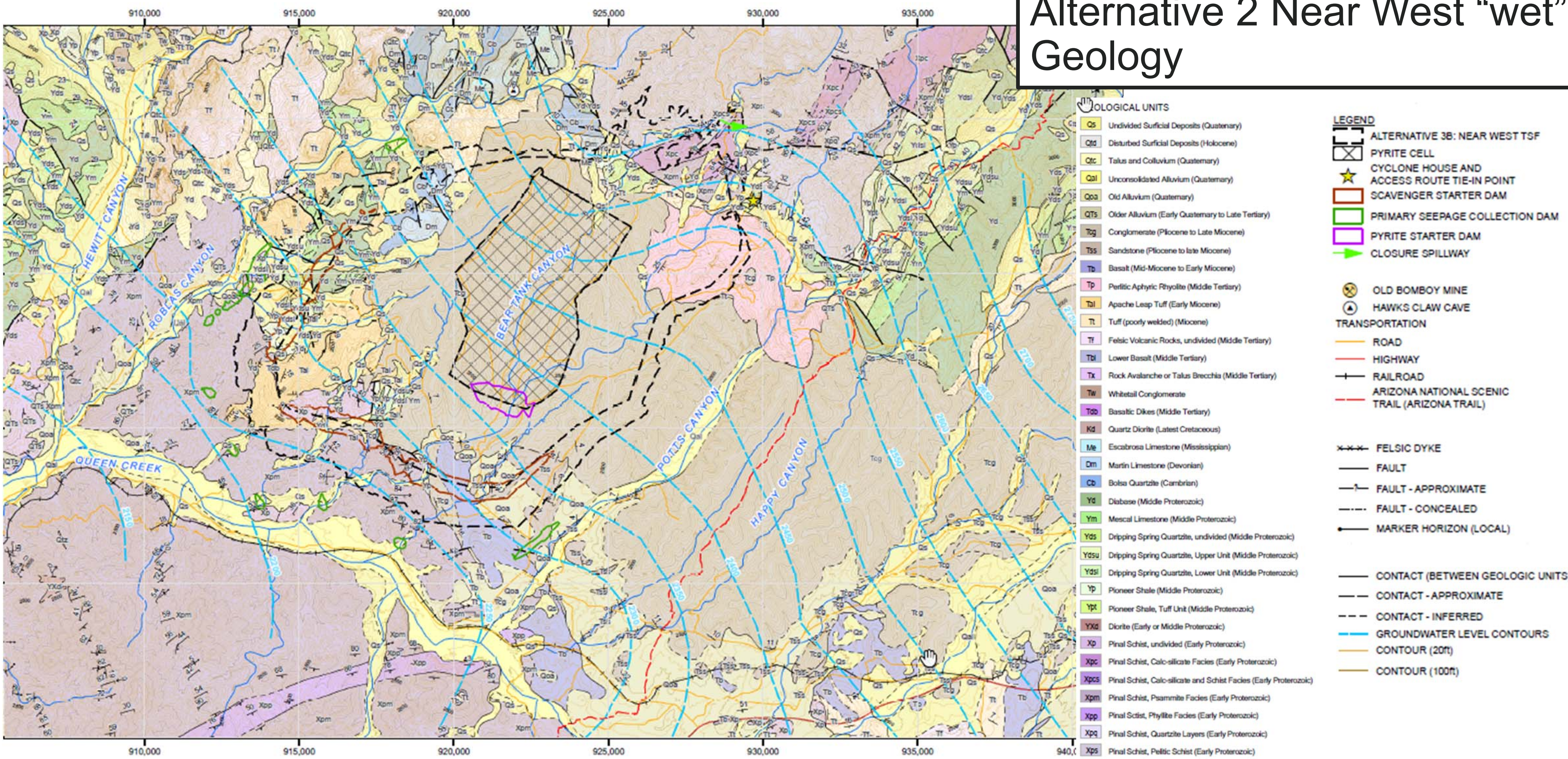


# *Alternative 2*

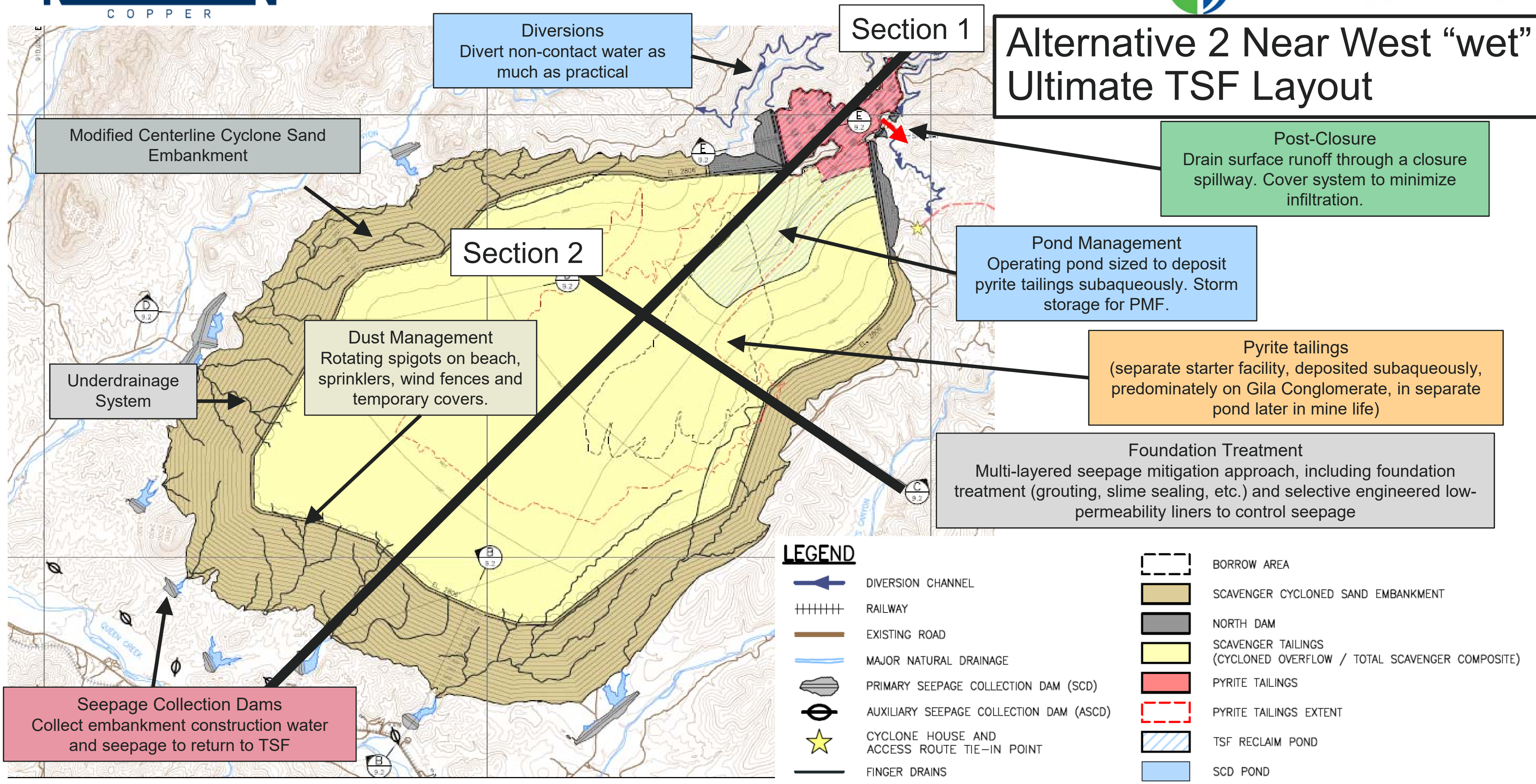
# *Near West ("wet")*

# *Seepage Control Levels*

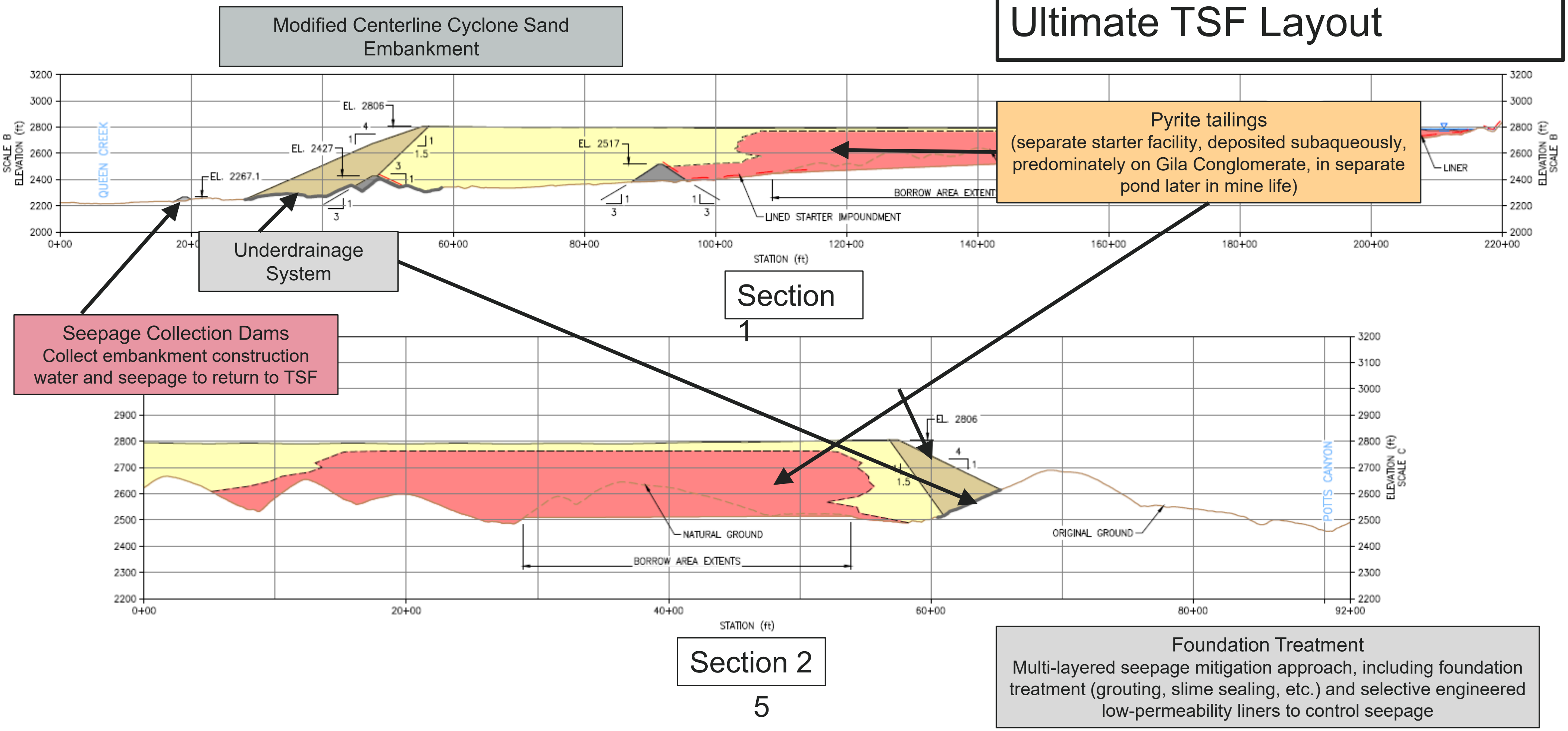
# Alternative 2 Near West “wet” Geology



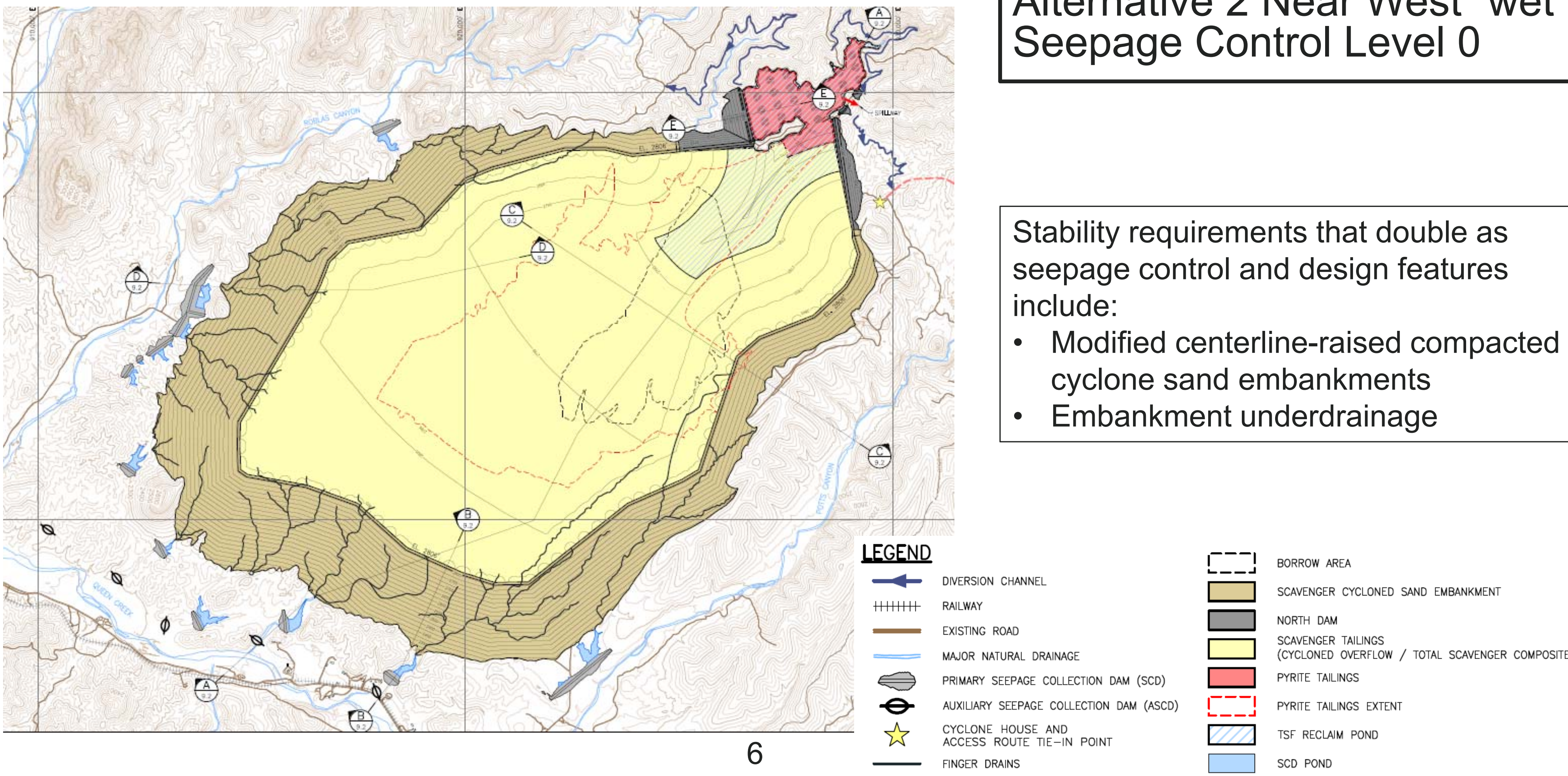
# Alternative 2 Near West "wet" Ultimate TSF Layout



# Alternative 2 Near West “wet” Ultimate TSF Layout



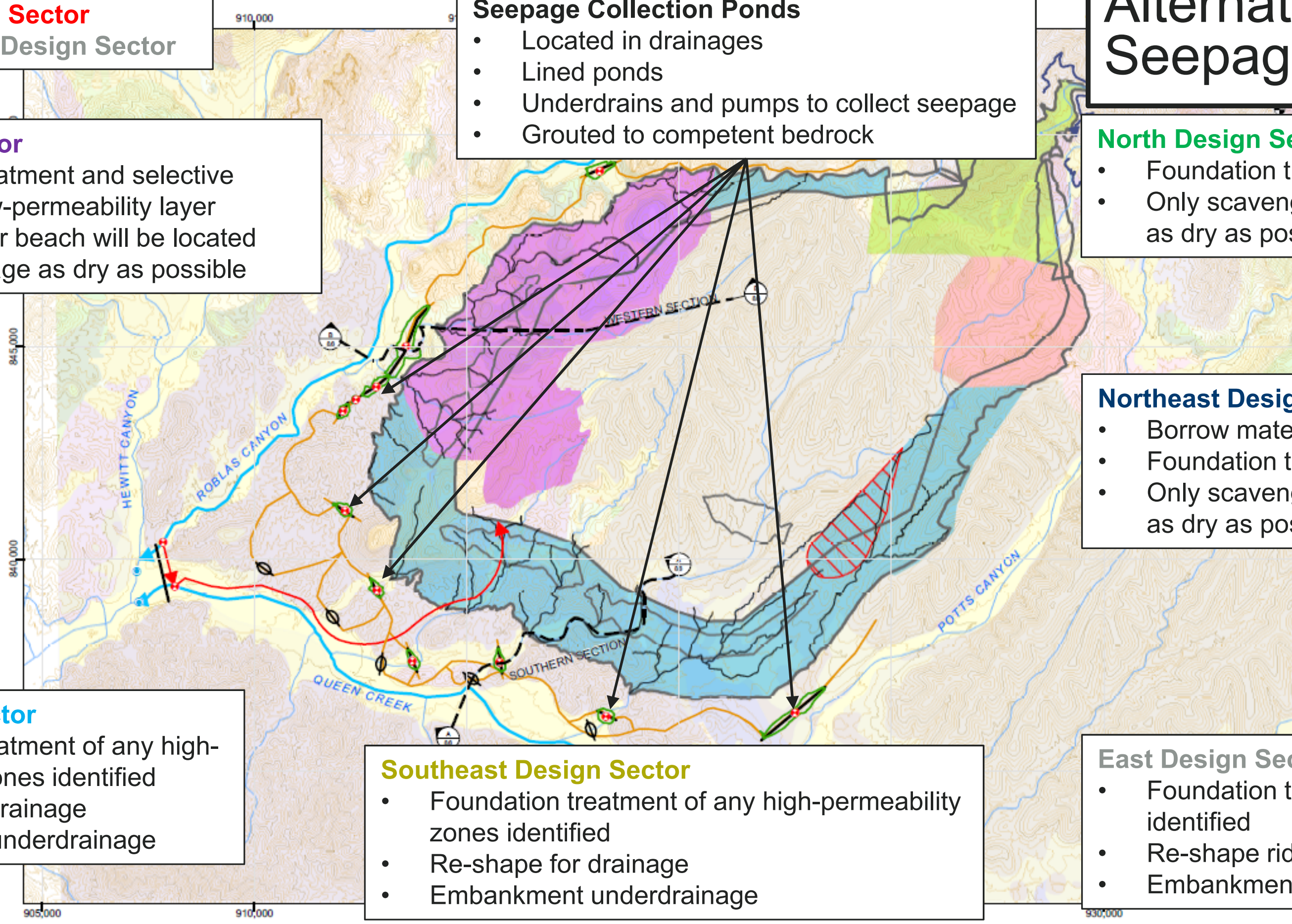
# Alternative 2 Near West "wet" Seepage Control Level 0




Stability requirements that double as seepage control and design features include:

- Modified centerline-raised compacted cyclone sand embankments
- Embankment underdrainage

# Alternative 2 Near West "wet" Seepage Control Level 1




**Northwest Design Sector**
- Same as East Design Sector

**Seepage Collection Ponds**
- Located in drainages
- Lined ponds
- Underdrains and pumps to collect seepage
- Grouted to competent bedrock

**West Design Sector**
- Foundation treatment and selective engineered low-permeability layer
- Only scavenger beach will be located here, will manage as dry as possible

**North Design Sector**
- Foundation treatment and selective lining
- Only scavenger beach will be located here, will manage as dry as possible

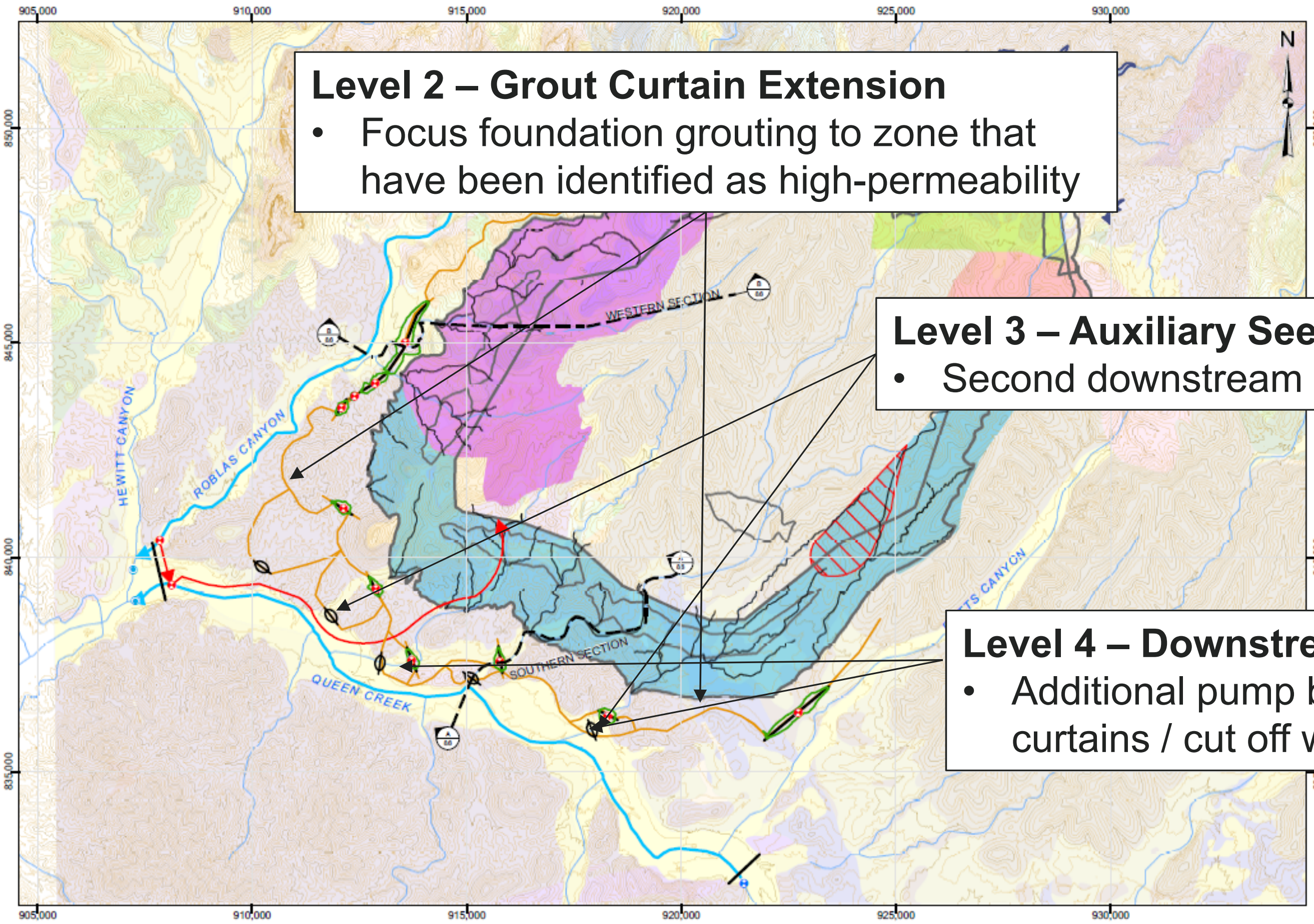
**Northeast Design Sector**
- Borrow material area -> reshape for drainage
- Foundation treatment and selective lining, if required
- Only scavenger beach will be located here, will manage as dry as possible

**South Design Sector**
- Foundation treatment of any high-permeability zones identified
- Re-shape for drainage
- Embankment underdrainage

**Southeast Design Sector**
- Foundation treatment of any high-permeability zones identified
- Re-shape for drainage
- Embankment underdrainage

**East Design Sector**
- Foundation treatment of any high-permeability zones identified
- Re-shape ridges to drain to the south
- Embankment underdrainage

# Alternative 2 Near West "wet" Seepage Control Level 2 to 4

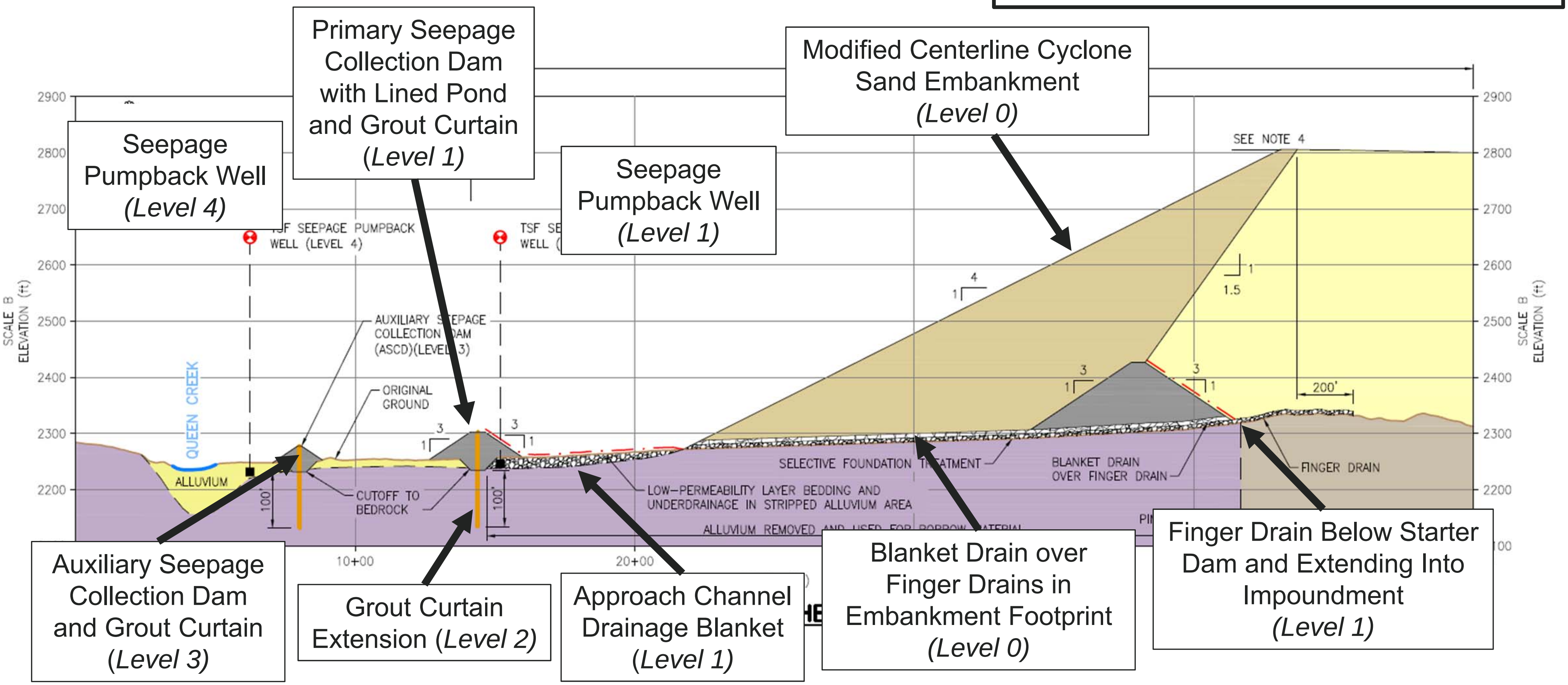



**Level 2 – Grout Curtain Extension**
- Focus foundation grouting to zone that have been identified as high-permeability

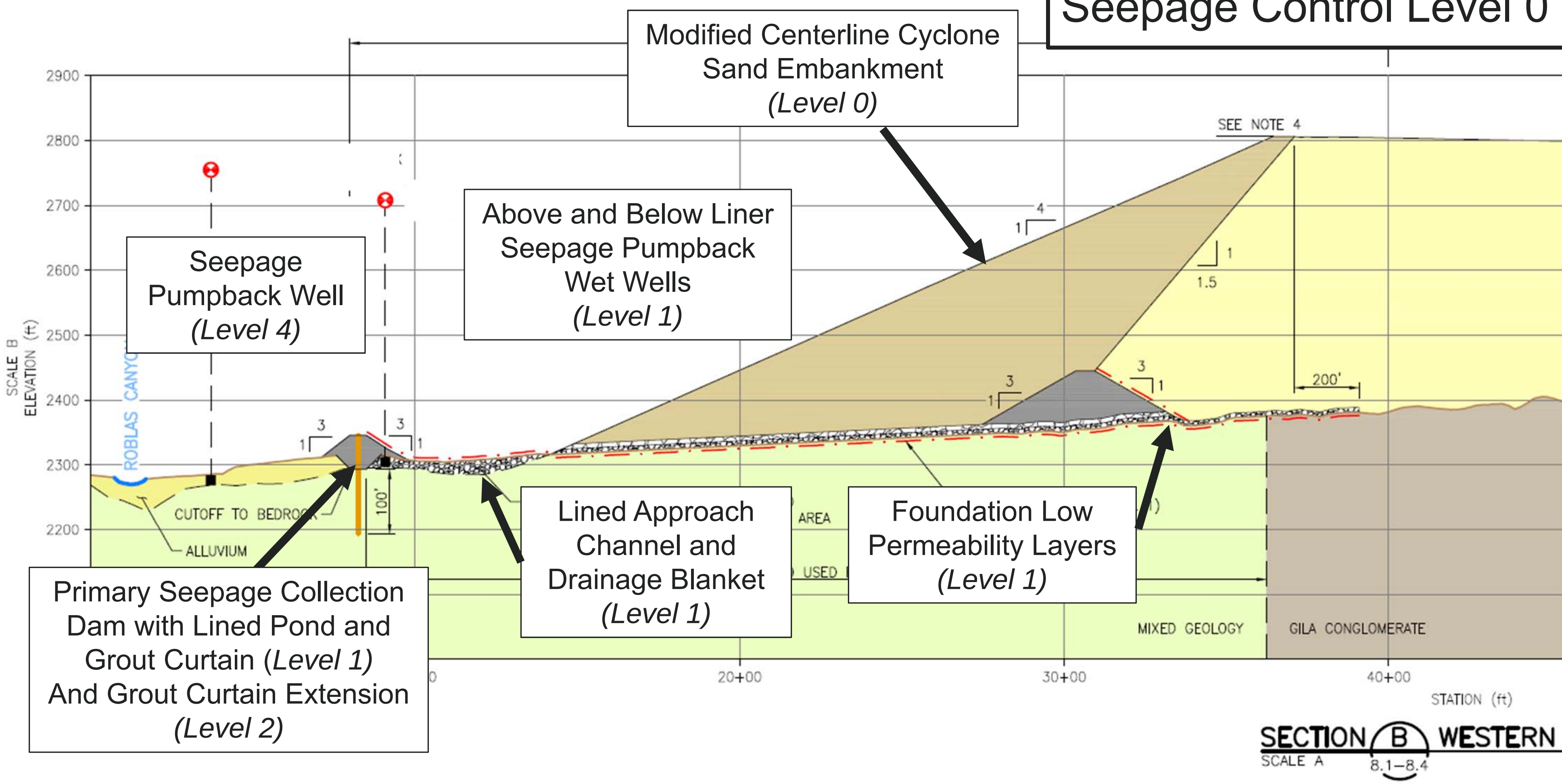
**Level 3 – Auxiliary Seepage Collection Ponds**
- Second downstream collection

**Level 4 – Downstream Pumping Wells**
- Additional pump back wells and grout curtains / cut off walls.

# Alternative 2 Near West “wet” Seepage Control Level 0 to 4



# Alternative 2 Near West "wet" Seepage Control Level 0 to 4



# *Alternative 3*
# *Near West ("dry")*

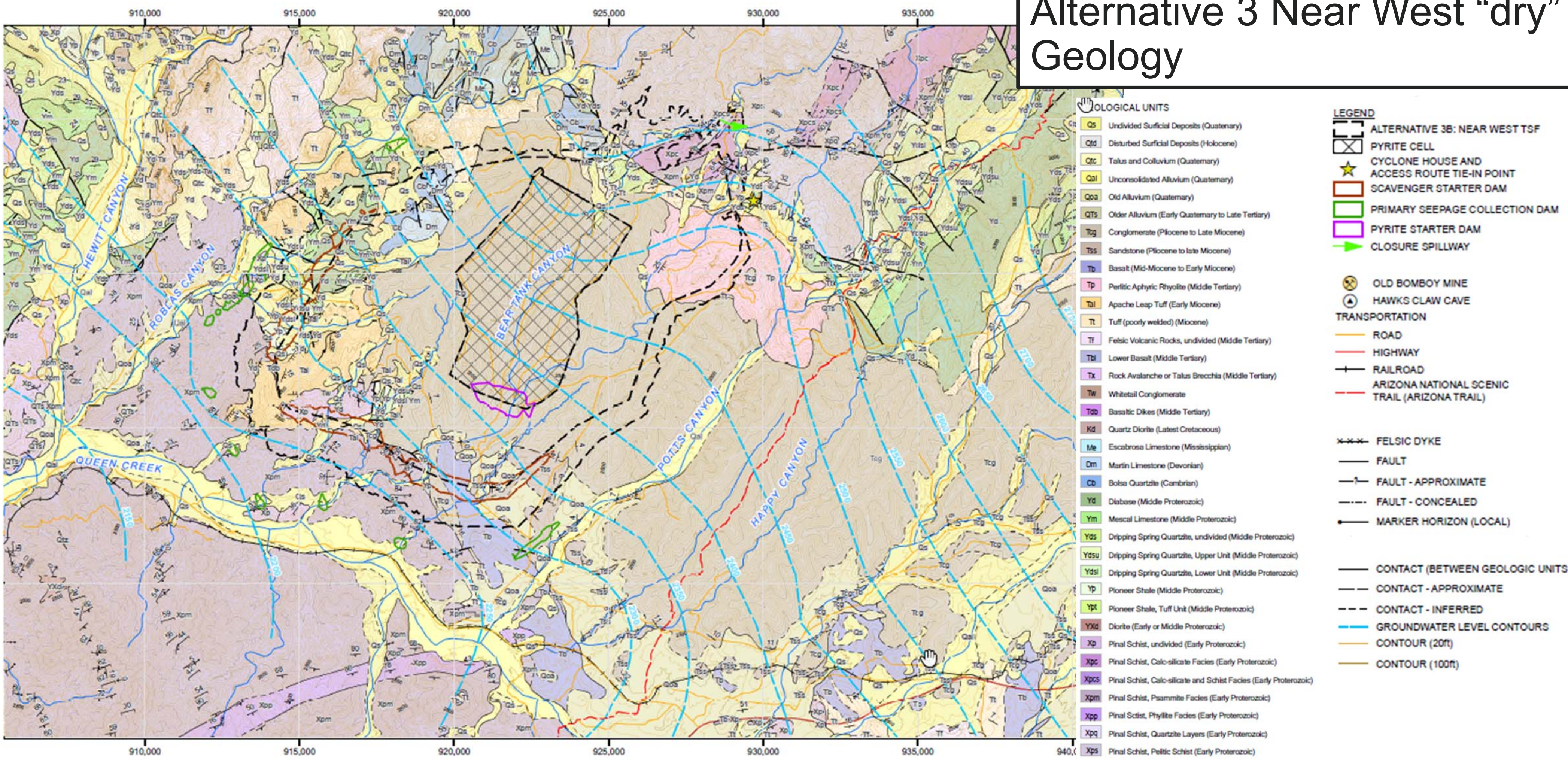
# *Seepage Control Levels*

RESOLUTION COPPER

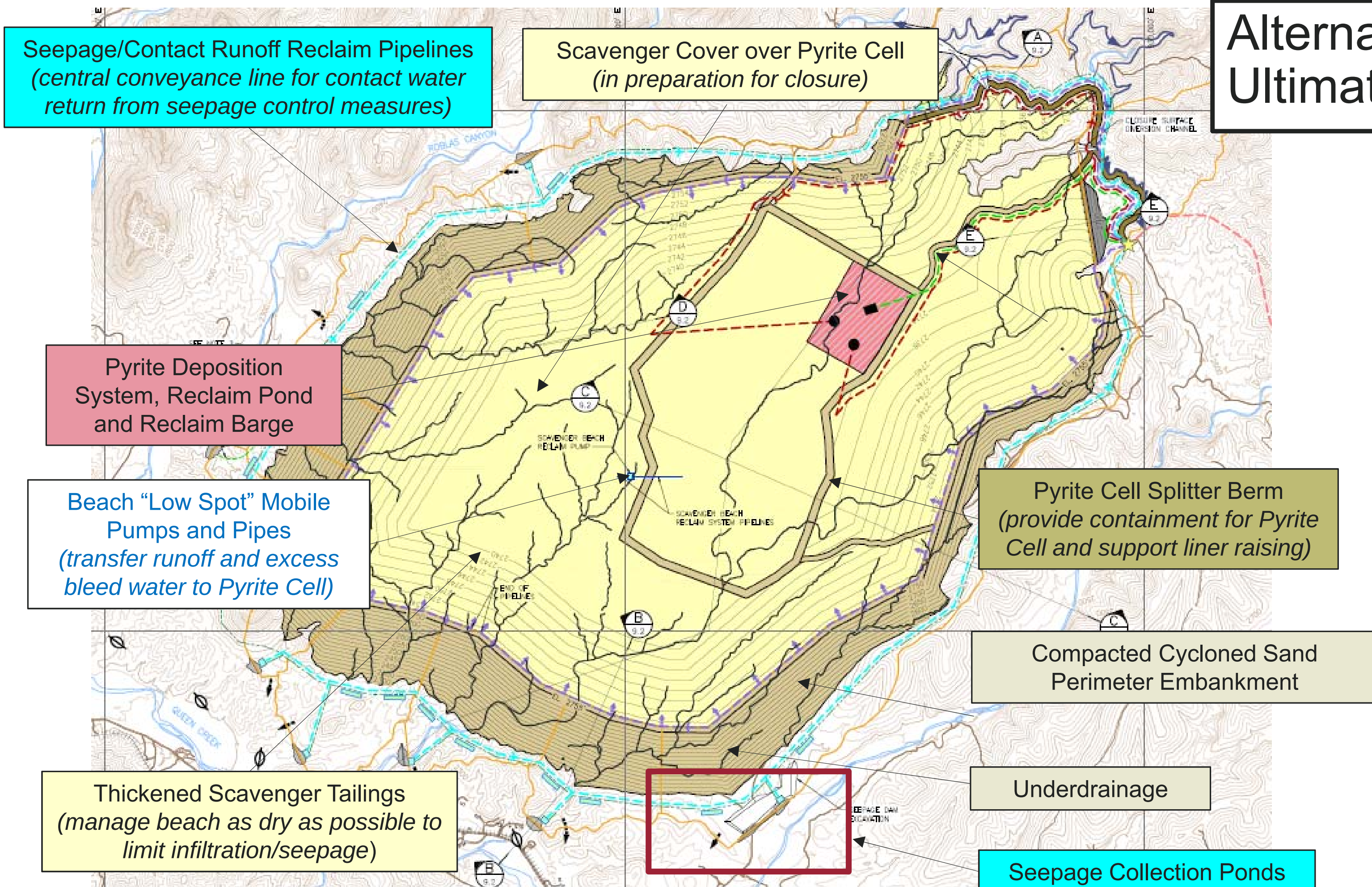
February 2019 EIS Tailings Alternatives – Seepage Control Levels

Klohn Crippen Berger

# Alternative 3 Near West "dry" Geology



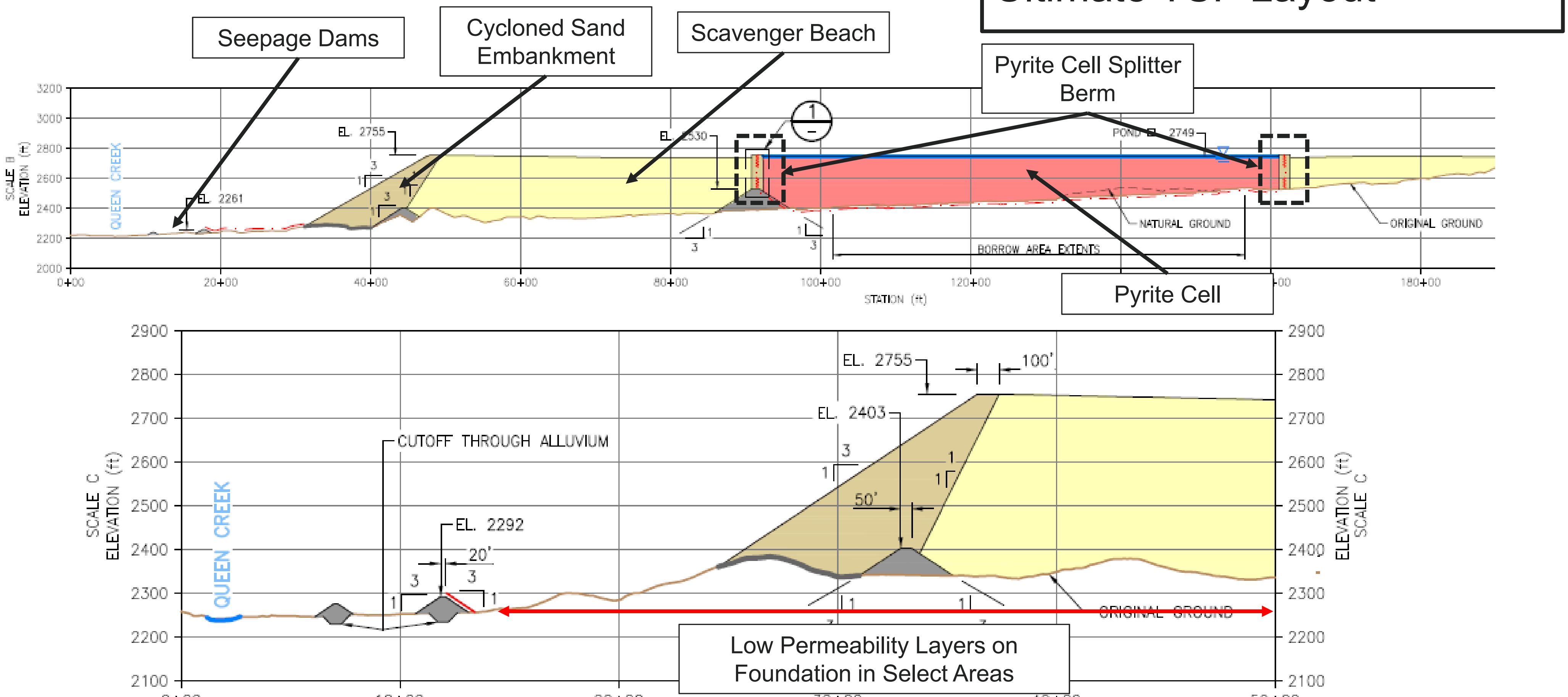
# Alternative 3 Near West "dry" Ultimate TSF Layout



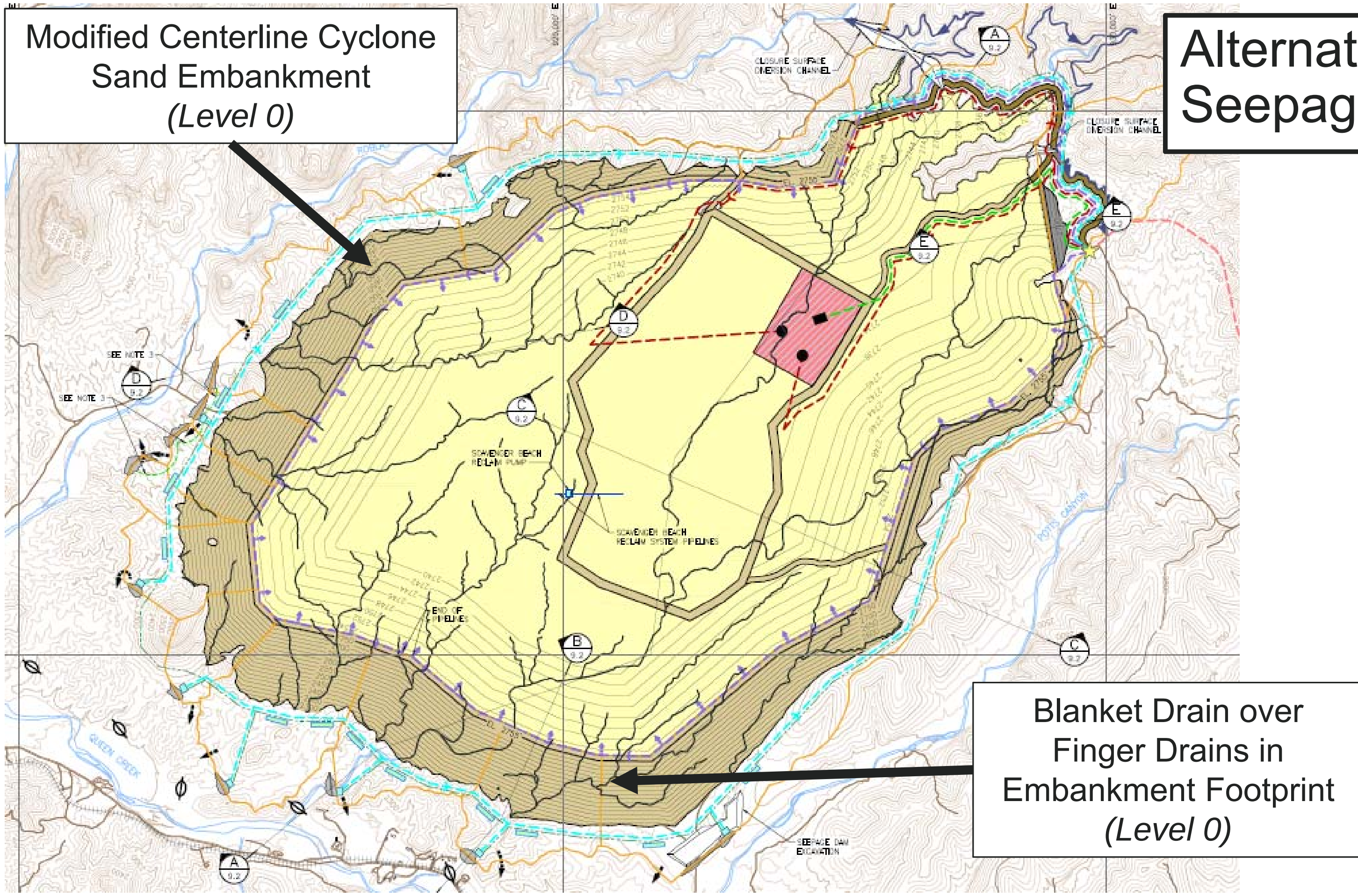

LEGEND

- DIVERSION CHANNEL
- RAILWAY
- EXISTING ROAD
- MAJOR NATURAL DRAINAGE
- PRIMARY SEEPAGE COLLECTION DAM (SCD)
- AUXILIARY SEEPAGE COLLECTION DAM (ASCD)
- SLIMES POND
- SCAVENGER TAILINGS DISCHARGE
- SPILLWAY
- CYCLONE HOUSE AND ACCESS ROUTE TIE–IN POINT
- RECLAIM BARGE / WATER PUMP
- PYRITE DEPOSITION SYSTEM
- WET WELL AND PUMP
- SCAVENGER PIPELINE
- PYRITE PIPELINE
- WATER PIPELINE
- SEEPAGE WATER RECLAIM PIPELINE
- ACCESS ROUTE TO WEST PLANT
- POWER AND FIBER LINES
- NORTH CONTAINMENT DAM
- SCAVENGER CYCLONED SAND EMBANKMENT, SPLITTER BERM, AND ACCESS ROAD
- SCAVENGER TAILINGS (CYCLONED OVERFLOW / TOTAL SCAVENGER MIXTURE)
- PYRITE TAILINGS
- TSF RECLAIM POND
- ACCESS ROAD OUTSIDE OF IMPOUNDMENT
- CATCHMENT BOUNDARY
- FINGER DRAIN

# Alternative 3 Near West “dry” Ultimate TSF Layout



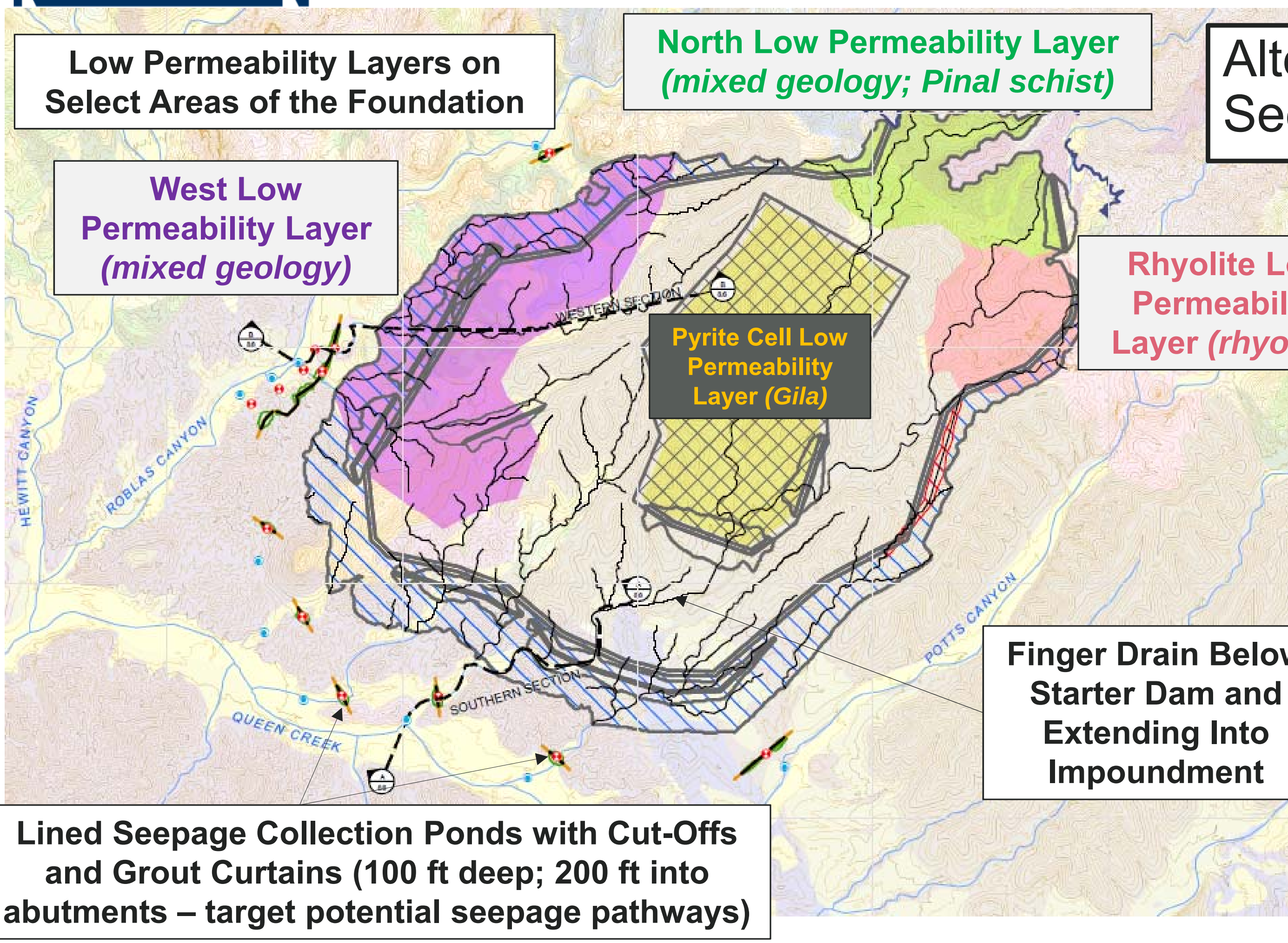
# Alternative 3 Near West "dry" Seepage Control Level 0




LEGEND

- DIVERSION CHANNEL
- RAILWAY
- EXISTING ROAD
- MAJOR NATURAL DRAINAGE
- PRIMARY SEEPAGE COLLECTION DAM (SCD)
- AUXILIARY SEEPAGE COLLECTION DAM (ASCD)
- SLIMES POND
- SCAVENGER TAILINGS DISCHARGE
- SPILLWAY
- CYCLONE HOUSE AND ACCESS ROUTE TIE-IN POINT
- RECLAIM BARGE / WATER PUMP
- PYRITE DEPOSITION SYSTEM
- WET WELL AND PUMP
- SCAVENGER PIPELINE
- PYRITE PIPELINE
- WATER PIPELINE
- SEEPAGE WATER RECLAIM PIPELINE
- ACCESS ROUTE TO WEST PLANT
- POWER AND FIBER LINES
- NORTH CONTAINMENT DAM
- SCAVENGER CYCLONED SAND EMBANKMENT, SPLITTER BERM, AND ACCESS ROAD
- SCAVENGER TAILINGS (CYCLONED OVERFLOW / TOTAL SCAVENGER MIXTURE)
- PYRITE TAILINGS
- TSF RECLAIM POND
- ACCESS ROAD OUTSIDE OF IMPOUNDMENT
- CATCHMENT BOUNDARY
- FINGER DRAIN

# Alternative 3 Near West "dry" Seepage Control Level 1




**LEGEND**

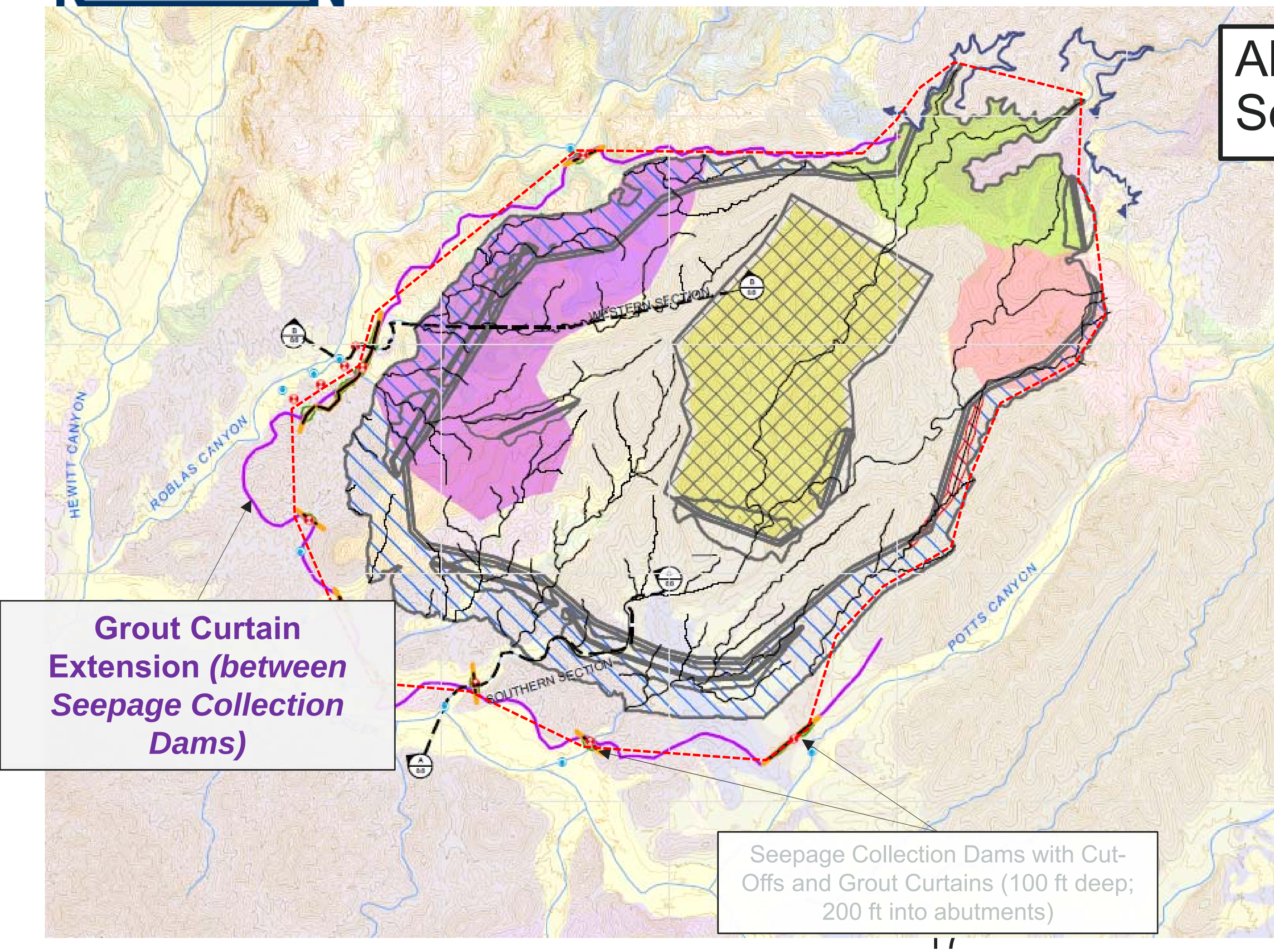
- NEAR WEST TSF (INCLUDING STARTER DAMS, INTERIM CONTAINMENT DYKE AND NORTH CONTAINMENT DAM
- PYRITE CELL
- CONCEPTUAL SECTION LOCATIONS
- UPSTREAM DIVERSION
- POINT OF COMPLIANCE (POC) TO BE LOCATED A MAXIMUM OF 750 ft DOWNSTREAM OF POLLUTION MANAGEMENT AREA (PMA)
- MAJOR NATURAL DRAINAGE
- CONTOUR (20ft)
- CONTOUR (100ft)

**SEEPAGE MANAGEMENT**

*LEVEL 1*

- TSF SEEPAGE PUMPBACK WELL
- FINGER DRAIN
- GROUT CURTAIN
- CUT-OFF WALL
- PRIMARY SEEPAGE COLLECTION DAM
- BLANKET DRAIN
- EXCAVATION (TO FILL) AND REGRADING (SEE NOTE 3)
- NORTH LINED AREA
- RHYOLITE QUARRY AREA AND LINED AREA
- WEST LINED AREA
- PYRITE CELL LINED AREA

# Alternative 3 Near West "dry" Seepage Control Level 2




LEGEND

- NEAR WEST TSF (INCLUDING STARTER DAMS, INTERIM CONTAINMENT DYKE AND NORTH CONTAINMENT DAM
- PYRITE CELL
- CONCEPTUAL SECTION LOCATIONS
- UPSTREAM DIVERSION
- POINT OF COMPLIANCE (POC) TO BE LOCATED A MAXIMUM OF 750 ft DOWNSTREAM OF POLLUTION MANAGEMENT AREA (PMA)
- MAJOR NATURAL DRAINAGE
- CONTOUR (20ft)
- CONTOUR (100ft)

SEEPAGE MANAGEMENT

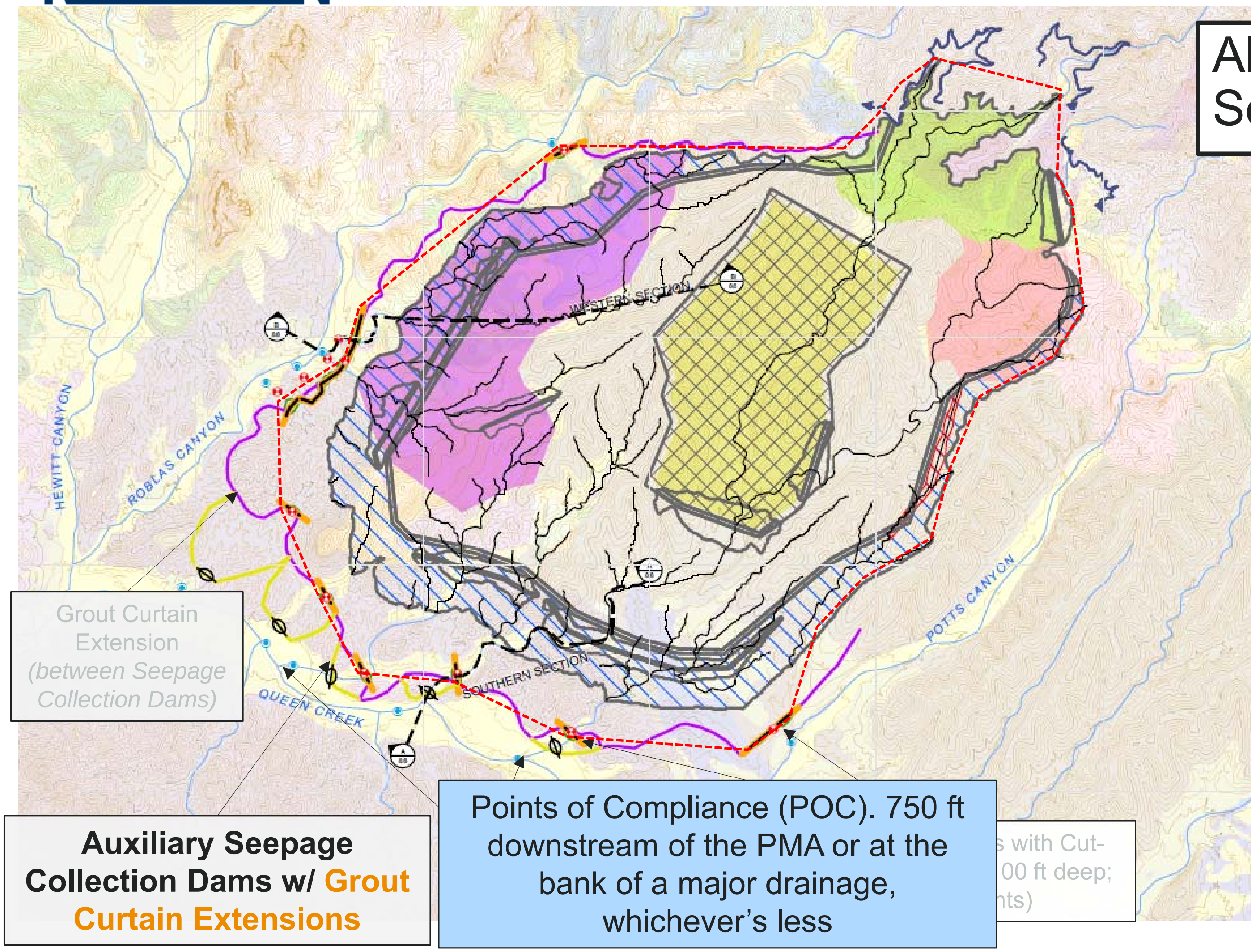
*LEVEL 1*

- TSF SEEPAGE PUMPBACK WELL
- FINGER DRAIN
- GROUT CURTAIN
- CUT-OFF WALL
- PRIMARY SEEPAGE COLLECTION DAM
- BLANKET DRAIN
- EXCAVATION (TO FILL) AND REGRADING (SEE NOTE 3)
- NORTH LINED AREA
- RHYOLITE QUARRY AREA LINED AREA
- WEST LINED AREA
- PYRITE CELL LINED AREA

*LEVEL 2*

- GROUT CURTAIN EXTENSION

# Alternative 3 Near West “dry” Seepage Control Level 3




LEGEND

- NEAR WEST TSF (INCLUDING STARTER DAMS, INTERIM CONTAINMENT DYKE AND NORTH CONTAINMENT DAM
- PYRITE CELL
- CONCEPTUAL SECTION LOCATIONS
- UPSTREAM DIVERSION
- POINT OF COMPLIANCE (POC) TO BE LOCATED A MAXIMUM OF 750 ft DOWNSTREAM OF POLLUTION MANAGEMENT AREA (PMA)
- MAJOR NATURAL DRAINAGE
- CONTOUR (20ft)
- CONTOUR (100ft)

SEEPAGE MANAGEMENT

*LEVEL 1*

- TSF SEEPAGE PUMPBACK WELL
- FINGER DRAIN
- GROUT CURTAIN
- CUT-OFF WALL
- PRIMARY SEEPAGE COLLECTION DAM
- BLANKET DRAIN
- EXCAVATION (TO FILL) AND REGRADING (SEE NOTE 3)
- NORTH LINED AREA
- RHYOLITE QUARRY AREA AND LINED AREA
- WEST LINED AREA
- PYRITE CELL LINED AREA

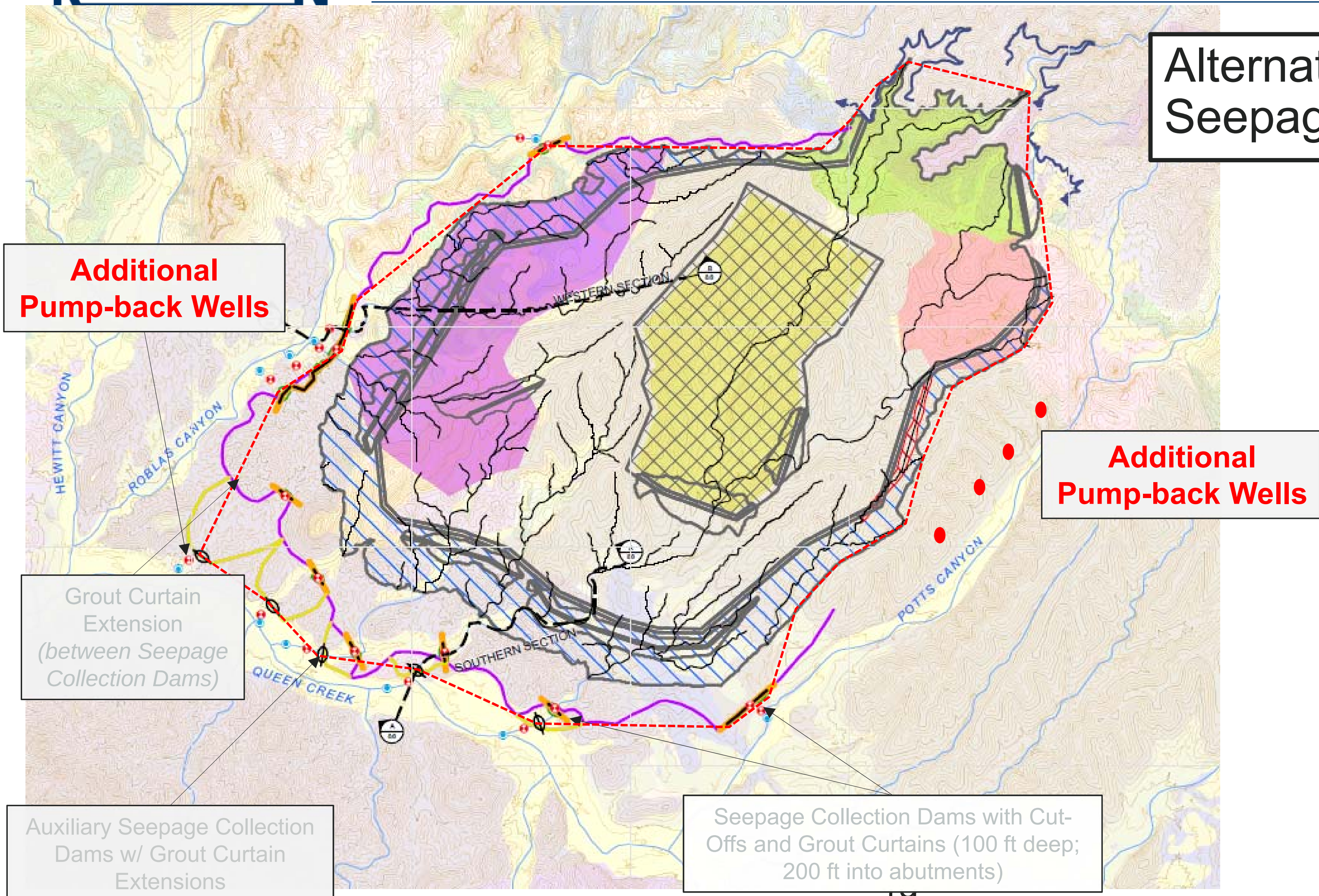
*LEVEL 2*

- GROUT CURTAIN EXTENSION

*LEVEL 3*

- AUXILIARY SEEPAGE COLLECTION DAM
- GROUT CURTAIN EXTENSION

# Alternative 3 Near West "dry" Seepage Control Level 4




LEGEND

- NEAR WEST TSF (INCLUDING STARTER DAMS, INTERIM CONTAINMENT DYKE AND NORTH CONTAINMENT DAM
- PYRITE CELL
- CONCEPTUAL SECTION LOCATIONS
- UPSTREAM DIVERSION
- POINT OF COMPLIANCE (POC) TO BE LOCATED A MAXIMUM OF 750 ft DOWNSTREAM OF POLLUTION MANAGEMENT AREA (PMA)
- MAJOR NATURAL DRAINAGE
- CONTOUR (20ft)
- CONTOUR (100ft)

SEEPAGE MANAGEMENT

*LEVEL 1*

- TSF SEEPAGE PUMPBACK WELL
- FINGER DRAIN
- GROUT CURTAIN
- CUT-OFF WALL
- PRIMARY SEEPAGE COLLECTION DAM
- BLANKET DRAIN
- EXCAVATION (TO FILL) AND REGRADING (SEE NOTE 3)
- NORTH LINED AREA
- RHYOLITE QUARRY AREA AND LINED AREA
- WEST LINED AREA
- PYRITE CELL LINED AREA

*LEVEL 2*

- GROUT CURTAIN EXTENSION

*LEVEL 3*

- AUXILIARY SEEPAGE COLLECTION DAM
- GROUT CURTAIN EXTENSION

*LEVEL 4*

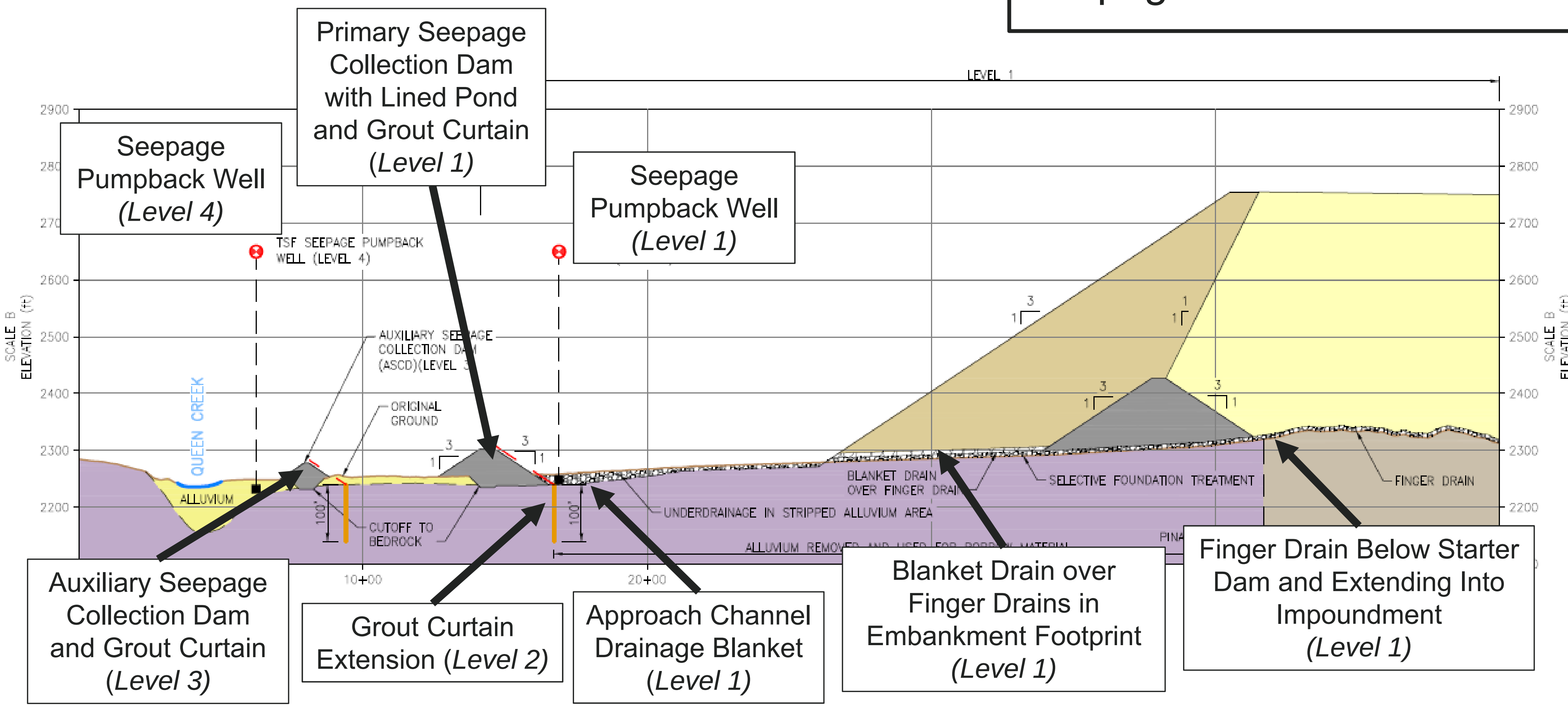
- TSF SEEPAGE PUMPBACK WELL (SEE NOTE 4)

RESOLUTION COPPER

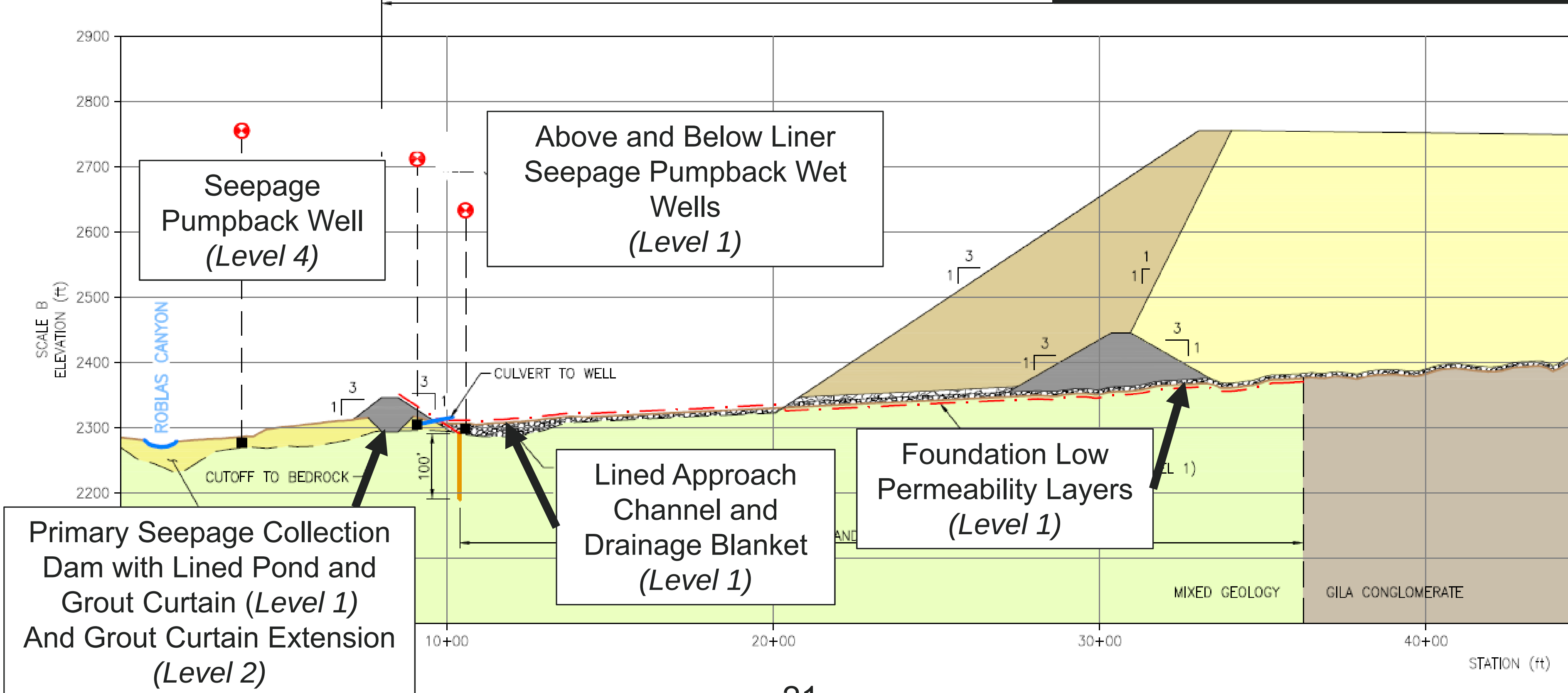


Klohn Crippen Berger

# Alternative 3 Near West "dry" Seepage Control Sections



# Alternative 3 Near West “dry” Seepage Control Sections

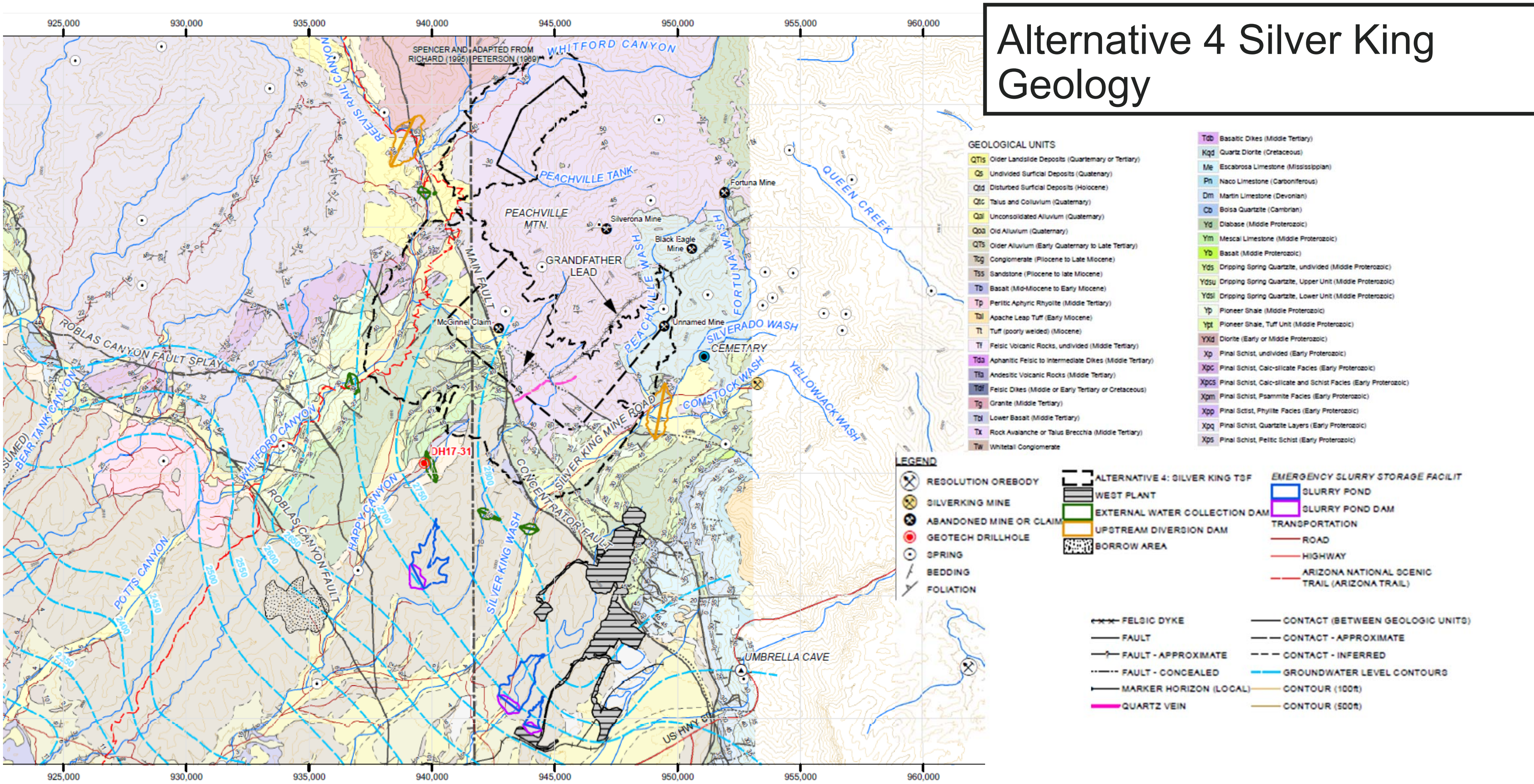


# *Alternative 4*

# *Silver King*

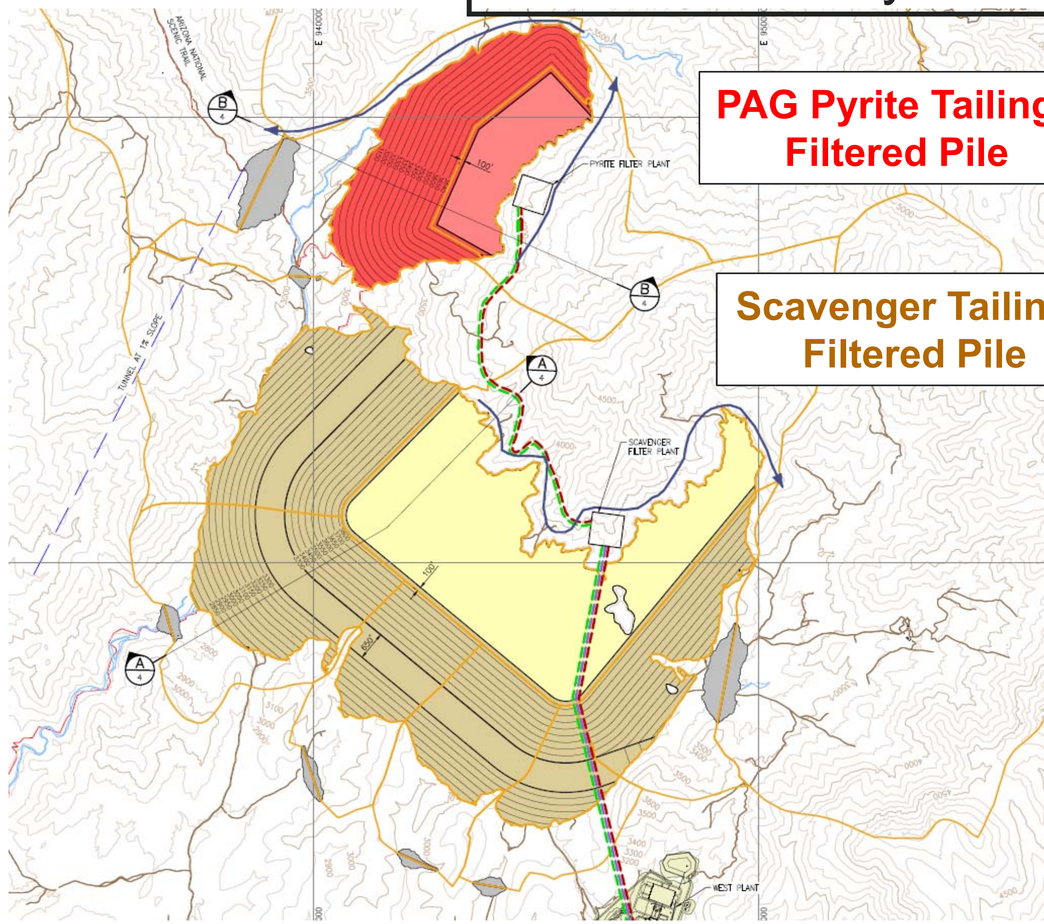
# *Seepage Control Levels*

# Alternative 4 Silver King Geology



# Alternative 4 Silver King Ultimate TSF Layout

1. Pump tailings from West Plant to filter plants
2. Filter tailings
3. Convey tailings from filter plants to separate facilities
4. Place and compact tailings in structural and non-structural zones
5. Divert upstream non-contact water as much as possible
6. Collect and manage contact water separately
7. Slopes would be progressively reclaimed
8. Top surface would be susceptible to dusting, would require dust suppressants



# Alternative 4 Silver King Ultimate TSF Layout

Convey tailings from filter plants to separate facilities

Top surface would be susceptible to dusting, would require dust suppressants

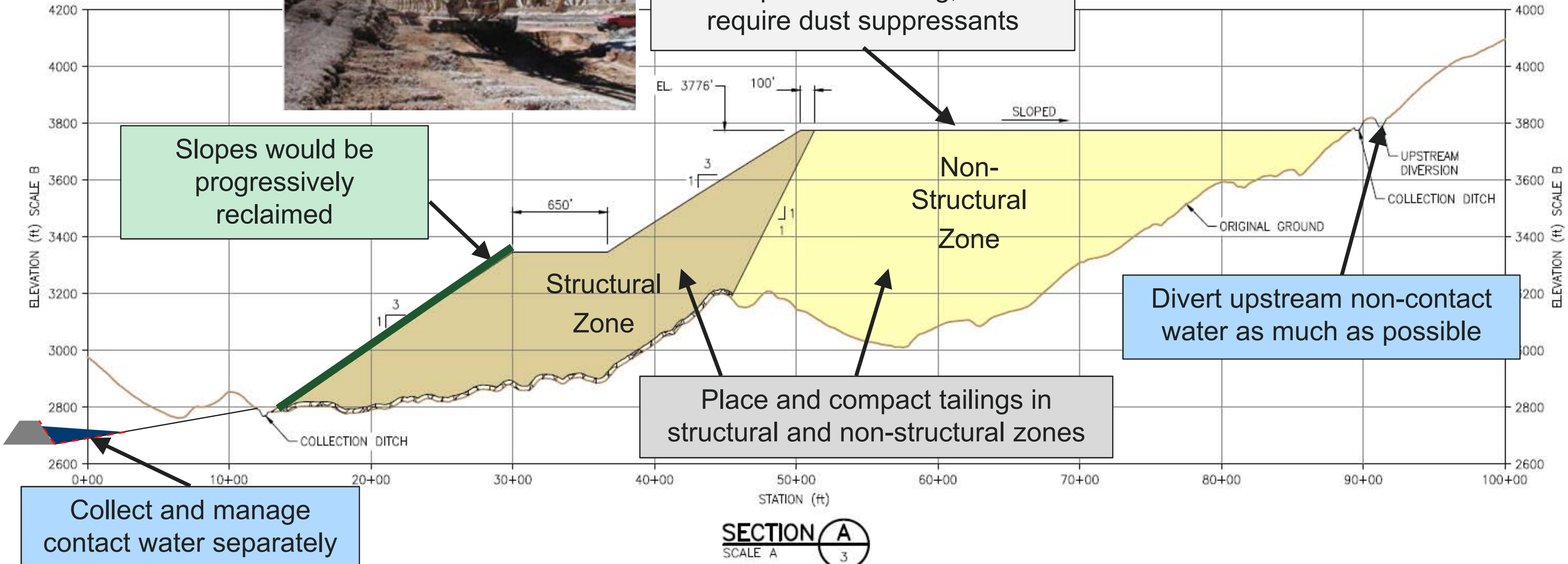
Slopes would be progressively reclaimed

Divert upstream non-contact water as much as possible

Place and compact tailings in structural and non-structural zones

Collect and manage contact water separately

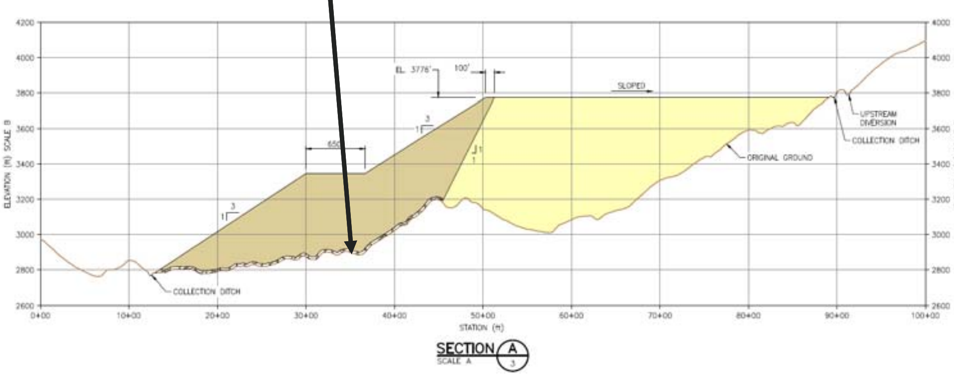
**Predominantly meant for surface water.**

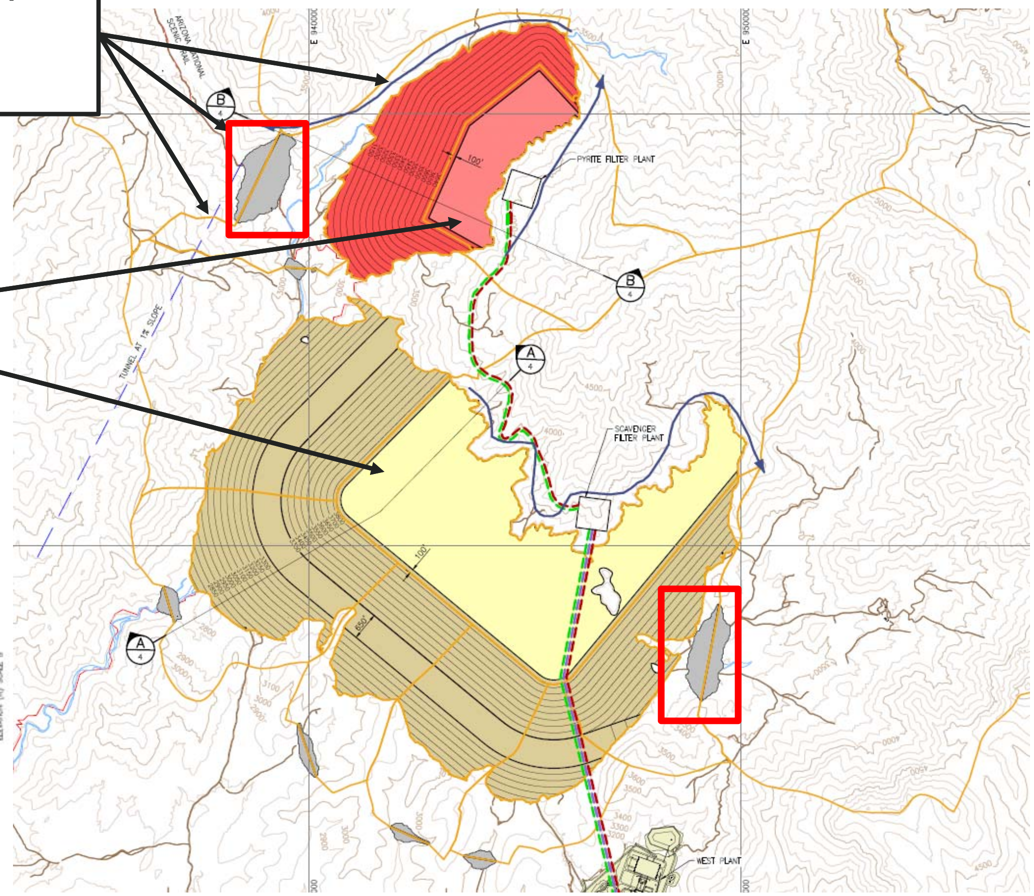


# Alternative 4 Silver King Seepage Control Level 0

Surface Water Diversion Structures include:
- Large diversion structures (dams and tunnels/pipelines)

Features required for stability that also act as seepage control features:
- Dewatered (filter) tailings
- Underdrainage system beneath the compacted structural zones of the embankment

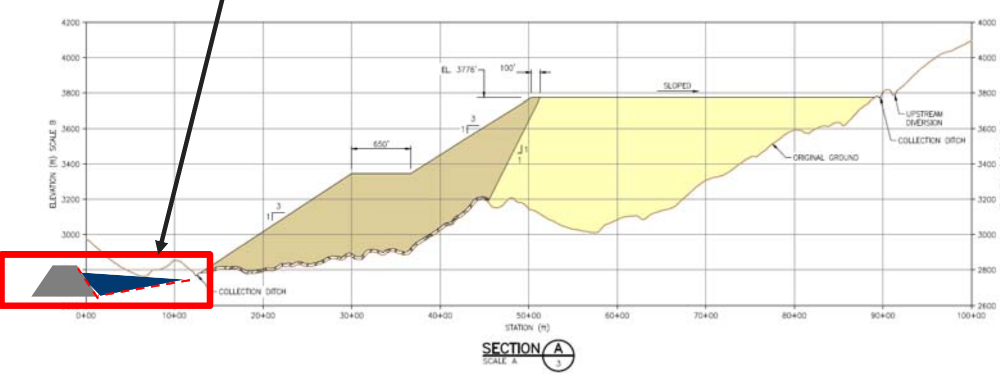


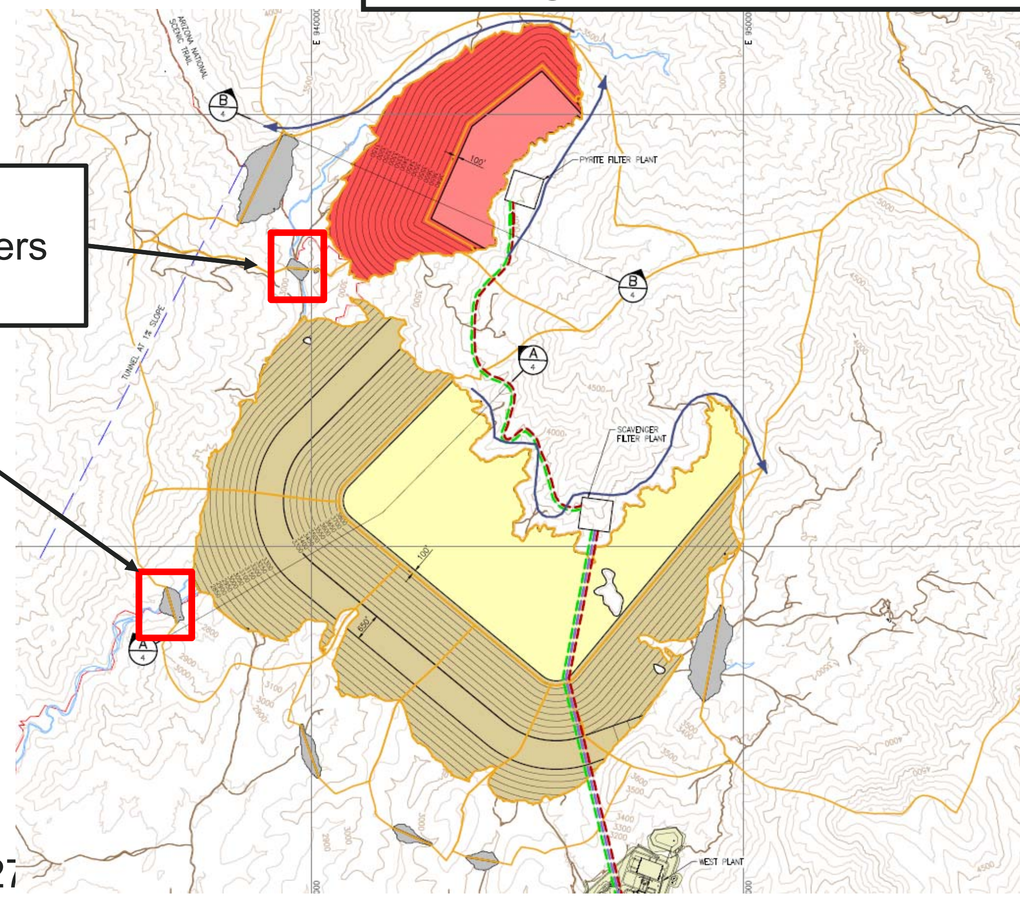



# Alternative 4 Silver King Seepage Control Level 1

In addition to Level 0:

- Collection ditches and collection ponds that cut off seepage through the use of engineered hydraulic barriers
- No ponded water on pile surface

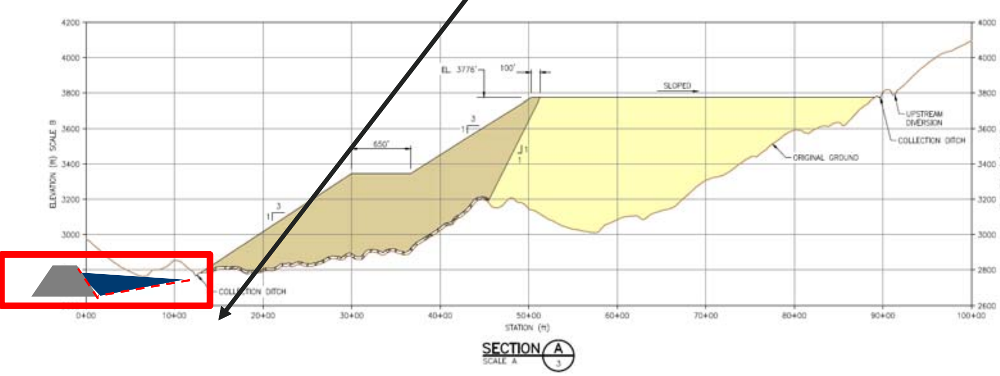


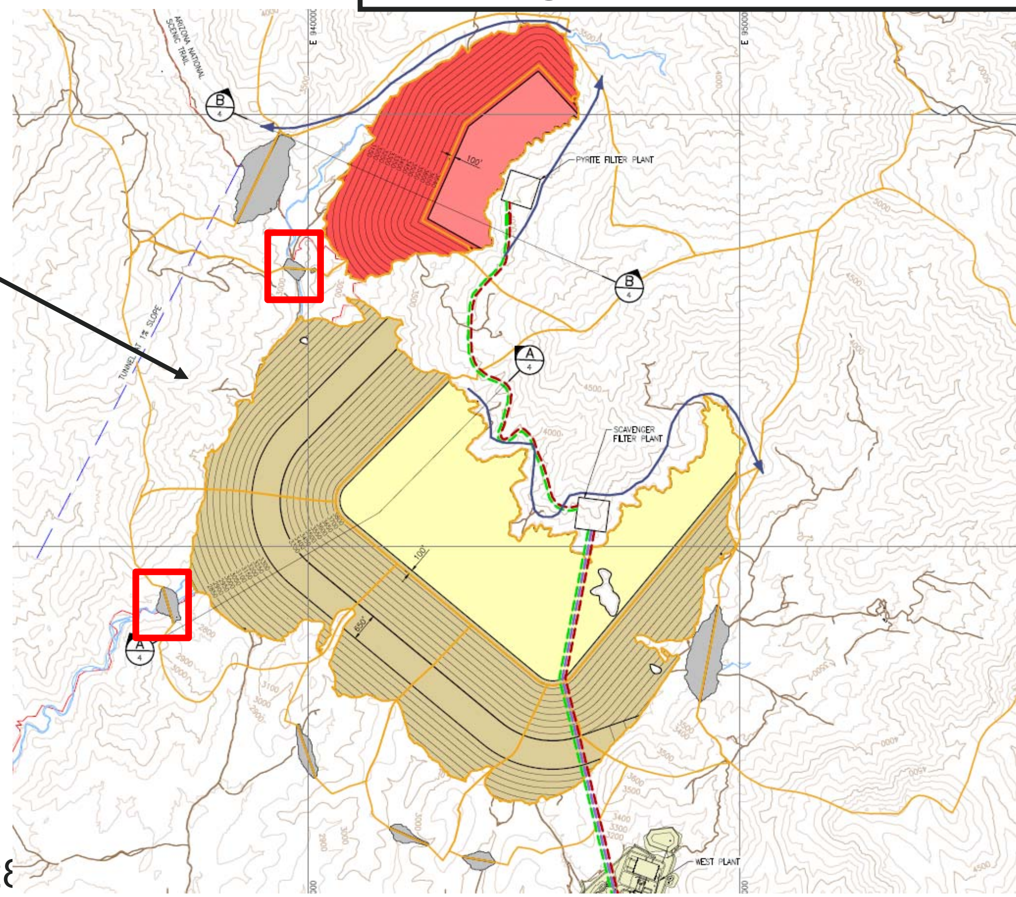



# Alternative 4 Silver King Seepage Control Level 2

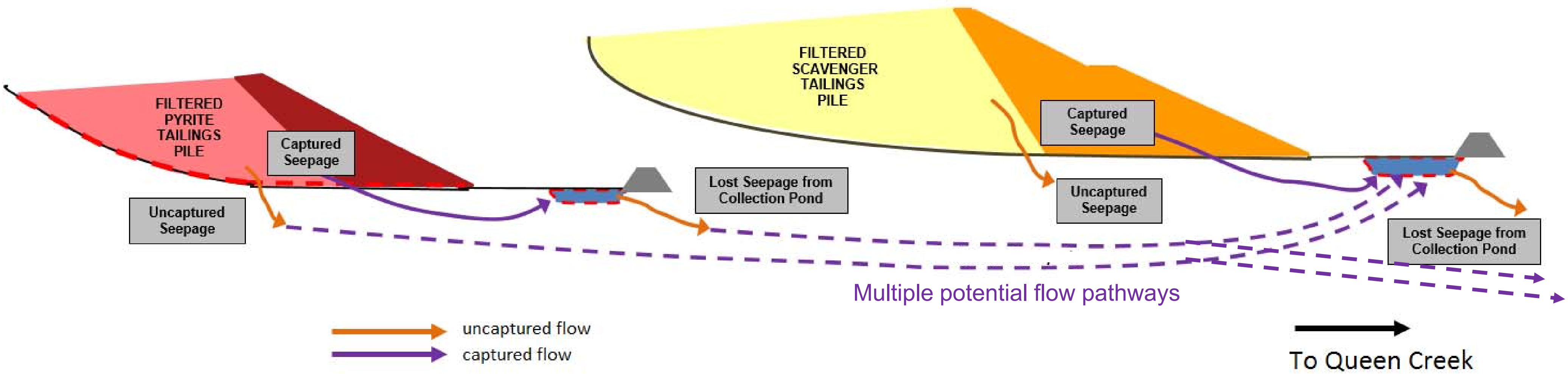
In addition to Level 0 and 1:

- Additional seepage control measures to include targeted grouting of fractures (potential seepage pathways) and pump back wells.



# Alternative 4 Silver King Seepage Control

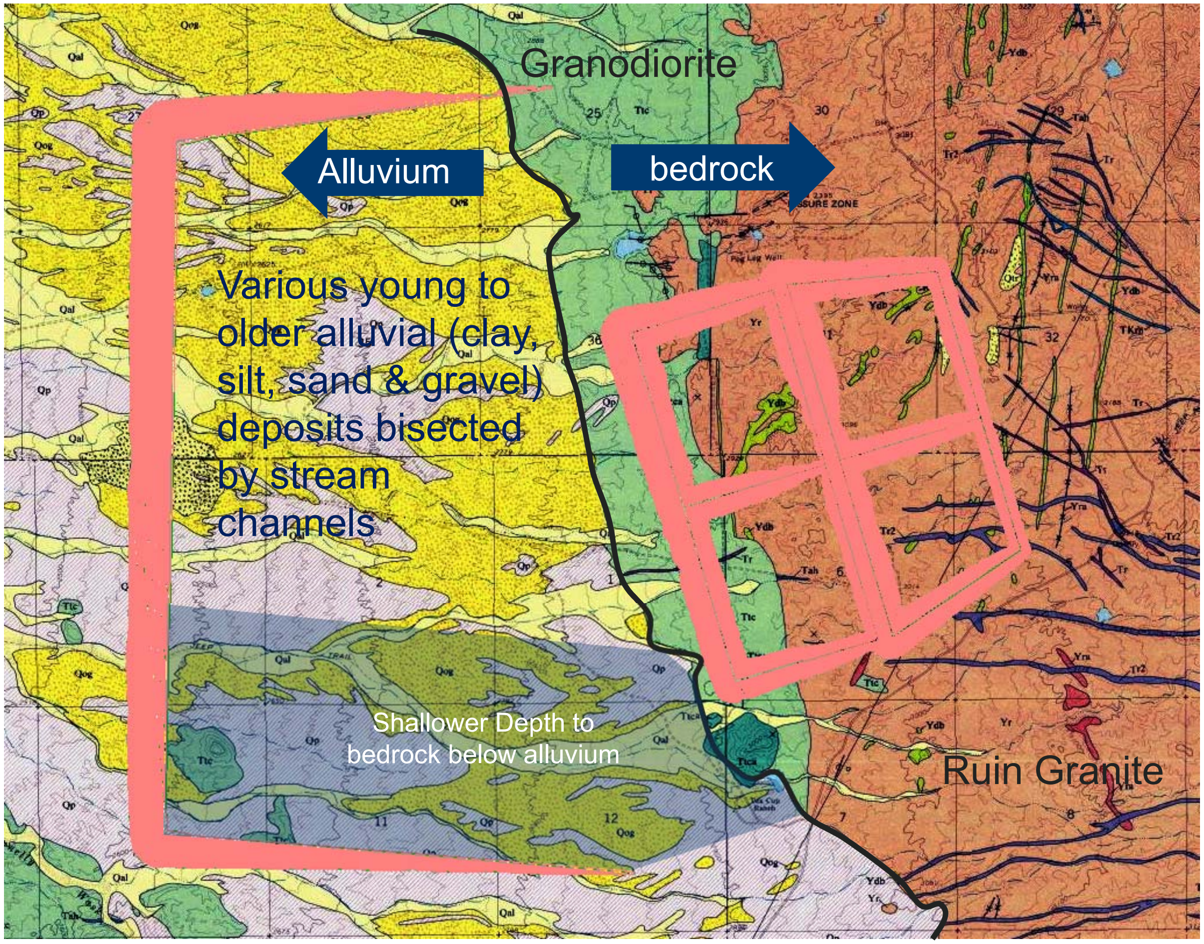


# *Alternative 5*

# *Peg Leg*

# *Seepage Control Levels*

# Alt 5 Peg Leg Geology



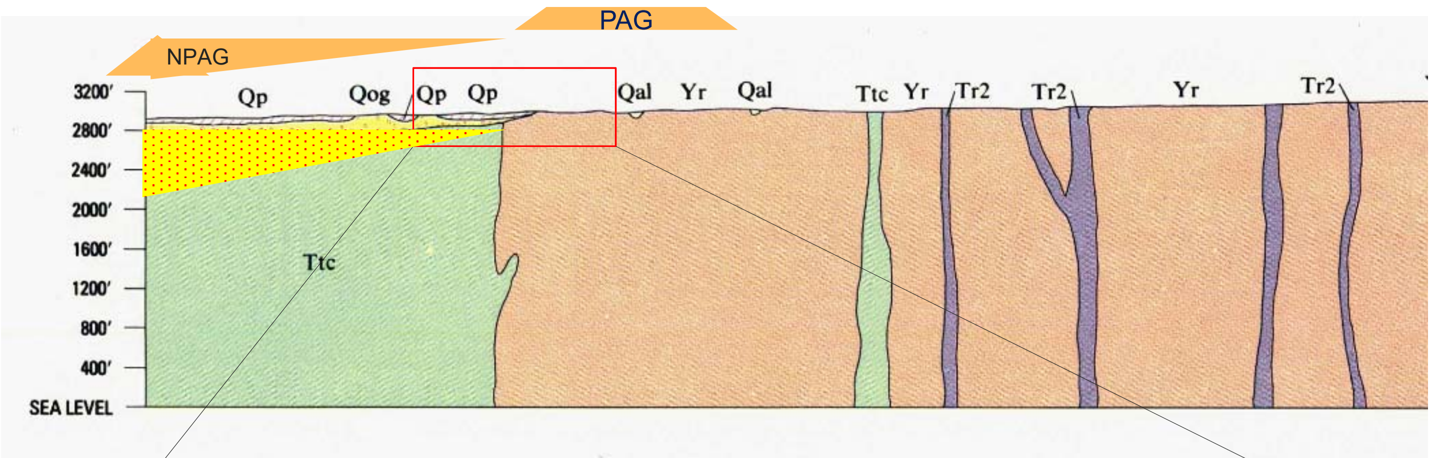

Relatively simple geology consisting of granodiorite bedrock to east and basin fill (alluvium to west)

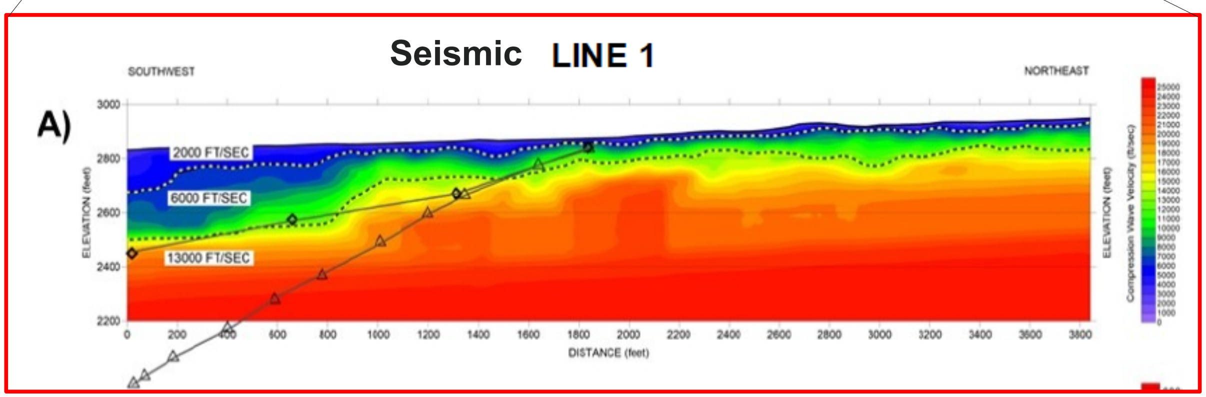
**GEOLOGIC LEGEND WITHIN ULTIMATE FOOTPRINT**

| | |
|---|---|
| Qal | Qal - ALLUVIUM |
| Qtr | Qtr - TRAVERTINE |
| Qp | Qp - PEDIMENT VENEER |
| Qog | Qog - OLDER GRAVEL |
| Tah | Tah - ANDESITE |
| Tr2 | Tr2 - RHYODACITE PORPHYRY |
| Tr | Tr - RHYODACITE PORPHYRY |
| Ttca | Ttca - ALPITE, TEA CUP GRANODIORITE |
| Ttc | Ttc - TEA CUP GRANODIORITE |
| Ydb | Ydb - DIABASE |
| Yr | Yr - RUIN GRANITE |

# Alt 5 Peg Leg Geologic Cross sections

Increasing alluvium depth westward below NPAG facility



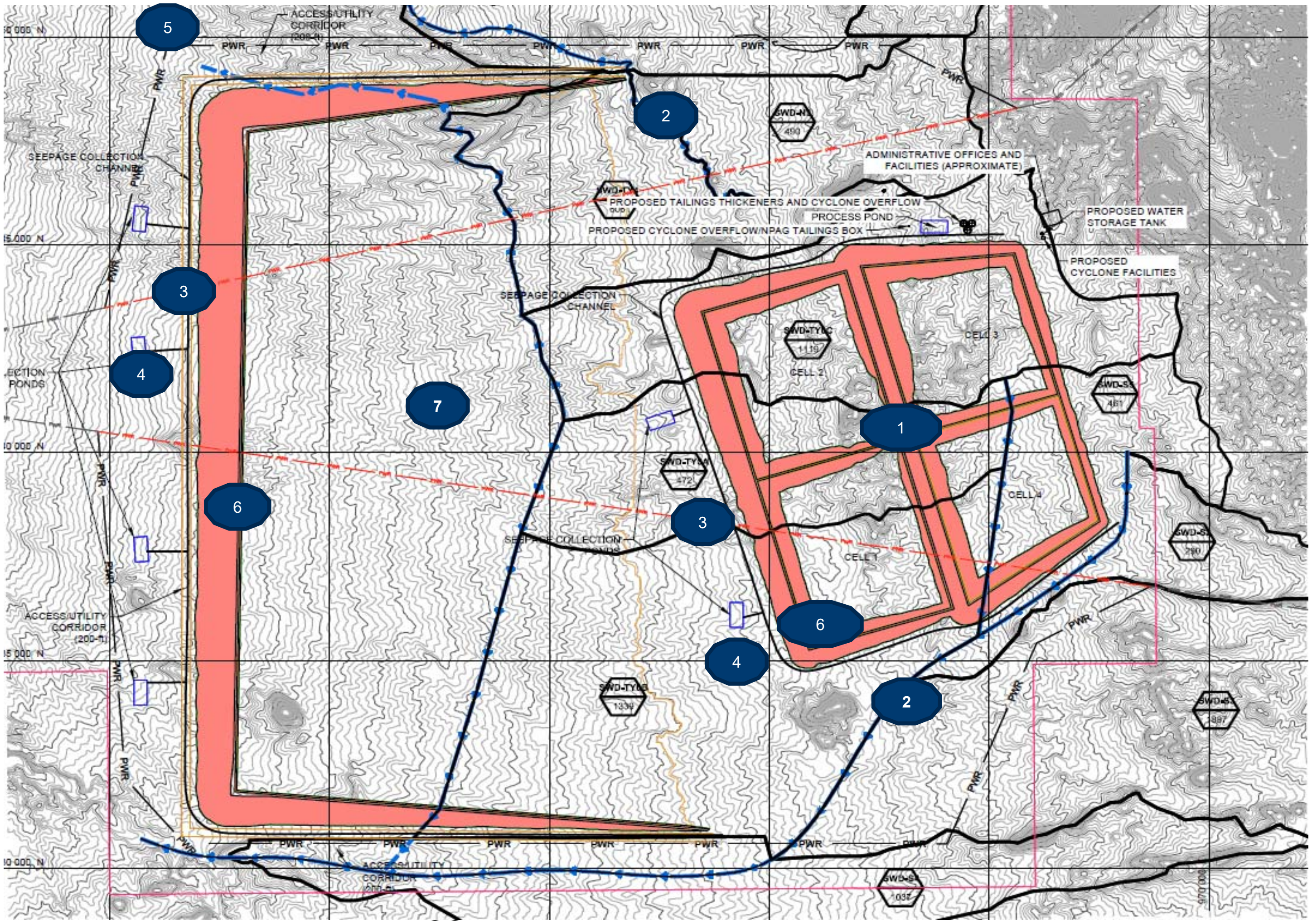

**GEOLOGIC LEGEND WITHIN ULTIMATE FOOTPRINT**

- Qal - ALLUVIUM
- Qtr - TRAVERTINE
- Qp - PEDIMENT VENEER
- Qog - OLDER GRAVEL
- Tah - ANDESITE
- Tr2 - RHYODACITE PORPHYRY
- Tr - RHYODACITE PORPHYRY
- Ttca - ALPITE, TEA CUP GRANODIORITE
- Ttc - TEA CUP GRANODIORITE
- Ydb - DIABASE
- Yr - RUIN GRANITE

# Peg Leg Alternative 5 – Level 0 Seepage Controls

**Level 0 – Seepage Controls for geotechnical stability**

1. Location of PAG cells on bedrock
2. Surface Water diversion
3. Toe collection ditch
4. Toe collection ponds
5. Pump back to reclaim tank
6. Embankment underdrain
7. Large NPAG surface area for low rate of rise



RESOLUTION COPPER

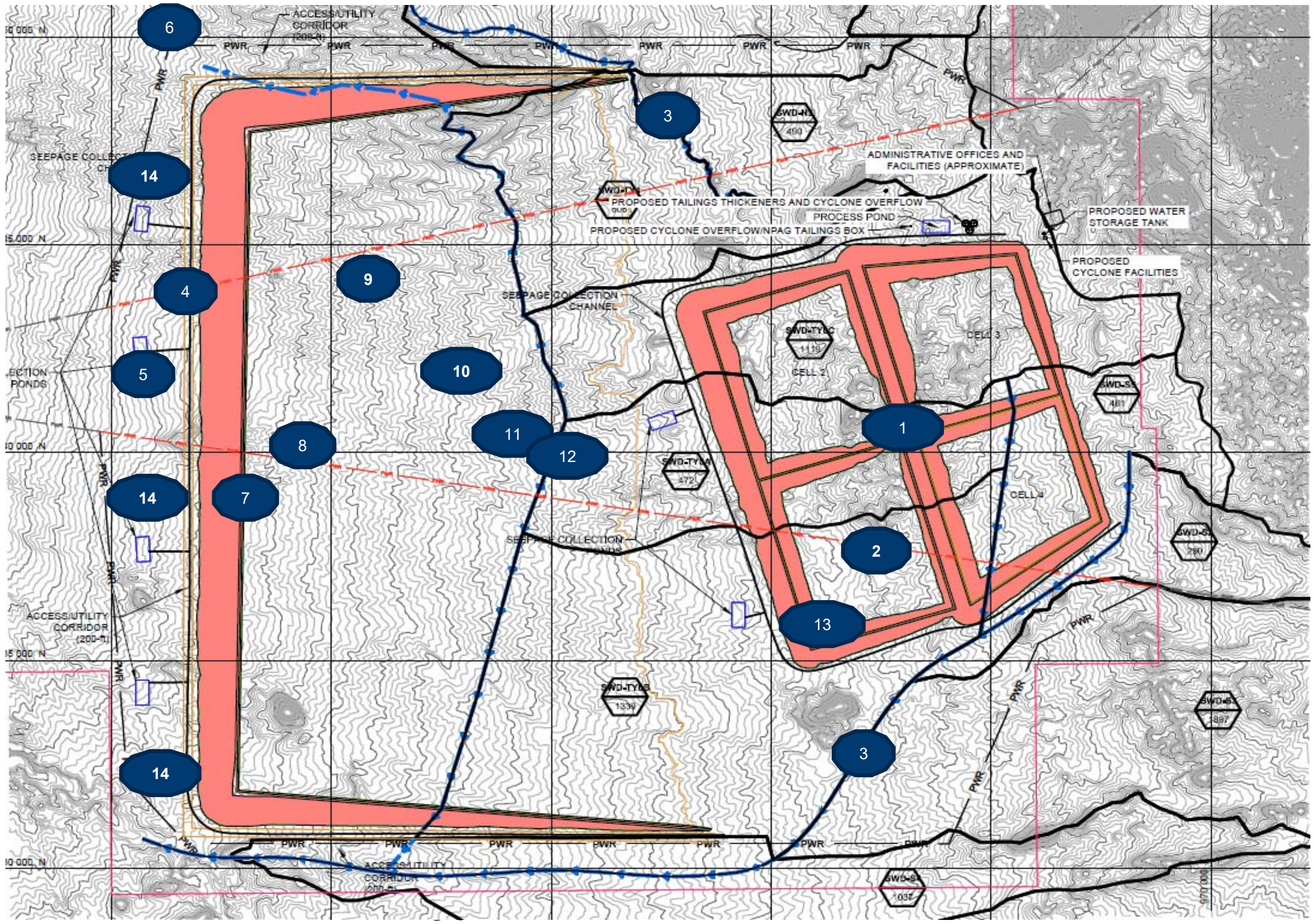
# Peg Leg Alternative 5 – Level 1 Thickened Overflow Deposition

GOLDER

**Level 1 - Demonstrated Control Technology (DCT) – Seepage Controls**

1. Location of PAG cells on bedrock
2. **Small PAG cell footprint**
3. Surface Water diversion
4. Toe collection ditch
5. Toe collection ponds
6. Pump back to reclaim tank
7. Embankment **underdrain**
8. Impoundment underdrain
9. **Thickened overflow tailings deposition**
10. **Large NPAG surface area** for low rate of rise
11. Select geomembrande lining of reclaim pond
12. Small reclaim pond
13. Low permeability embankment zone
14. **Pump back wells**

**Bold indicates primary DCT seepage measures**

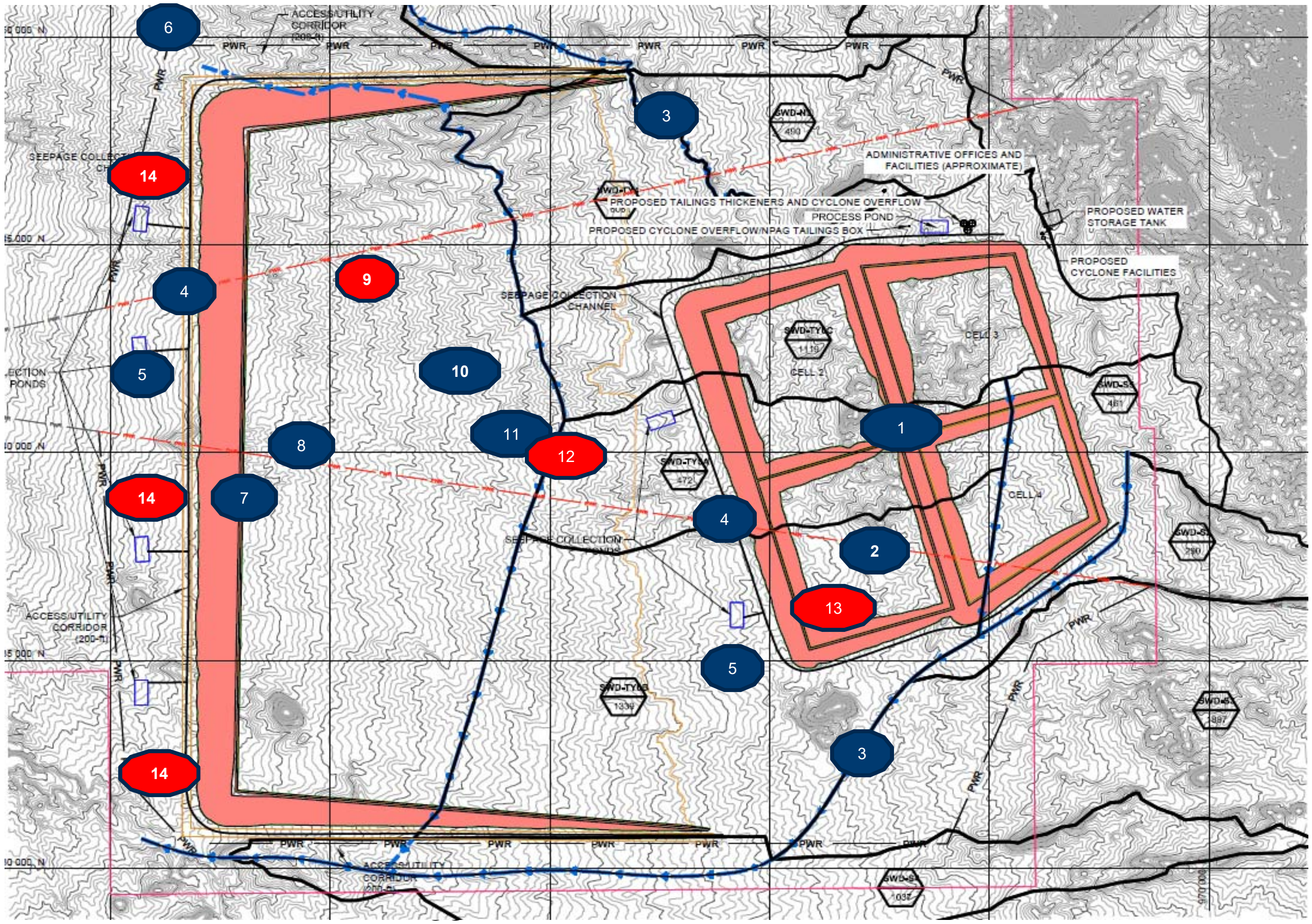


# Peg Leg Alternative 5a – Level 2 - Thin Lift Deposition

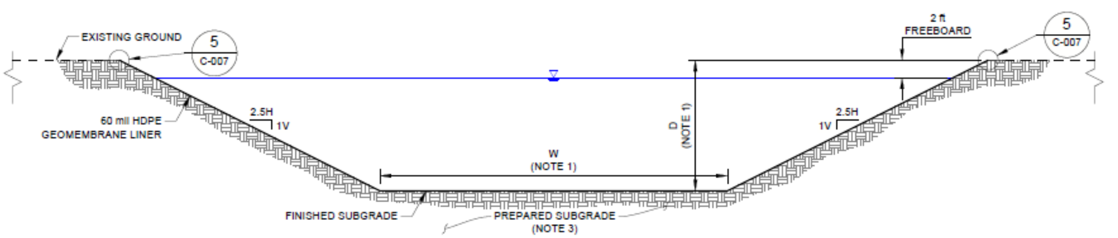
**Level 2 - Demonstrated Control Technology (DCT) – Enhanced Seepage Controls with thin lift deposition**

1. Location of PAG cells on bedrock
2. Small PAG cell footprint
3. Surface Water diversion
4. Toe collection ditch
5. Toe collection ponds
6. Pump back to reclaim tank
7. Embankment underdrain
8. Impoundment underdrain
9. Thickened overflow, **thin lift** tailings deposition
10. Large surface area for low rate of rise / desiccation
11. Lining of reclaim pond
12. **Small to no reclaim pond**
13. **Geomembrane lining of PAG cells**
14. **Fewer** Pump back wells

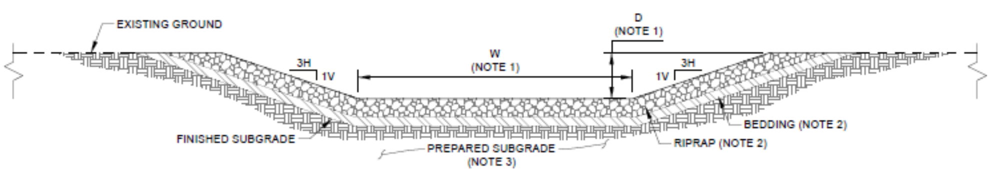
Red font indicates Level 2 controls



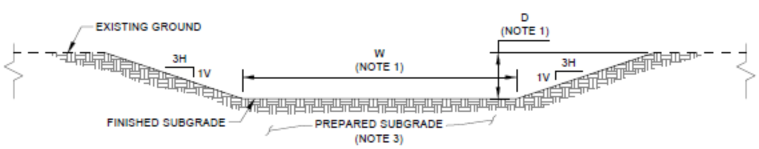
# Level 0 - Toe Collection and Diversion Details



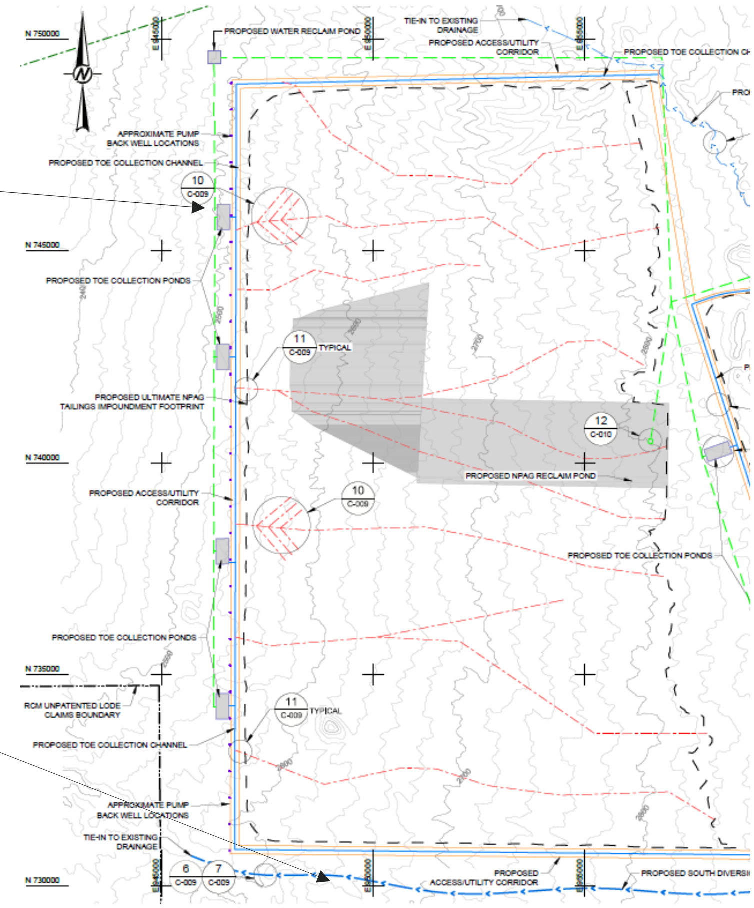

NOT TO SCALE 9 C-009 TYPICAL TOE COLLECTION POND DETAIL




NOT TO SCALE 6 C-009 TYPICAL ARMORED DIVERSION CHANNEL DETAIL



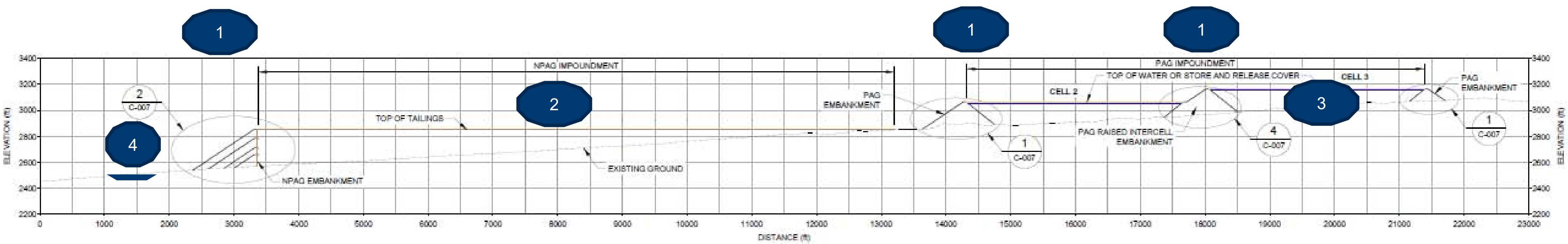

NOT TO SCALE 7 C-009 TYPICAL UNARMORED DIVERSION CHANNEL DETAIL



# Level 0 - TSF Environmental Controls

## Dust Management:

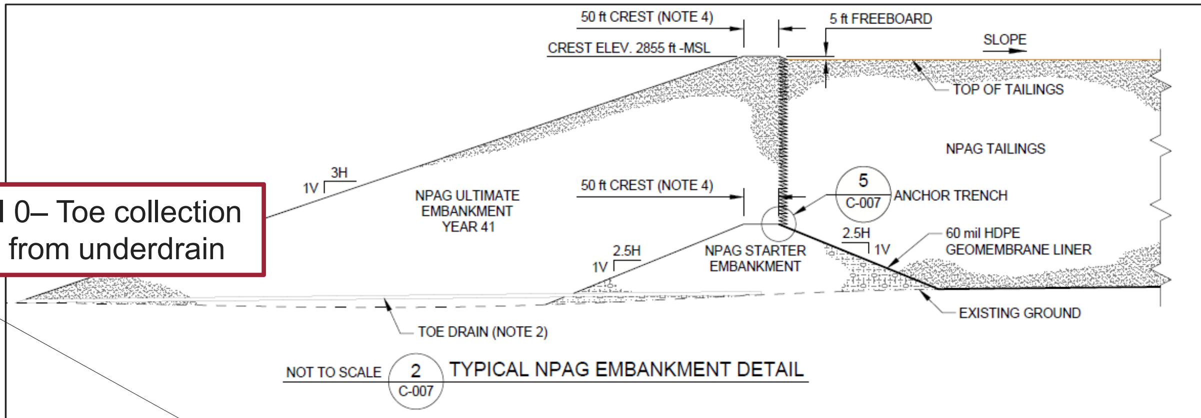
1. Wetted hydraulic cyclone sand cells
2. Thin lift deposition w/frequent deposition to promote wetting / drying and thin layers
3. 10 ft water cover above PAG cells
4. Seepage collection ponds to collect embankment seepage



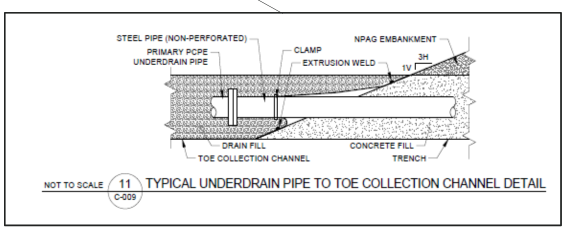

HORIZ. SCALE 1" = 800'
VERT. SCALE 1" = 400'
A C-006 NPAG AND PAG FACILITIES CROSS-SECTION A

# Level 0 - NPAG Embankment Details and Seepage Controls

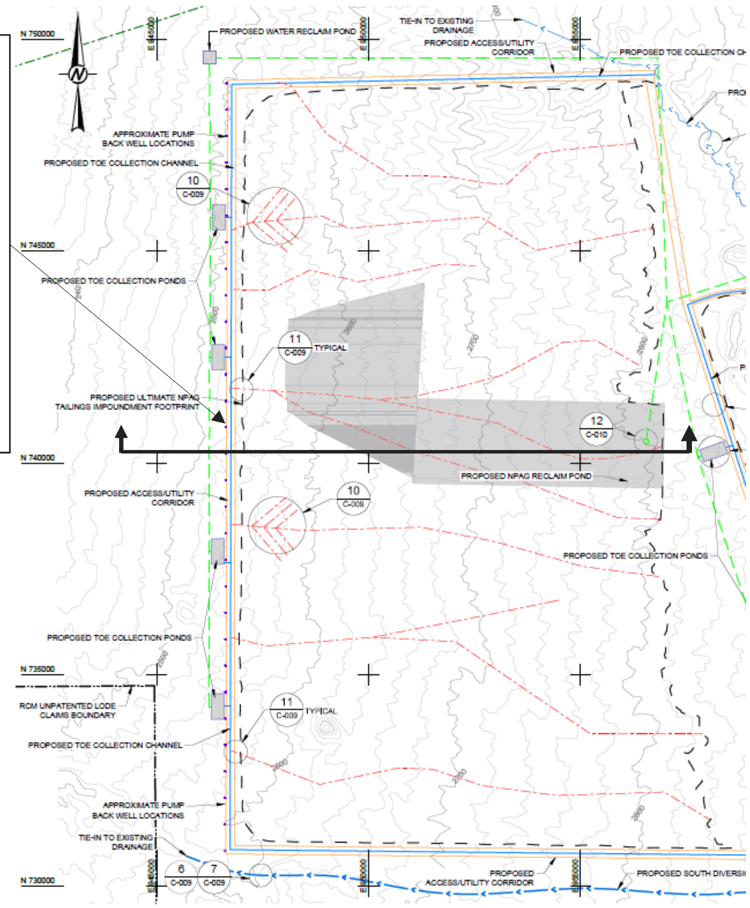
Level 0– Toe collection pond from underdrain



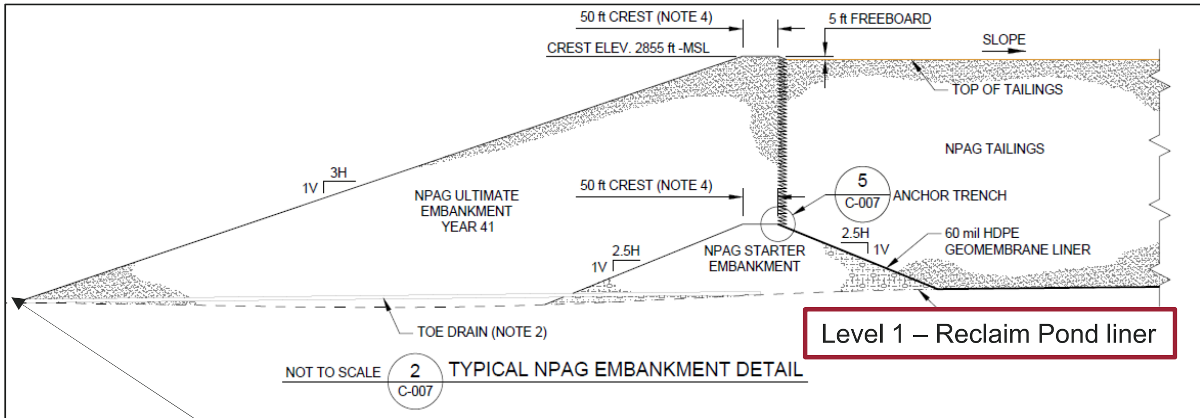
TYPICAL NPAG EMBANKMENT DETAIL



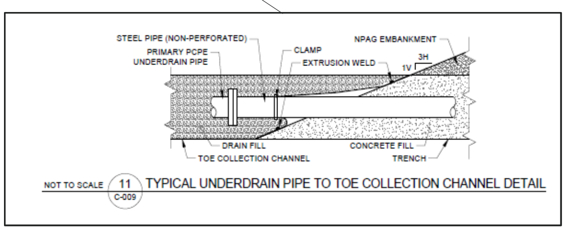
TYPICAL UNDERDRAIN PIPE TO TOE COLLECTION CHANNEL DETAIL



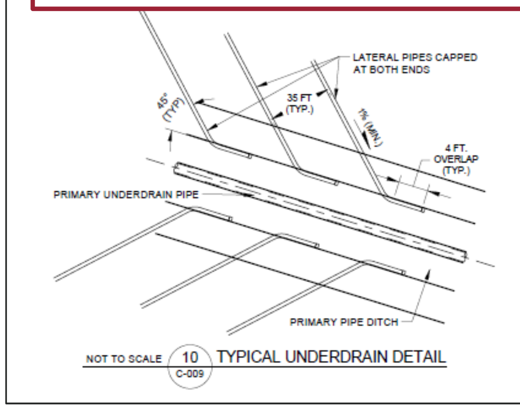
# Level 1 & 2 - NPAG Embankment Details and Seepage Controls



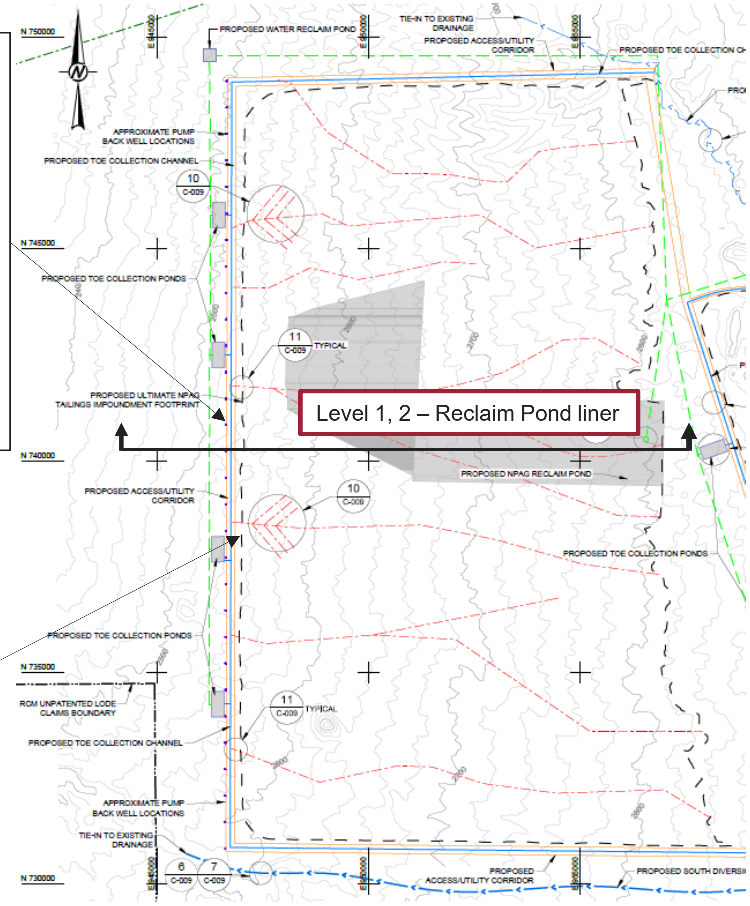

Level 1 – Reclaim Pond liner




Level 1, 2 – Impoundment Undrain

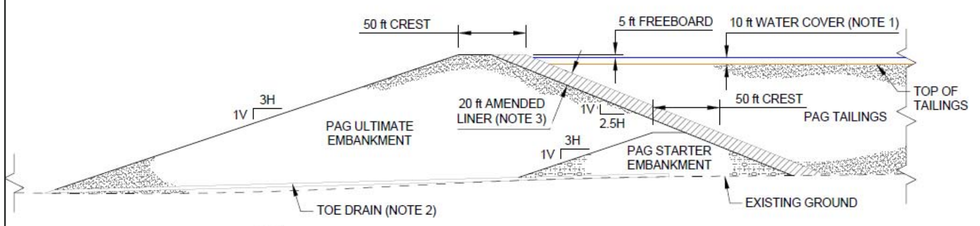



Level 1, 2 – Pump Back Wells

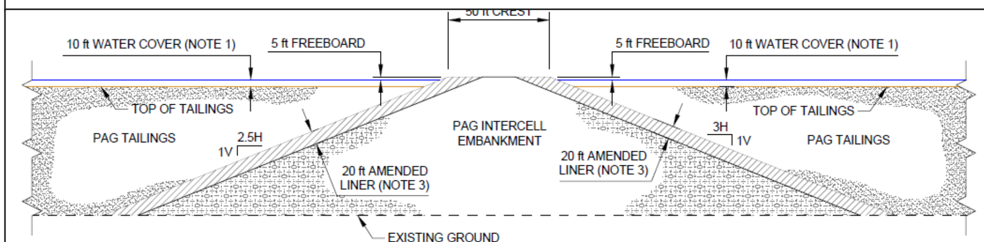



Level 1, 2 – Reclaim Pond liner

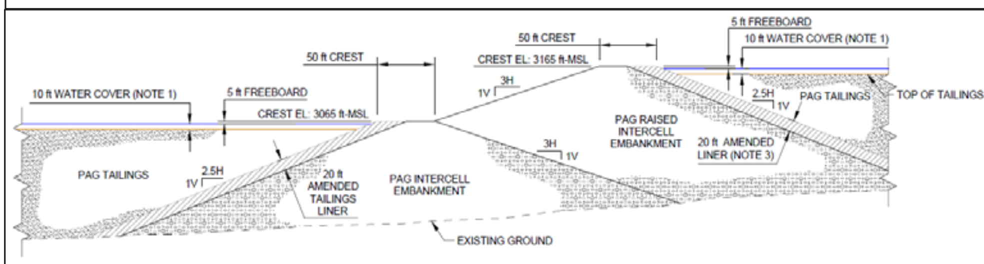
# Level 1 - PAG Embankment Details and Seepage Controls



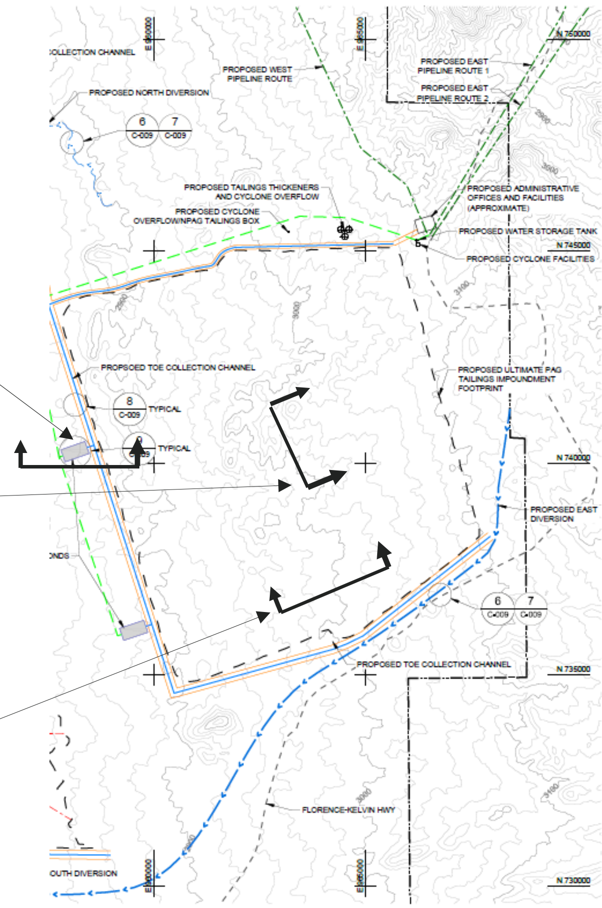

NOT TO SCALE 1 C-007 TYPICAL PAG TAILINGS EMBANKMENT DETAIL



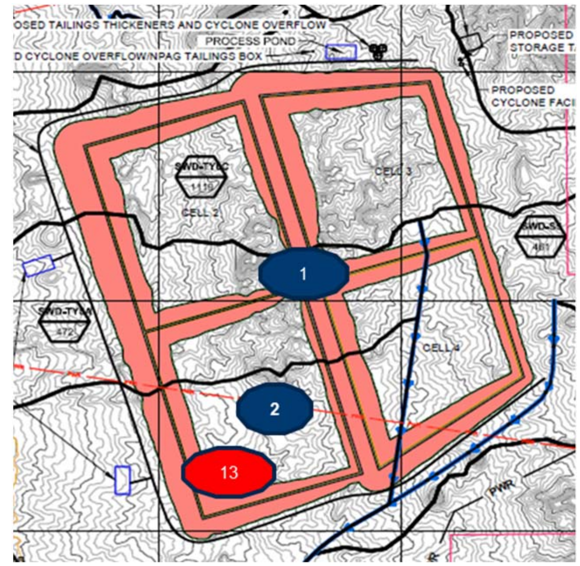

NOT TO SCALE 3 C-007 TYPICAL PAG TAILINGS INTERCELL EMBANKMENT DETAIL



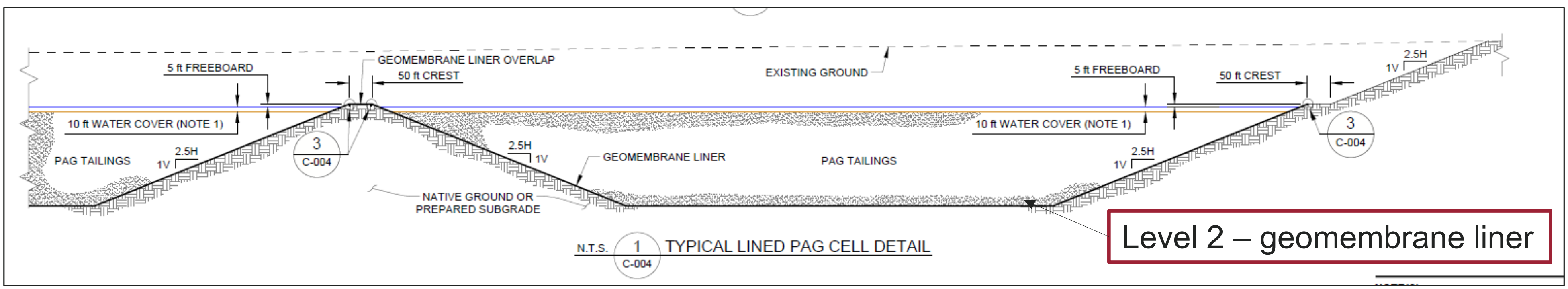

NOT TO SCALE 4 C-007 TYPICAL PAG TAILINGS RAISED INTERCELL EMBANKMENT DETAIL



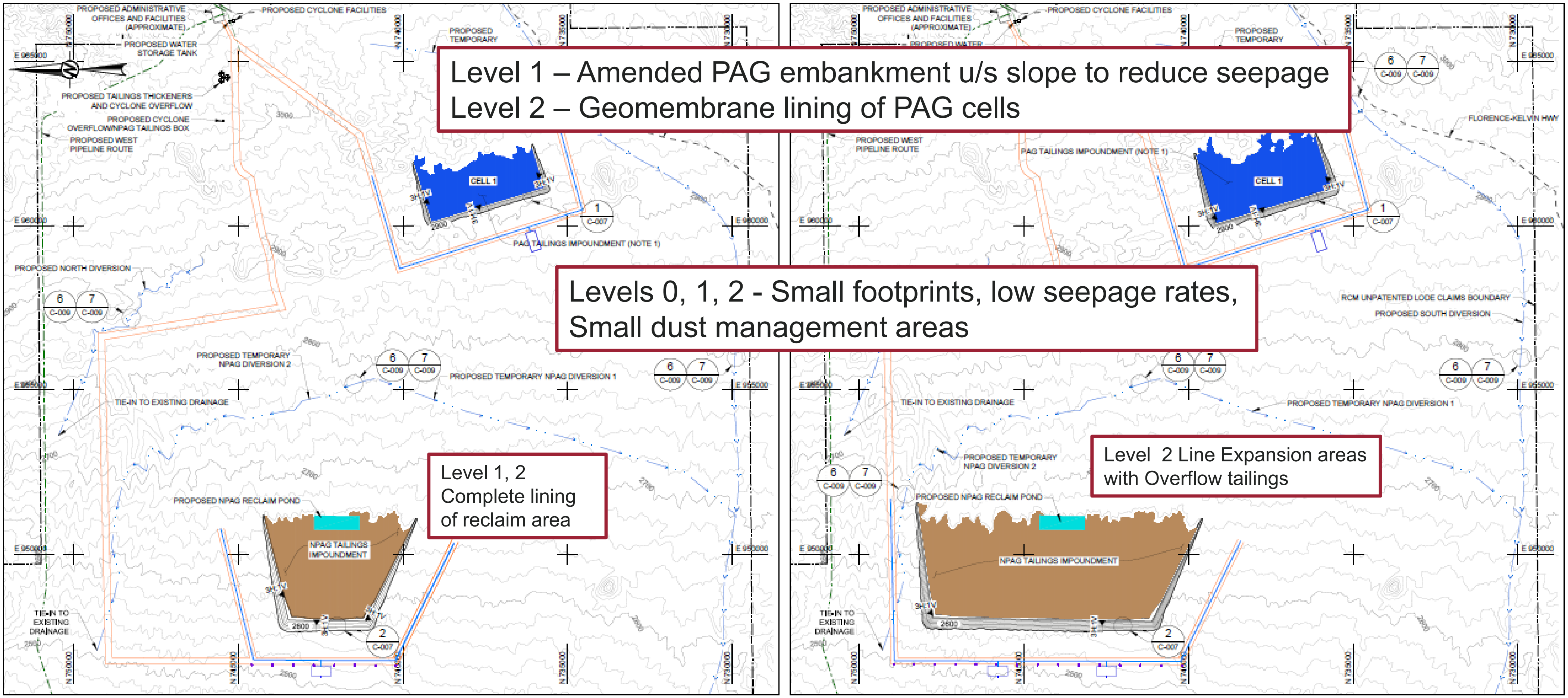
# Level 2 - Enhanced PAG Embankment Seepage Controls




PAG Embankments were designed to permit geomembrane liner installation in addition to amended soil liner



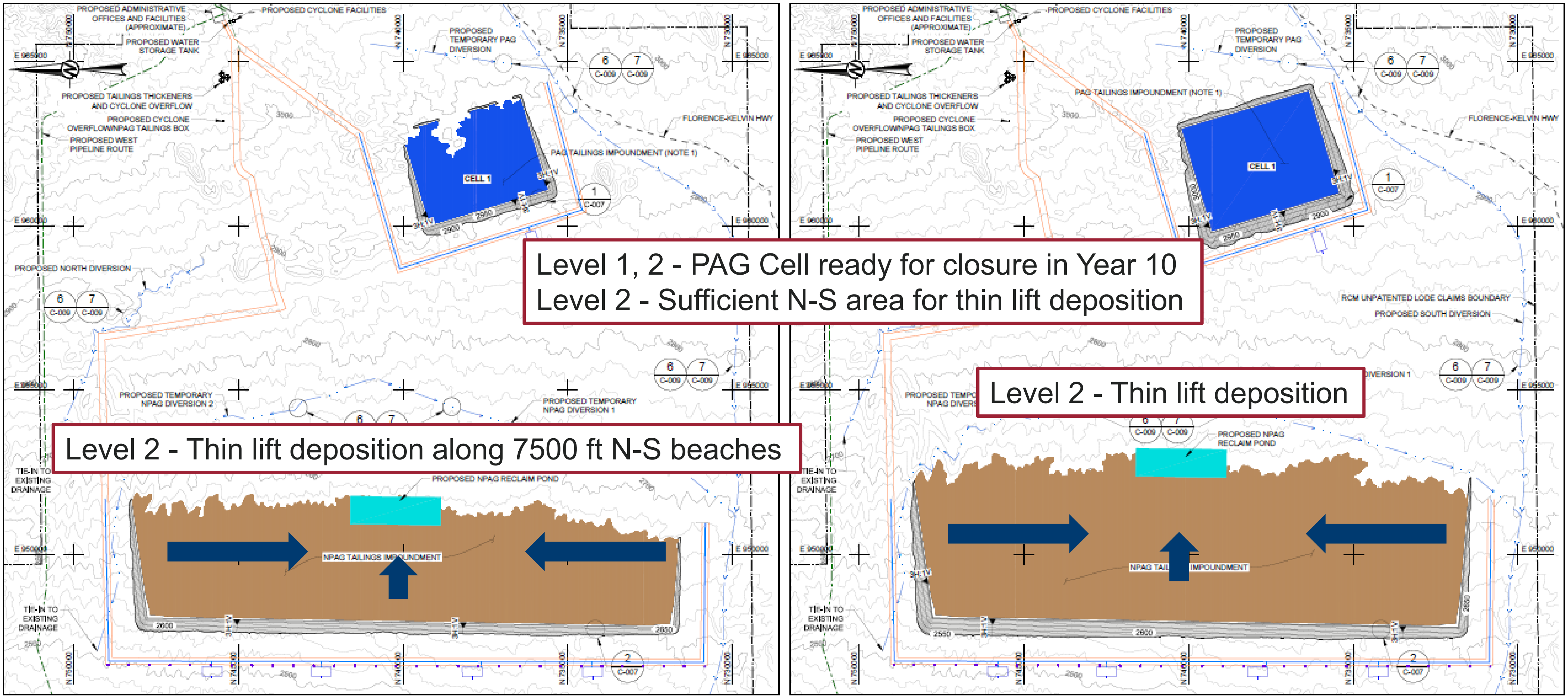
# Level 0, 1, 2 – Progressive Development of TSF to permit tailings management improvement throughout time and verification of construction methods




STARTER PAG AND NPAG IMPOUNDMENTS

YEAR 4 PAG AND NPAG IMPOUNDMENTS

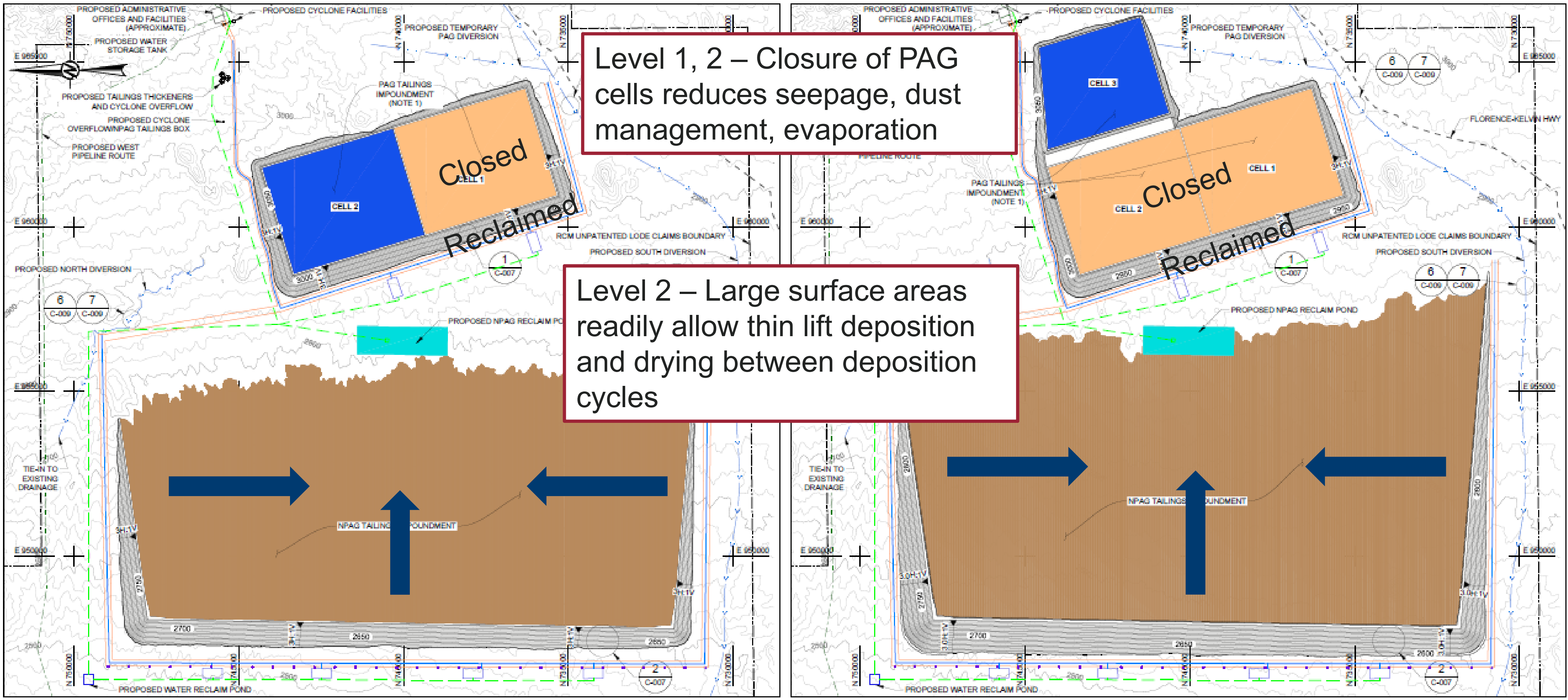
# Level 1, 2 – Development of thin lift deposition on long beach areas




YEAR 6 PAG AND NPAG IMPOUNDMENTS
SCALE 1" = 1500'

YEAR 10 PAG AND NPAG IMPOUNDMENTS
SCALE 1" = 1500'

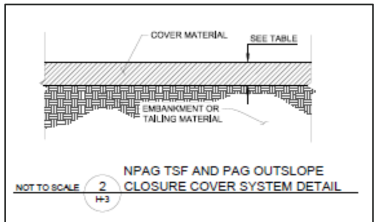
# Level 1, 2 – Progressive Reclamation of PAG cells and large surface areas assure functionality of thin lift deposition

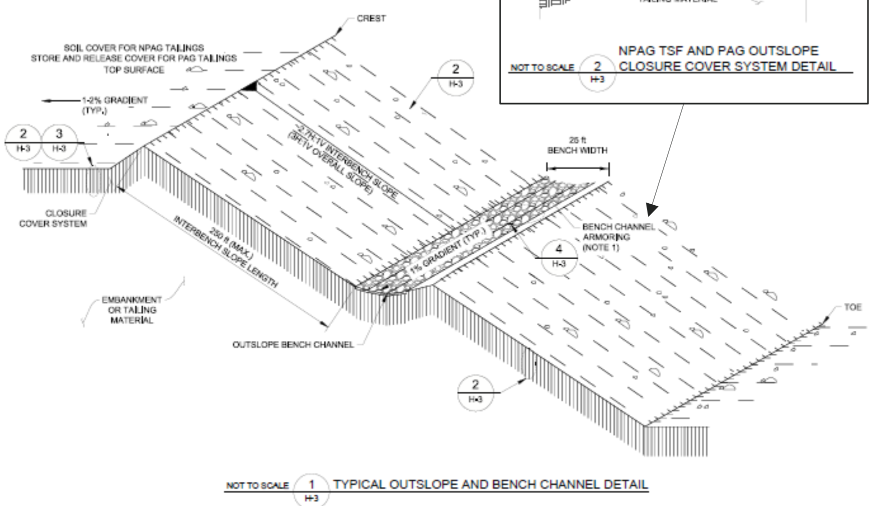


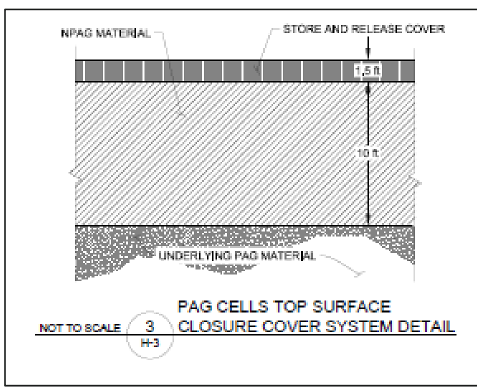

YEAR 20 PAG AND NPAG IMPOUNDMENTS
SCALE 1" = 1500'

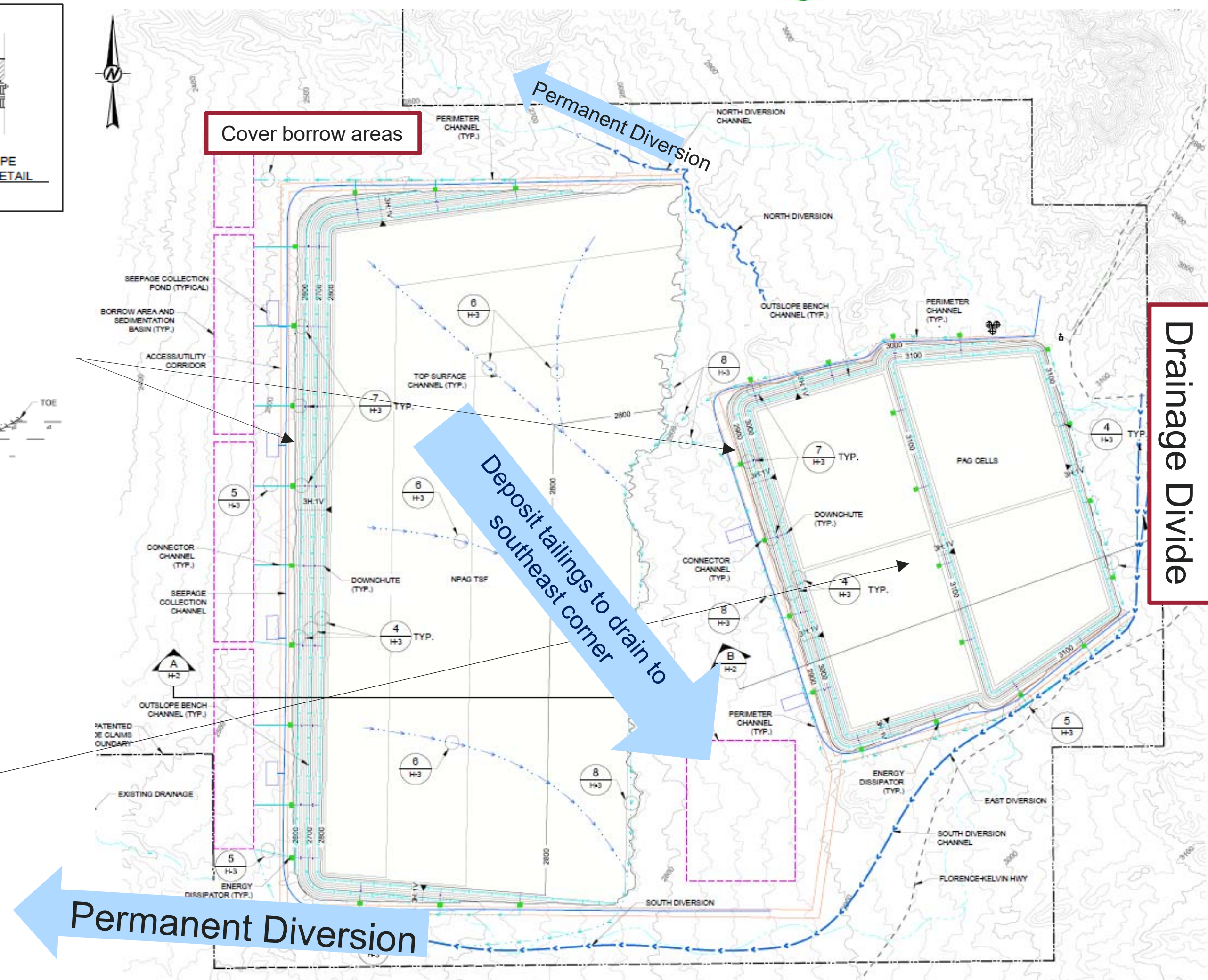
YEAR 30 PAG AND NPAG IMPOUNDMENTS
SCALE 1" = 1500'

# Levels 1, 2
# TSF Closure Details



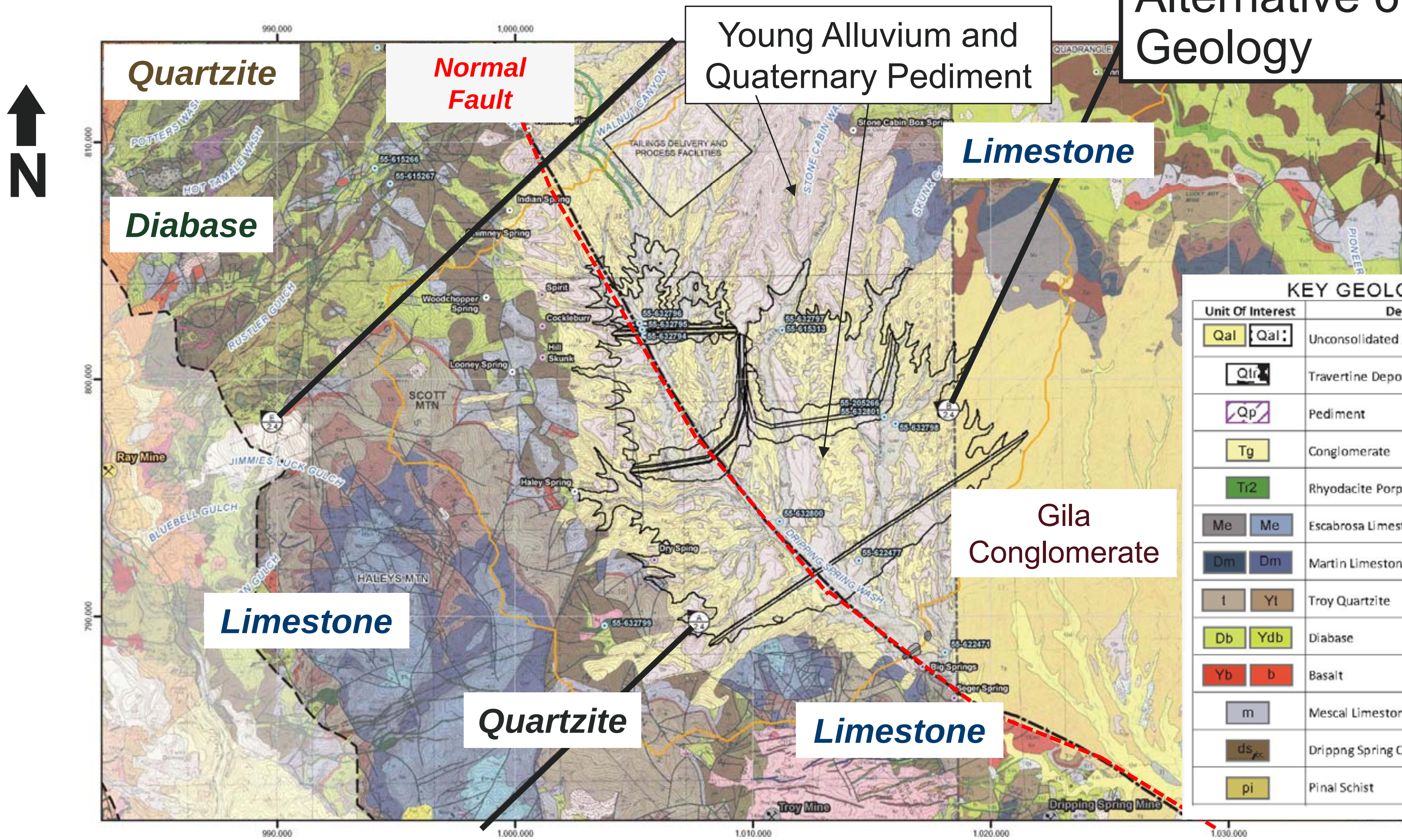



# *Alternative 6*

# *Skunk Camp*

# *Seepage Control Levels*

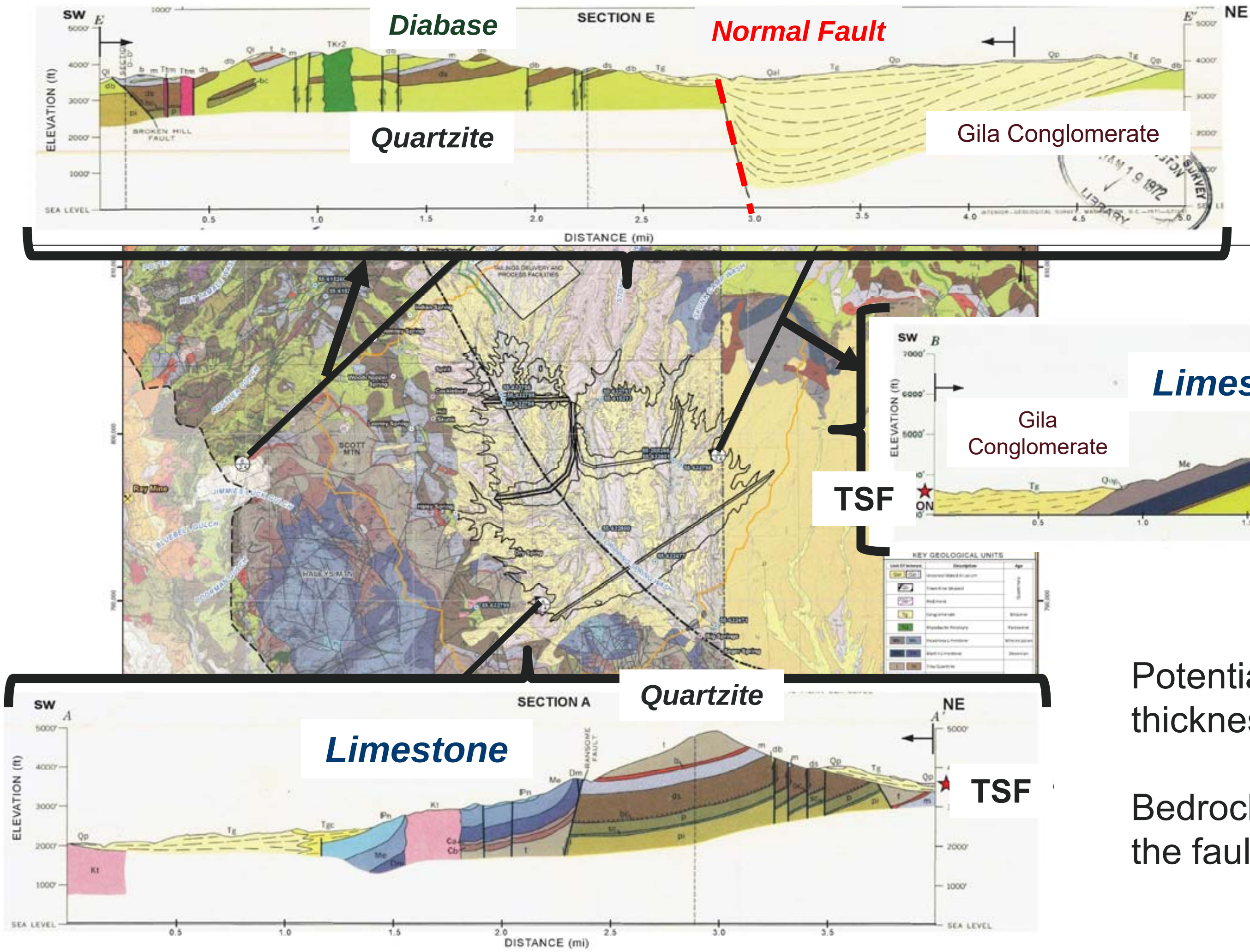
# Alternative 6 Skunk Camp Geology

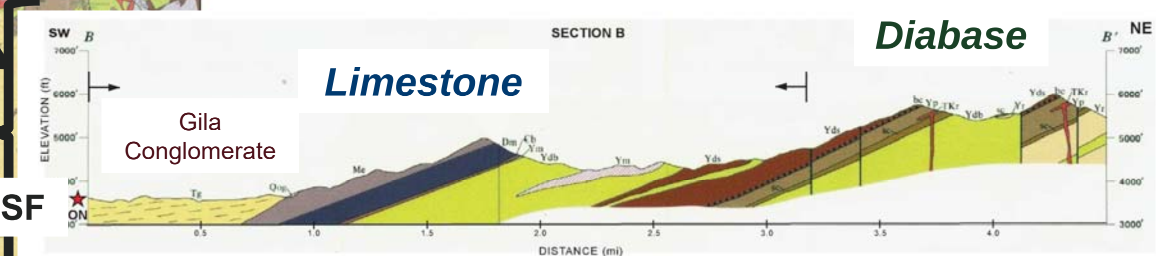



KEY GEOLOGIC UNITS

| Unit Of Interest | Description | Age |
|---|---|---|
| Qal, Qal | Unconsolidated Alluvium | Quaternary |
| Qlr | Travertine Deposit | Quaternary |
| Qp | Pediment | Quaternary |
| Tg | Conglomerate | Miocene |
| Tr2 | Rhyodacite Porphyry | Paleocene |
| Me, Me | Escabrosa Limestone | Mississippian |
| Dm, Dm | Martin Limestone | Devonian |
| t, Yt | Troy Quartzite | PreCambrian |
| Db, Ydb | Diabase | PreCambrian |
| Yb, b | Basalt | PreCambrian |
| m | Mescal Limestone | PreCambrian |
| ds | Drippng Spring Quartzite | PreCambrian |
| pi | Pinal Schist | PreCambrian |

# Alternative 6 Skunk Camp Geology

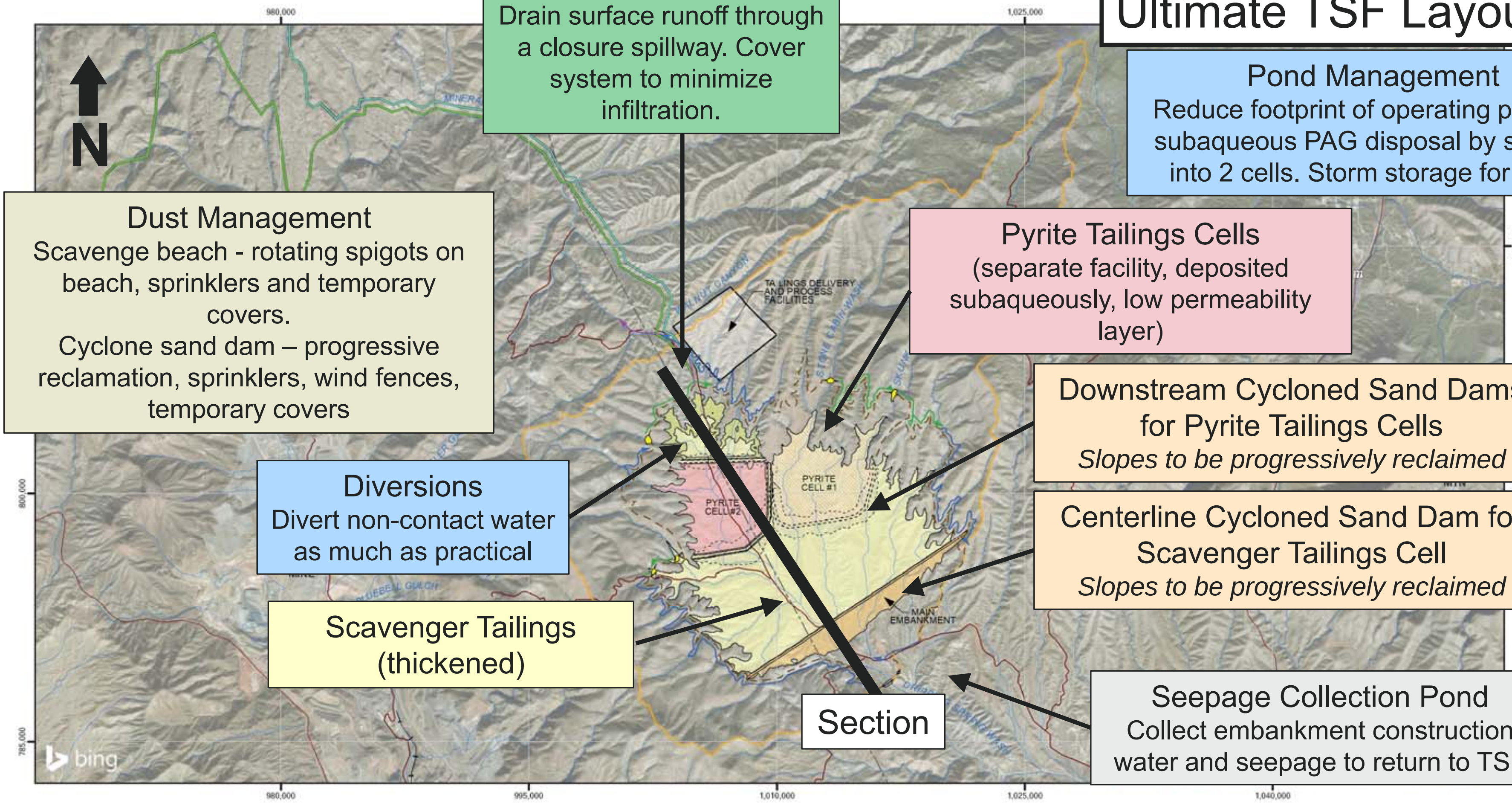



Potential for relatively shallow Gila thickness west of the normal fault.

Bedrock is at greater depth to the east of the fault.

# Alternative 6 Skunk Camp Ultimate TSF Layout




**Post-Closure**
Drain surface runoff through a closure spillway. Cover system to minimize infiltration.

**Pond Management**
Reduce footprint of operating pond for subaqueous PAG disposal by splitting into 2 cells. Storm storage for PMF.

**Dust Management**
Scavenge beach - rotating spigots on beach, sprinklers and temporary covers.
Cyclone sand dam – progressive reclamation, sprinklers, wind fences, temporary covers

**Pyrite Tailings Cells**
(separate facility, deposited subaqueously, low permeability layer)

**Downstream Cycloned Sand Dams for Pyrite Tailings Cells**
*Slopes to be progressively reclaimed*

**Diversions**
Divert non-contact water as much as practical

**Centerline Cycloned Sand Dam for Scavenger Tailings Cell**
*Slopes to be progressively reclaimed*

**Scavenger Tailings (thickened)**

**Section**

**Seepage Collection Pond**
Collect embankment construction water and seepage to return to TSF

# Alternative 6 Skunk Camp Ultimate TSF Layout

**Dust Management**
Scavenge beach - rotating spigots on beach, sprinklers and temporary covers.
Cyclone sand dam – progressive reclamation, sprinklers, wind fences, temporary covers

**Pond Management**
Reduce footprint of operating pond for subaqueous PAG disposal by splitting into 2 cells. Storm storage for PMF.

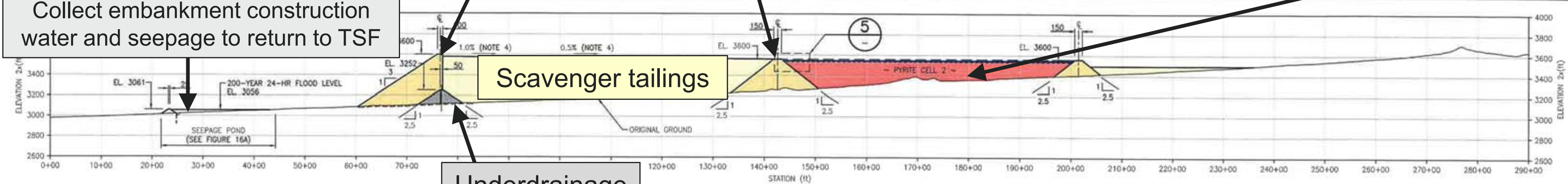
**Centerline Cycloned Sand Dam for Scavenger Tailings Cell**
*Slopes to be progressively reclaimed*

**Post-Closure**
Drain surface runoff through a closure spillway. Cover system to minimize infiltration.

**Downstream Cycloned Sand Dams for Pyrite Tailings Cells**
*Slopes to be progressively reclaimed*

**Pyrite Tailings Cell 2**
(separate facility, deposited subaqueously, low permeability layer)

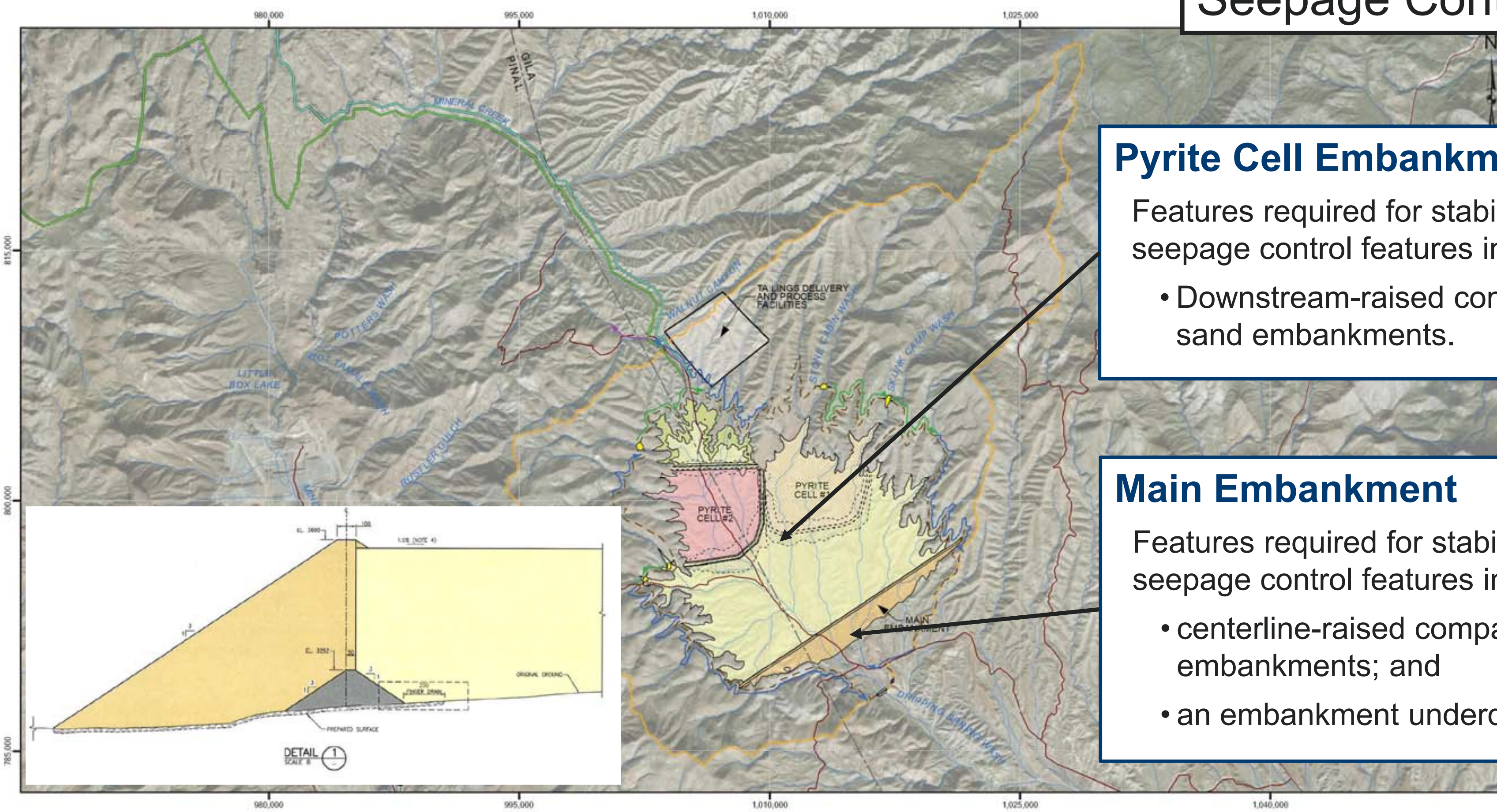
**Seepage Collection Pond**
Collect embankment construction water and seepage to return to TSF




**Underdrainage System**

Vertically exaggerated 2x

# Alternative 6 Skunk Camp Seepage Control Level 0




## Pyrite Cell Embankments

Features required for stability and act as seepage control features include:

- Downstream-raised compacted cycloned sand embankments.

## Main Embankment

Features required for stability and act as seepage control features include:

- centerline-raised compacted cycloned sand embankments; and
- an embankment underdrainage system.

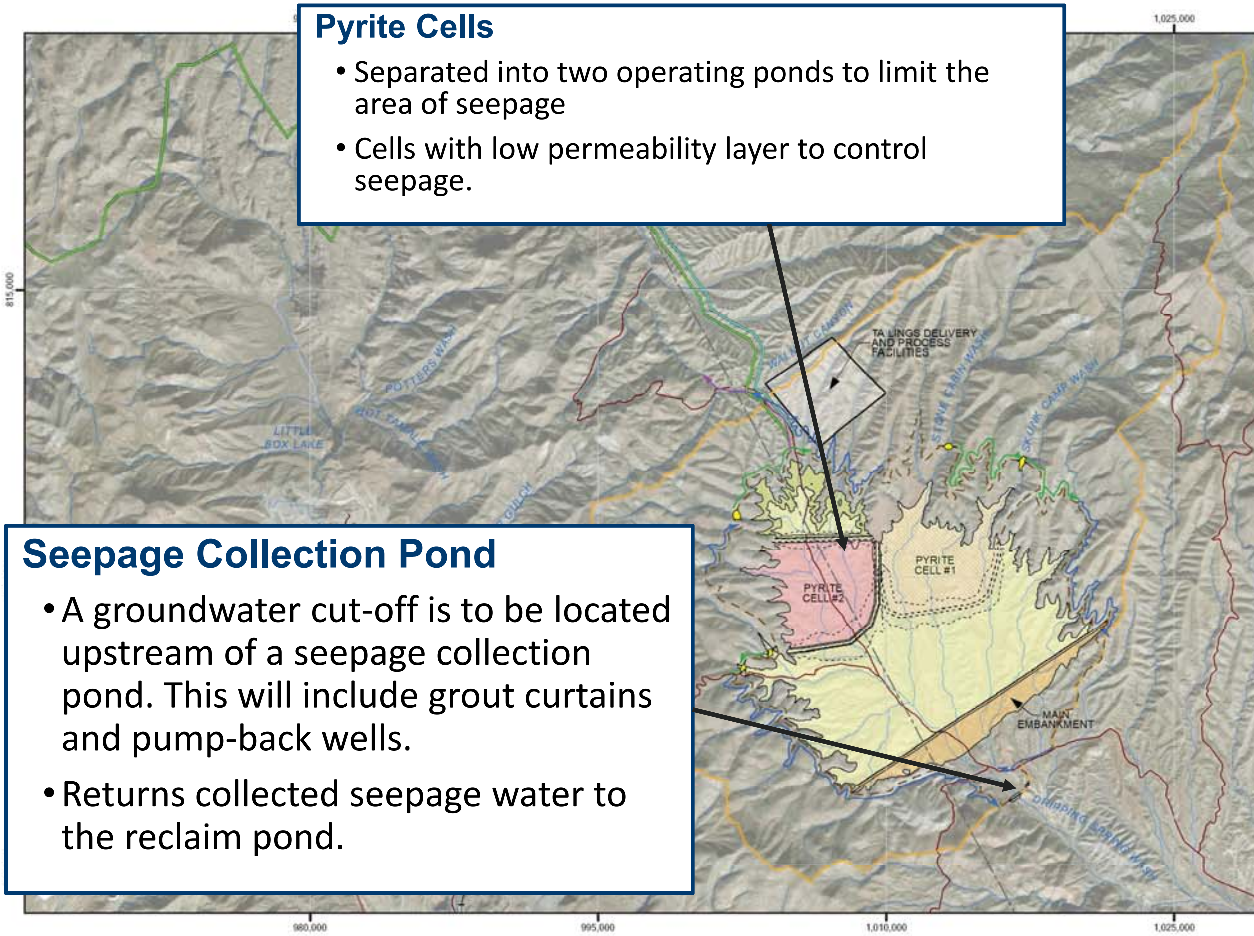
# Alternative 6 Skunk Camp Seepage Control Levels 1 to 3

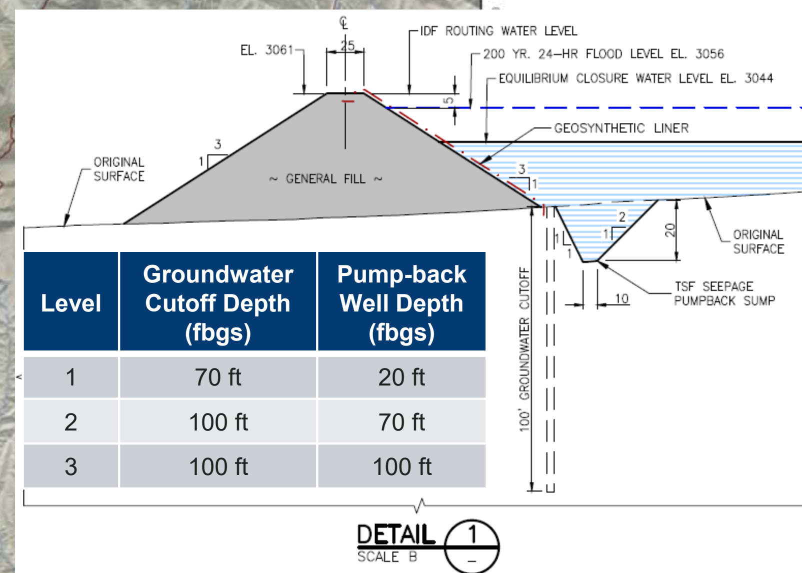
### Pyrite Cells

- Separated into two operating ponds to limit the area of seepage
- Cells with low permeability layer to control seepage.

### Seepage Collection Pond

- A groundwater cut-off is to be located upstream of a seepage collection pond. This will include grout curtains and pump-back wells.
- Returns collected seepage water to the reclaim pond.



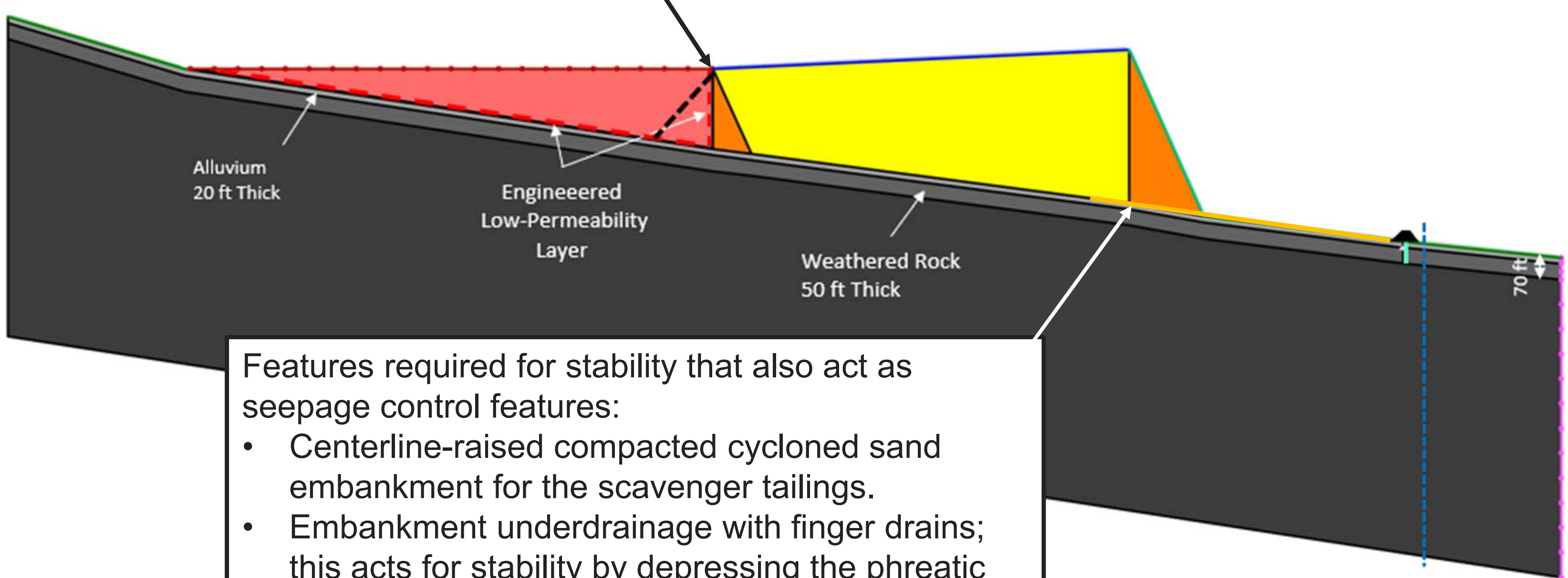




| Level | Groundwater Cutoff Depth (fbgs) | Pump-back Well Depth (fbgs) |
|---|---|---|
| 1 | 70 ft | 20 ft |
| 2 | 100 ft | 70 ft |
| 3 | 100 ft | 100 ft |

# Alternative 6 Skunk Camp Seepage Control Level 0

Features required for stability that also act as seepage control features:
- Downstream-raised compacted cycloned sand embankment for the pyrite cells.

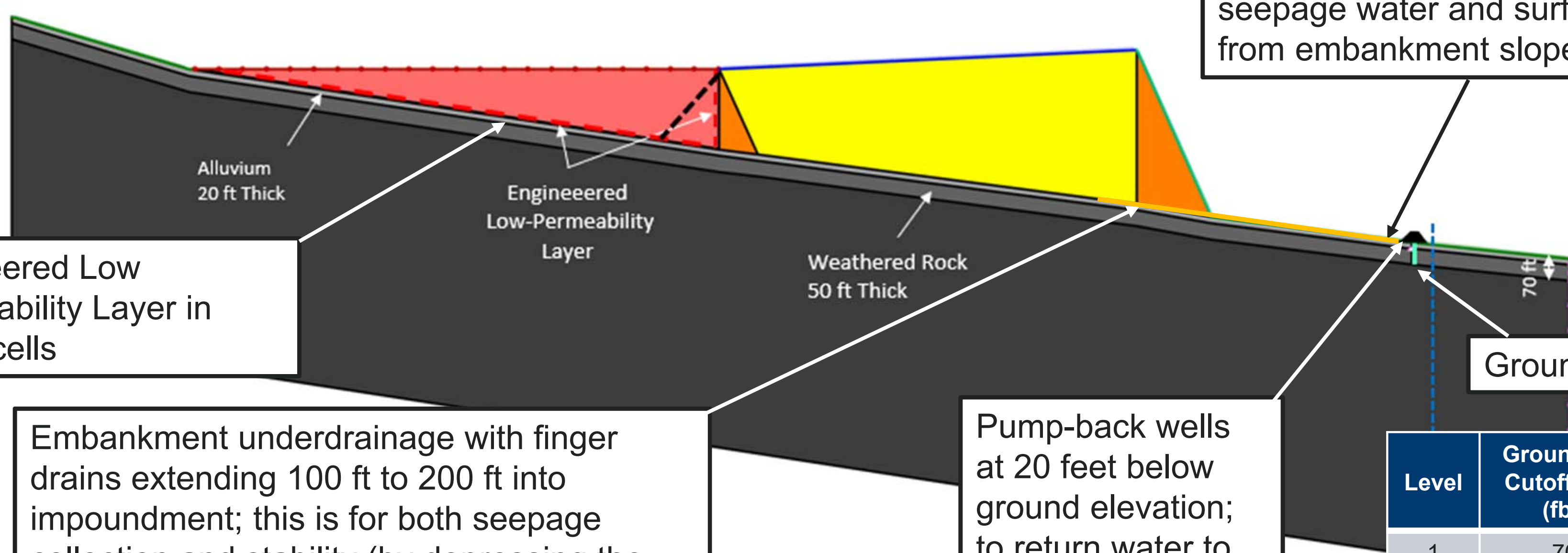
**5x Vertical Exaggeration:**




Features required for stability that also act as seepage control features:
- Centerline-raised compacted cycloned sand embankment for the scavenger tailings.
- Embankment underdrainage with finger drains; this acts for stability by depressing the phreatic surface. These will convey seepage to the Seepage Collection Pond through drainage channels.

# Alternative 6 Skunk Camp Seepage Control Level 1 to 3

**5x Vertical Exaggeration:**




Seepage Collection Pond (SCP) would be constructed to collect seepage water and surface runoff from embankment slope.

Engineered Low Permeability Layer in pyrite cells

Groundwater Cutoff

Embankment underdrainage with finger drains extending 100 ft to 200 ft into impoundment; this is for both seepage collection and stability (by depressing the phreatic surface). These will convey seepage to the SCP through drainage channels.

Pump-back wells at 20 feet below ground elevation; to return water to pyrite cells.

| Level | Groundwater Cutoff Depth (fbgs) | Pump-back Well Depth (fbgs) |
|---|---|---|
| 1 | 70 ft | 20 ft |
| 2 | 100 ft | 70 ft |
| 3 | 100 ft | 100 ft |