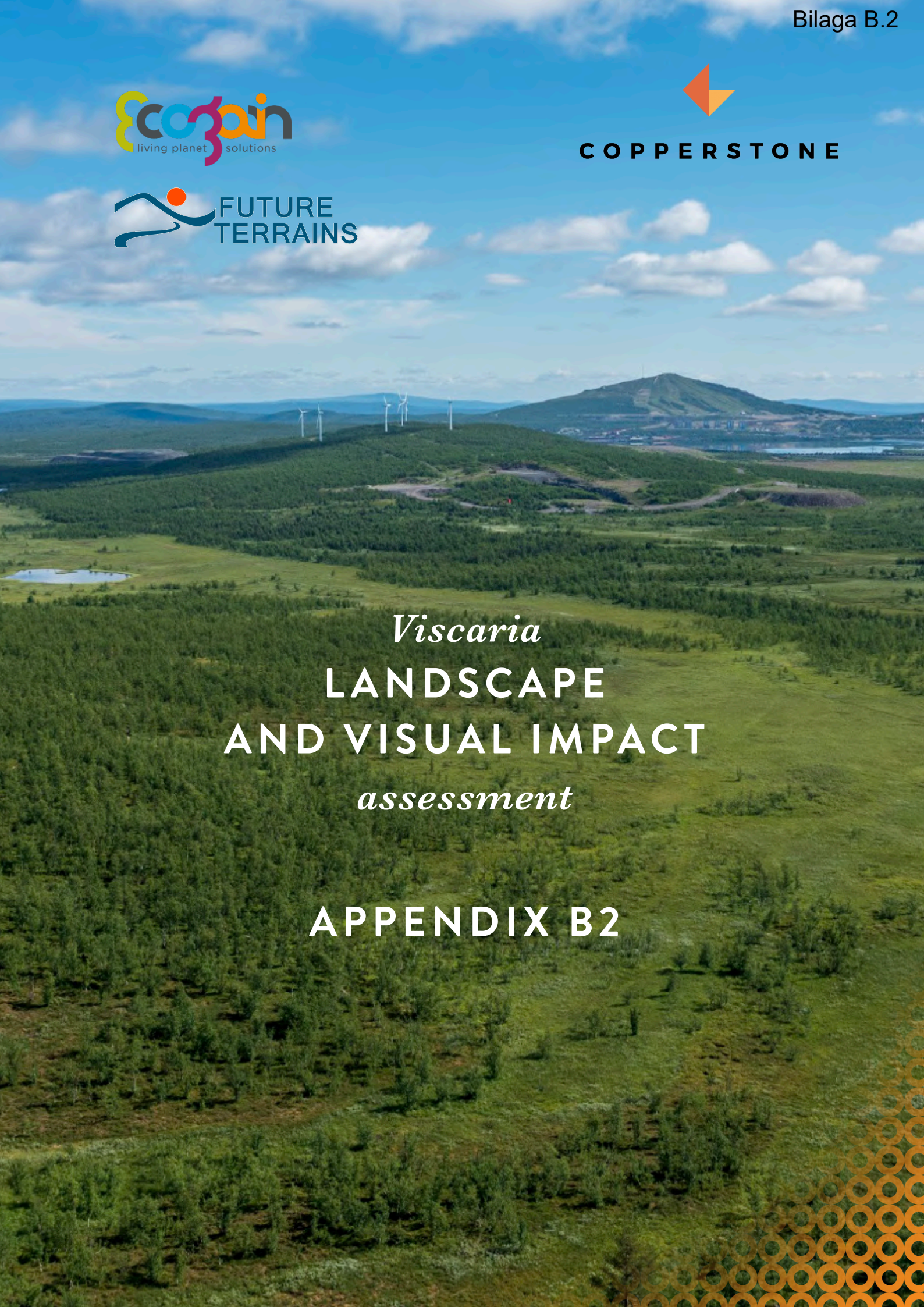

COPPERSTONE

Viscaria
LANDSCAPE AND VISUAL IMPACT
assessment

APPENDIX B2

Copperstone Viscaria AB

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Photos and illustrations by Future terrains and Ecogain if nothing else mentions.

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ICKE-TEKNISK SAMMANFATTNING

Copperstone Viscaria AB har för avsikt att återöppna Viscaria koppargruva. Som en del av underlaget inför Copperstones ansökan om tillstånd har en landskapsanalys tagits fram. Syftet med landskapsanalysen är att identifiera vilken påverkan på landskapet, både gällande förändringar i landskapets uppbyggnad och på landskapsbilden, det vill säga den visuella upplevelsen av landskapet, som återöppnandet av gruvan kan medföra. Landskapet analyseras både utifrån dess värde som resurs, och utifrån människors uppfattning och visuella upplevelse.

Den europeiska landskapskonventionen definierar landskap som

> *”…ett område sådant som det uppfattas av människor och vars karaktär är resultatet av påverkan av och samspel mellan naturliga och/eller mänskliga faktorer.”*

Att landskap ska skyddas vid exploateringar framgår av miljöbalken, där effekter på landskapet utgör en del av miljöbedömningen i samband med tillståndsansökan. Att landskapet ska skyddas framgår också av Sveriges ratificering av den europeiska landskapskonventionen. Ansvaret delas mellan myndigheterna, länsstyrelserna och kommunerna.

Detta är en icke-teknisk sammanfattning av landskapsanalysen som sammanfattar den detaljerade, tekniska landskapsanalysen som tagits fram till stöd för projektets miljötillståndsansökan. Sammanfattningen är inte avsedd att täcka all information som finns i huvudrapporten.

Projektområdet Viscaria

Projektområdet Viscaria innefattar den tidigare koppargruvan Viscaria som lades ner 1997. Det ligger cirka tre kilometer väster om Kiruna tätort i Kiruna kommun och strax nordväst om LKAB:s gruvområde. Projektområdet har en total yta på 858 ha och en omkrets på 11,5 km.

Projektområdet ligger i en ekologisk, socioekonomisk, visuell och kulturell övergångszon, eller korridor, mellan de urbana och industriella områdena inom och i närmaste omgivningen runt Kiruna och den kringliggande naturen. Närområdet präglas av arktisk natur och renskötsel. Både den visuella och fysiska närheten till den storslagna naturen är en central del av Kirunas kulturella identitet och en viktig tillgång för dess invånare.

Mineralfyndigheterna i Viscaria uppskattas till omkring 59 miljoner ton kopparmalm och fem miljoner ton järnmalm. Gruvverksamheten kommer att utgöras av bland annat dagbrott och sandmagasin och inkludera aktiviteter som sprängning, fraktning av malmrik sten till produktionsområdet och fraktning av avfall till deponier. Avfallet från gruvbrytningen kommer att deponeras i gråbergsupplag och sandmagasin. Ett antal byggnader kommer att uppföras för att inhysa produktionslokaler, kontor och besöksytor. Därtill kommer infrastruktur byggas för att möjliggöra väg- och järnvägstransport av gods såväl som människor till och från platsen.

De huvudsakliga faserna i projektet kan delas in i anläggning, drift, stängning och efterbehandling med efterföljande övervakning och kontrollprogram. Förfarandet i varje fas skiljer sig åt och ger därför olika påverkan på landskapet. De olika faserna har därför utvärderats separat.

Metod

Landskapsanalysen har genomförts enligt rådande metodik för en så kallad LVIA (landscape and visual impact assessment). LVIA-metodiken utgår principiellt från Guidelines for Landscape and Visual Impact Assessment, third edition (The Landscape Institute); An Approach to Landscape Character Assessment och An Approach to Landscape Sensitivity Assessment – to Inform Spatial Planning and Land Management. Båda riktlinjerna är utgivna av DEFRA, som är den brittiska motsvarigheten till Naturvårdsverket. Det finns idag inga officiella svenska riktlinjer för hur en landskapsanalys ska tas fram eller vad den ska innehålla.

LVIA-metodiken är en metod för landskapsanalys som utgörs av två separata men sammanflätade processer. I det första steget fastställs grundförutsättningarna för landskapet, med syfte att beskriva landskapets natur- och kulturvärden, topografi, geologi och visuella kontext, vilka tillsammans beskriver hur landskapet är uppbyggt. Landskapsförutsättningarna analyseras sedan

tillsammans med projektbeskrivningen för att kunna avgöra vilken påverkan som projektet sannolikt kommer medföra på landskapet och landskapsbilden. Därefter ges rekommendationer kring hur konsekvenserna av påverkan bör hanteras eller hur de kan mildras.

Informationen i studien inhämtades från ett flertal olika källor och innefattar en skrivbordsstudie med genomgång av existerande källor, platsbesök, diskussioner med relevanta aktörer samt en synbarhetsanalys i GIS (ZVI, zone of visual influence). Fotomontage av platsen har också tagits fram för ett antal utsiktspunkter för att visa på nuvarande vy från utsiktspunkten och den framtida, förändrade vyn till följd av exploateringen. En mörkerstudie gjordes också och finns tillgänglig som bilaga till huvudrapporten. Arbetet påverkades till stor del av restriktioner från den rådande pandemin vilket begränsade antalet fysiska möten för projektdeltagarna.

Landskapets förutsättningar

Ett område med 10 kilometer stor radie runt projektområdet valdes ut som undersökningsområde för landskapsanalysen. Undersökningsområdet innefattar flertalet olika landskapselement och landskapskaraktärer med flera sorters markanvändning samt natur- och kulturvärden koncentrerat på en liten yta. Inom utredningsområdet ligger ett antal nationellt skyddade naturområden, inklusive två Natura 2000-områden. Det överlappar också med områden utpekade som riksintressen för friluftsliv. Vidare är Kiruna stad och LKAB är också nationellt kända kulturmiljöer. I bergsmassivet nordväst om Kiruna finns fyra av landets tretton toppar över 2000 meter, däribland Kebnekaise, och detta har ett viktigt kulturellt värde. Utsikten från Kiruna mot bergen i väst och norr är i och med detta högt värderad.

I analysen delas utredningsområdet in i så kallade lokala landskapskaraktärsområden. En landskapskaraktär är ett distinkt, igenkännbart och konsekvent mönster av element i landskapet som skiljer ett landskap från ett annat. Ett lokalt landskapskaraktärsområde är ett individuellt, geografiskt avskilt område.

Landskapskaraktären där Viscaria koppargruva tidigare låg präglas dels av naturmark där vegetationen har börjat återetablerats, dels av tidigare gruvdrift såväl som stadsutveckling. En ytterligare kulturell aspekt som ger en förståelse för den tidsrymd under vilken landskapet utvecklats är att området varit brukat av samer under tusentals år. Renskötsel är en central näring i det samiska samhället och renarna är känsliga för störningar såsom gruvdrift.

Projektområdet är i hög grad synligt från flera platser i Kiruna såväl som från det omgivande landskapet inklusive transportvägar norr och väst om Kiruna. LKAB:s gruvverksamhet öster om Viscaria har medfört en omfattande påverkan på landskapet och står i stor visuell kontrast till Viscarias projektområde. Viscariaområdet ger betraktaren en vilsammare upplevelse med naturen och bergen synliga bortom berget Kiirunavaara och LKAB. Den vidsträckta utsikten gör att området blir en visuell korridor till vildmarken. Denna effekt förstärks under vinterhalvåret då avsaknaden av stadsljus även gör det möjligt att uppleva norrsken här, vilket lockar besökare. Dessutom fungerar området som en entré till vildmarken för kirunabor och turister eftersom flera rekreativa värden så som skoterleder och skidstråk utgår från en befintlig parkering vid områdets norra gräns.

Innan konsekvensanalysen kunde genomföras, identifierades vilka lokala landskapskaraktärsområden som finns i projektområdets närhet. Fyra lokala landskapskaraktärsområden identifierades och dessa sammanfattas nedan:

- **Kiruna gruvområde:** ett mycket dynamiskt, degraderat och onaturligt gruvlandskap som inkluderar Viscaria-området och är nära sammanflätat med Kiruna tätort. Inom karaktärsområdet finns områden med tidigare gruvverksamhet som numera är förhållandevis väl återetablerade med vegetation, om än med låga ekologiska värden. Karaktärsområdet är av högt kulturellt värde och är nationellt utpekat som riksintresse, tillsammans med Kiruna stad. Det finns en stark känsla av plats och kulturell identitet inom området, med distinkta landformer som dominerar omgivningen och social acceptans bland lokalbefolkningen. De dynamiska och tydligt exploaterade landformerna gör att landskapets sårbarhet är låg.
- **Kiruna tätort**: ett kulturellt betydelsefullt område med dynamisk stadsbild och arkitektur som utvecklats utifrån de miljömässiga, sociala och ekonomiska utmaningarna i att utveckla en viktig industristad i en avlägsen, arktisk omgivning. Kiruna är emellertid också en föränderlig tätort som på samma gång både bevarar och utvecklar stadskärna och stadsbild samtidigt som en flytt av staden blivit oundviklig till följd av gruvdriften. Kirunas läge och närhet till vildmarken, fjällen och orörd natur förstärker känslan av lokal förankring och kulturell identitet. Dessa aspekter påverkas också av de andra landskapskaraktärerna som beskrivs här.

- **Fjällbjörkskogen:** en urtida, lugn, fjällmiljö som domineras av utbredd fjällbjörkskog och myrmark. Fjällbjörkskogen går enkelt att nå från Kirunas stadskärna och är en viktig del av den lokala turismen. Det är också en uppskattad miljö bland lokalbor som vandrar och gör utflykter på fritiden. Utsikten från toppen Ädnamvaara och Ädnamvaarastugan är enastående. Området är något av en institution för friluftsliv i Kiruna och är både nationellt och internationellt känd för sin unika natur och ekologi. Området är även viktigt ur rennäringsperspektiv och för samebyarna i området.
- **Barrskogen:** precis som fjällbjörkskogen karaktäriseras barrskogen av den urtida, lugna och arktiska fjällmiljön, men domineras istället av vintergröna barrträd. De båda landskaps-karaktärerna överlappar med varandra, men projektområdet Viscaria är beläget på längre avstånd från barrskogen än fjäll-björkskogen. Precis som fjällbjörkskogen är barrskogen lätt att nå från Kiruna och är viktig för turistnäring såväl som för lokalbefolkningen. Landskapet är också vida känt för den unika naturen och ekologin och är viktigt ur rennäringsperspektiv och för samebyarna i området.

Inom undersökningsområdet finns många upplevelsevärden som värderas högt av både invånare och turister samt marknadsförs för att locka besökare. Visuellt är området skiftande med uppskattade vyer mot vildmark och fjäll-värld såväl som mot framträdande urbana områden påverkade av gruvdrift. Denna mångsidighet förstärks av de visuella skillnader som uppstår i relation till säsongsvariationerna. Vyerna förändras både snabbt och ofta. Sjutton utsiktspunkter valdes ut och bedömdes utifrån deras värde, mottaglighet och känslighet från olika delar av Kiruna och från landskapet som omger projekt-området Viscaria.

Bedömning av påverkan på landskap och landskapsbild

Gruvverksamheten vid Viscaria kommer att påverka landskapet och landskapsbilden. Effekter som kommer att bidra till påverkan är människor och fordon som rör sig i området, buller, vibrationer, ljus, reflektioner, lukt, att befintlig infrastruktur och befintlig vegetation avlägsnas, nya onaturliga landformer, nya vertikala och linjära strukturer, skyltning, utsläppsplymer, damm, missfärgning av vattendrag och återetablering av växtlighet. Alla effekter kommer inte att medföra signifikant påverkan individuellt, men tillsammans bildar de en helhetspåverkan. Påverkan kommer att variera och vara olika påtaglig under olika delar av gruvans verksamhetstid, under olika tider på dygnet och med årstiderna. Vissa effekter kommer sannolikt påverka renar negativt, och därav potentiellt medföra negativa socioekonomiska konsekvenser för renskötare.

Negativ påverkan på landskapet kan mildras genom att anpassa gruvans design, och genom anpassade förvaltningsåtgärder. Åtgärder som mildrar den negativa påverkan beaktades innan den kvarvarande påverkan på landskapet och landskapsbilden fastställdes.

Den kvarvarande påverkan på landskapet och landskapsbilden fastställdes för fyra olika faser:

- **Anläggning** – anläggning och byggnation pågår, inklusive borttagning av de befintliga vindkraftverken, röjning av vegetation och tillkomst av nya byggnader och infrastruktur.
- **Drift** (**år 5**) – period med maximal produktion och maximal påverkan på landskapet och landskapsbilden, inklusive gråbergsupplag och sandmagasin som ännu till största del inte är efterbehandlade, plymer av rök, ljud och vibrationer.
- **Stängning** – aktiviteter för stängning pågår, inklusive nedmontering av strukturer, återfyllning, återvinning, efterbehandling av gråbergsupplag och sandmagasin.
- **10 år efter stängning** – den ekologiska efterbehandlingen pågår. Eftersom vegetationen etableras och växer långsamt är den fortfarande gles.

Sammantaget, på en landskapsnivå, är Fjällbjörkskogen det lokala landskapskaraktärsområde som är mest känsligt för Viscariagruvans effekter. Fjällbjörkskogen är lättillgänglig och en väg ut i naturen för både Kirunabor och turister. Områdets lokala landskapskaraktär kommer att påverkas av gruvetableringen, till en omfattning där ”vildmarkskänslan” i området kring Ädnamvaara och tillhörande leder förminskas.

Under anläggningen kommer påverkan på landskapet och landskapsbilden att uppstå inom alla fyra lokala landskapskaraktärsområden, men speciellt för Kiruna gruvområde och Fjällbjörkskogen. Effekterna medför störst påverkan på Fjällbjörkskogen, eftersom detta lokala landskapskaraktärsområde är mest känsligt för förändring. Fjällbjörkskogen påverkas av bland annat förändrad marktäckning, färg och textur, nya strukturer, ljud- och ljusföroreningar samt människor och fordon som rör sig i projektområdet. Visuell påverkan blir som störst inom 5 km väster, norr och öster om projektområdet. Det området inkluderar Ädnamvaarastugan, lederna till Ädnamvaarastugan, E10 norr om Kiruna, Máttaráhkká Northern Lights Lodge, Maria Taavenikkus Gata, parkeringen vid Luossavaara och Luossavaaras topp.

Många av anläggningsfasens effekter på landskap och landskapsbild kommer att finnas kvar även under driftsfasen. Ny påverkan tillkommer under driftsfasen i och med de växande gråbergsupplagen och sandmagasinen, utökad belysning och rökplymer. Störst är påverkan på det lokala landskapskaraktärsområdet Fjällbjörkskogen.

Påverkan kommer att minska under stängningsfasen eftersom till exempel utsläppsplymer försvinner och framträdande landformer omformas till ett mer naturligt utseende. Projektområdet kommer dock fortfarande att vara en källa till ljus och buller. Marken kommer däremot ha vegetation som börjat växa på de återställda ytorna, vilket gör att området bättre smälter in med omgivande natur.

Tio år efter stängningen kommer det att finnas en mindre, kvarstående påverkan på landskapet, framför allt inom Fjällbjörkskogen. Även påverkan på landskapsbilden kommer kvarstå, främst till följd av de nya landformerna.

När det gäller landskapsbild kan anläggningen delvis medföra positiv påverkan initialt i och med att de befintliga vindkraftverken tas bort. Detta kommer minska hur iögonfallande området är, särskilt i norra delen av området, eftersom de uppstickande vindkraftverken tas bort. Men med ökande altitud och

med ökat avstånd från området kommer sedan större delen av projektområdet att vara synligt från vissa platser, särskilt från Ädnamvaara, Maria Taavenikkus Gata och Luossavaara. Det innebär att byggverksamhet, inklusive rörelse, ljus, borttagande av vegetation och nya strukturer kommer att vara synliga och att ha en stor negativ påverkan.

Den största påverkan på landskapsbilden kommer uppstå under driften eftersom dagbrott, gråbergsupplag och sandmagasin kommer att vara aktiva och mycket synliga. Få områden kommer att ha återställts eller vara efterbehandlade vid det här laget. Elledningarna som går över den norra delen av området kommer att flyttas utanför anläggningen. Detta innebär en försumbar förbättring av områdets visuella påverkan. Utsläppsplymer kommer att vara mycket synliga i kallt väder. Utsiktspunkter väster, norr och öster om platsen kommer att påverkas särskilt negativt. De viktiga siktlinjerna för visuella receptorer mellan Luossavaara och Ädnamvaara samt mellan staden och de höga bergen i norr och väster kommer att försämras.

Vid gruvstängningsfasen kommer den övergripande påverkan på landskapsbilden att vara liknande som för under drifttiden. Någon gång under stängningen kommer gruvbrytningen att upphöra, vilket bland annat resulterar i att de mycket synliga utsläppsplymerna upphör vid kallt väder. Denna landskapsanalys förutsätter att det kommer att finnas en överlappning mellan start av gruvstängningen och avslutande av gruvbrytningen, vilket kommer att innebära en stor påverkan på landskapsbilden. Utsiktspunkter väster, norr och öster om platsen kommer att påverkas särskilt negativt.

Tio år efter stängning, efter att alla byggnader och infrastruktur tagits bort, kommer området att bli ekologiskt och visuellt integrerad i omgivningen. Deponierna och upplagen kommer att vara mycket mindre framträdande, eftersom de kommer att utformas naturligt (med hjälp av geomorfologisk design) och därmed integreras med det omgivande naturliga landskapet. Området kommer långsamt återetableras av vegetation och detta kommer att förstärka integrationen med omgivande landskap ytterligare. Alla vyer kommer att förbättras, jämfört med de tidigare faserna av verksamhet på plats. Särskilt vyerna från E10 och de viktiga utsiktspunkterna på Ädnamvaara och Luossavaara kommer att förbättras. Siktlinjerna kommer dock att förbli väsentligt negativt påverkade jämfört med innan gruvetableringen eftersom Viscariaområdets nya landformer kommer förhindra siktlinjerna mot bergen i väster.

Kumulativa effekter

De huvudsakliga kumulativa effekterna på landskapet är:

- Minskad upplevelse av lugn, avskildhet och vildmark i Fjäll-björkskogen
- En växande visuell barriär mellan staden och naturen i väster
- • Fragmentering av landskapet
- Minskad platskänsla
- Minskad känsla av avskildhet och vildmark runt Máttaráhkká Northern Lights Lodge
- Minskad tillgång till området för allmänheten
- De huvudsakliga kumulativa effekterna på landskapsbilden är:
- Minskad visuell koppling mellan Kiruna och vildmarken/västra fjällen
- Utsläppsplymer
- Ljus som påverkar natthimlen vintertid
- Nya utsiktspunkter relaterade till stadsflytten
- Förändrad upplevelse av landskapet från bilvägen till Kiruna norrifrån via E10 nattetid

Förmildrande åtgärder

Stor beaktning måste tas till förmildrande åtgärder, särskilt under projekte-rings- och byggfasen. Vissa förmildrande åtgärder har redan vidtagits. Dessa är:

- Geomorfologisk design – naturlig utformning av gråbergsupplag och sandmagasin. Designen främjar ekologiska funktioner och bidrar till en effektivare ekologisk efterbehandling av området
- Borttagning av vindkraftverk och flytt av kraftledning, vilket minskar områdets synbarhet
- Flytt av Ädnamvaaraleden till en ny sträckning utanför gruvom-rådet

Utöver de åtgärder som redan vidtagits bör fler genomföras. Några rekommendationer:

- Minimera ytorna som tas i anspråk inom området, så att vegetation skadas i mindre utsträckning. Detta kommer att minska både påverkan på upplevelsen av landskapet och landskapsbilden under gruvans drifttid. Det kommer även att underlätta den ekologiska efterbehandlingen
- Begränsa synbarheten av deponier och sandmagasin ytterligare. I synnerhet är det viktigt att skydda de viktiga siktlinjer som identifierats i denna landskapsanalys
- Minimera utsläppsplymer
- Minimera ljusföroreningar och buller

Övervägas att skapa fler möjligheter för allmänheten att ta sig genom och förbi projektområdet, från tätorten till den omgivande naturen.

NON-TECHNICAL SUMMARY

A landscape and visual impact assessment (LVIA) of the landscape and visual effects of Copperstone Viscaria AB's proposed re-opening of the Viscaria copper mine at Kiruna has been carried out to identify the significant landscape and visual effects of the proposed project.

The European Landscape Convention defines "landscape" as

> *"…an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors."*

LVIA is a tool used to identify and assess the likely significance of effects resulting from a development on the landscape both as an environmental resource in its own right and on people's views and visual amenity.

Protecting the visual aspects of landscapes is enshrined in Sweden's Environmental Code and the protection of landscapes more generally also derives from Sweden's ratification of the European Landscape Convention. Responsibility for implementation is shared between all authorities, county administrative boards and municipalities.

This document is a non-technical overview of the LVIA and is aimed at a non-specialist audience. It summarises the detailed, technical LVIA report written in support of the project's environmental permit application and is not intended to convey all of the information to be found in the main LVIA report.

The Viscaria site

The Viscaria site is an ecological, socio-economic, visual and cultural transition zone, or figurative corridor, between the urban – industrial complex of Kiruna and the surrounding Arctic wilderness, inhabited by traditional Sami reindeer herding communities. This visual and physical accessibility of the wilderness is a key element of the cultural identity of Kiruna's people.

The site consists of the previously worked Viscaria copper mine, which closed in 1997. It is located immediately northwest of LKAB's Kiruna iron ore mine and about three kilometres west of Kiruna town in Kiruna municipality, Norrbotten County, in the far north of Sweden. The total surface area of the Viscaria project area is 858 ha, with a perimeter length of 11.5 km.

The proposed project aims to re-open the Viscaria copper mine. The mineral resource at Viscaria is estimated at approximately 59 million tonnes of copper ore and about five million tonnes of iron ore. The new mine will consist of open pit mining operations, including blasting rock and hauling ore-rich rock to the processing plant and waste rock to waste rock dumps. Mineral processing wastes (tailings) will be stored in a tailings impoundment. A range of surface buildings will be built to house processing facilities, offices, workshops and warehousing. Infrastructure will be built to provide services to the mine and allow the road and rail transport of goods and people to and from the site.

The project's main activity phases will consist of construction, operations, mine closure and ecological restoration and post-closure monitoring and aftercare. The precise nature of the activities in each phase differs, with correspondingly different landscape and visual effects. The LVIA analysed each phase of activity separately informed by good international industry practice, principally the Guidelines for Landscape and Visual Impact Assessment, third edition (The Landscape Institute); An Approach to Landscape Character Assessment and An Approach to Landscape Sensitivity Assessment – to Inform Spatial Planning and Land Management (both by Natural England). There is no formal Swedish guidance relating to a methodology for performing an LVIA.

Methodology

Landscape and visual impact assessments are separate – although linked – processes, with their own specific methodologies. The first stage in both determines the landscape or visual baseline, the purpose of which is to provide the project's landscape and visual contextual information. This is then reviewed together with the project description to predict the project's likely effects upon the landscape and visual amenity. These effects are then evaluated and, if necessary, recommendations for mitigation and management of the effects are proposed.

The landscape and visual baseline studies synthesised information derived from desktop review of existing information, site visits, discussions with stakeholders and the computer modelling of views (viewshed modelling). Photomontages of the site were also prepared for some specific viewpoints showing the current view and a predicted view during site activities. The LVIA was affected by restrictions to travel and face-to-face meetings during large parts of the study phase.

A dark skies/ lighting impact assessment was also carried out and is available as a supplementary report to the LVIA.

Baseline

A 10 km study area centred on the Viscaria site was determined for the landscape and visual impact assessment. The study area overlays various different landscape features, designations, land-uses, habitats and cultural associations. The project area is close to a number of national natural protected areas, including two Natura 2000 sites, and overlaps with areas of national interested for nature conservation, outdoor life and recreation. Kiruna city and LKAB are also nationally recognised. The views from Kiruna to the distant high mountains to the north and west, including four of Sweden's 13 mountain peaks over 2,000m, including Kebnekaise, the highest are also culturally highly valued. At the scale of the Viscaria study area such features and values interact to produce a complex, dynamic and integrated natural, socio-economic and cultural landscape concentrated into a small area.

Landscape character is a distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another. Landscape character areas are single unique areas consisting of their own discrete geographies.

The former Viscaria mine site is now partly revegetated with a landscape character that transitions between wilderness on one side and intense, degraded mining lands and urban development on the other. A further cultural and depth of time aspect to the landscape character is the occupation of the land by the Sami for thousands of years. They also husband reindeer, which are sensitive to mining-related disturbance.

The site is highly visible from many parts of Kiruna and the surrounding wild landscapes and transport routes from the north. The extensive, heavily degraded, adjacent mining landscape of LKAB provides a stark visual contrast to the qualities of the current Viscaria site. The Viscaria site also offers a visual 'pathway' for most visual receptors towards the wilderness and mountains beyond Kiirunavaara and LKAB. Viscaria is prominent from many locations; the space it occupies is a valued 'gap' through which the Kiruna residents and visitors can access – physically or emotionally – the wilderness on their doorstep. In winter and at night, the dark skies and lack of lighting over Viscaria enhance this perceptual corridor to the wilderness and enables views of the aurora borealis, which is also promoted to visitors.

A local landscape character assessment was conducted to identify the main landscape receptors in the vicinity of the project, before the impact analysis could be carried out. The features of each of the four local landscape character areas (LLCAs) identified are summarised below:

- **Kiruna Mining LLCA:** a highly dynamic, denuded and degraded, unnatural mining landscape that includes the Viscaria site and is closely associated with the Kiruna Urban LLCA. As a contradiction, although it is of low value ecologically it contains areas of former mining activity that are now quite well vegetated and add to the LLCA's character. Also, it is of high value culturally and is nationally designated as such, along with Kiruna town. There is a strong sense of place and cultural identity, with a distinctive skyline and landforms that dominate the surroundings, and social acceptance among local people. The dynamism of its landforms offers a low degree of vulnerability.
- **Kiruna Urban LLCA:** a culturally significant and dynamic townscape and architecture developed in response to the environmental, social and economic challenges of developing a major industrial town in a remote Arctic location. It is nationally recognised for its cultural significance. However, it is also a dynamic town and is – paradoxically – simultaneously conserving, reinventing and relocating its townscape and community through the necessity induced by encroaching mining subsidence. Its frontier spirit and closeness to extensive, wild terrain augments the already strong sense of place and cultural identity, which is heavily influenced by the other LLCAs described here.

- **Mountain Birch Forest/ Fjällbjörkskogen LLCA:** a pristine, tranquil, Arctic wilderness, dominated by expansive mountain birch forest and wetlands. It is easily accessible within the vicinity of Kiruna and is essential to the local tourism provision and a cultural and recreational foundation for the sense of identity of local people. The views from Ädnamvaara are exceptional. It is designated internationally and nationally for the integrity of its ecological systems and biodiversity. It is formally recognised as traditional Sami lands.
- **Coniferous Forest/ Barrskogen LLCA:** As for the Birch Forest/ Fjällbjörkskogen LLCA, this LLCA is characterised as a pristine, tranquil Arctic, forested wilderness, dominated by evergreen, coniferous trees. Both LLCAs are continuous with one another; however, the Viscaria site is located at some distance from the closest part of the Coniferous Forest/ Barrskogen LLCA. Like the Mountain Birch Forest/ Fjällbjörkskogen LLCA, it is easily accessible from Kiruna and is essential to local tourism and reinforces the sense of identity of local people. It is also designated internationally and nationally for its ecological values and is formally recognised as traditional Sami lands.

Many aspects of the visual amenity and character of the study area are highly valued by residents and visitors alike and are promoted widely to encourage tourism. Visually the area is highly diverse, offering valued views of wilderness and distant Arctic mountain scenery, and views of a variety of urban settings and heavily degraded land. This diversity is exacerbated by the marked visual differences relating to the intense seasonality – the vistas change rapidly and often. Seventeen viewpoints were assessed for their value, susceptibility and sensitivity from different parts of Kiruna city and the countryside surrounding the Viscaria site.

Assessment of landscape and visual effects

Over the mine's life, its predicted landscape and visual effects will include: the movement of vehicles and machinery, presence of people, noise, vibration, lights, reflections, odours, removal of pre-existing infrastructure, vegetation removal, soil clearance, unnatural landforms, vertical and linear structures, signage, emissions plumes, dust, discolouration of water courses/ bodies, and re-vegetation/ planting schemes. Each effect will not be considered alone by the landscape observer/ user, but will form an ensemble of interacting effects. Such effects will vary in severity according to the stage in the mine lifecycle, but also with the varying duration of time during day- and night-time and between winter and summer. Some of these effects are likely to adversely influence reindeer behaviour with potential socio-economic impacts on the reindeer herders.

The severity of the effects will be mitigated by modifying the locations and designs of the project's elements and through further management actions during the life of mine. Such mitigations are taken account of during the assessment of the significance of project effects (becoming residual effects).

The significance of the project's predicted residual landscape and visual effects were determined for the following stages in the life of mine:

- **Construction** – assuming peak construction activity, including removal of existing wind turbines, land clearance and the appearance of new structures;
- **Operations** (**year 5**) – the period of the maximum extent of ore production and related landscape and visual effects, including the waste rock dumps and tailings impoundment prior to most of the mitigations being applied, emissions plumes, noise and vibration;
- **Closure** – assuming the peak of mine closure activity, including demolishing structures, backfilling, reclamation and restoration of the waste rock dumps and tailings impoundment and revegetation, and
- **Post-closure** (**year 10**) – site appearance 10 years after mine closure when the process of ecological restoration will under way, but the trees will be small in stature due to slow growth rates.

Overall, at the landscape level, the Birch Forest/ Fjällbjörkskogen LLCA was determined to be the most sensitive to the Viscaria development. This is the easily accessible gateway to the wilderness for many Kiruna residents and visitors. Its landscape character will be degraded by the project development to the extent where a 'wilderness' experience in the Ädnamvaara area will be diminished.

Significant residual, adverse visual and landscape effects will occur in all four LLCAs during construction, but particularly the Kiruna Mining LLCA and the Mountain Birch Forest/ Fjällbjörkskogen LLCA. The effects on the latter are of particular concern. These effects will include: a change in land cover, colour and texture; the appearance of new structures; noise and lighting pollution; and movement of vehicles and the presence of people. Visual effects will particularly affect receptors within 5 km to the west, north and east of the site, including Ädnamvaara Cottage, Ädnamvaara Trail, E10 north of Kiruna, Máttaráhkká Northern Lights Lodge, Maria Taavenikkus Gata, Luossavaara car-park and Luossavaara summit.

Many of the construction phase's residual adverse, visual and landscape effects will transfer into the operations phase. Particular new effects will result from the growing waste rock dumps and tailings impoundment, lighting intrusions and emissions plumes. Most affected will be the Mountain Birch Forest/ Fjällbjörkskogen LLCA and the visual receptors mentioned above, including impacts on the landscape character and visual obstructions and intrusions.

The severity of effects will start to decline during the mine closure phase as, for example, emissions plumes disappear and prominent landforms become re-shaped into more natural-looking features. The site will still emanate light and noise and the reclaimed land will have little noticeable vegetation to assist visual integration into its surroundings.

Ten years after closure there will be remaining, but small, landscape effects, primarily on the Mountain Birch Forest/ Fjällbjörkskogen LLCA, but some important effects on visual receptors will remain resulting mainly from the dimensions of the new landforms.

In terms of visual effects, the construction phase could be partly beneficial with the removal of the existing wind turbines. Their removal will initially

reduce the visibility of the site to visual receptors especially in the north of the area because the movement of the existing wind turbines, which draws the viewer's attention to the site, will be removed so the site will be become less obvious for a while during construction. With increasing elevation and distance from the northern perimeter, particularly from the Ädnamvaara, Maria Taavenikkus Gata and Luossavaara areas, most of the site will be visible, which means all of the construction activity, including movement, lights, ground clearance and new structures will be highly visible and will have a major adverse impact.

The site will be at its most visually intrusive during operations because the open pits, waste rock dumps and tailings impoundment will be highly visible and active. Few areas will have been reclaimed and ecologically restored by this time. The powerlines across the northern part of the site will be relocated off-site, marking a negligible improvement in the site's visual perspective. Emissions plumes will be highly visible in cold weather. Viewpoints to the west, north and east of the site will be particularly adversely affected. The important sight-lines for visual receptors between Luossavaara and Ädnamvaara, and between the city and the high mountains to the north and west, will be degraded.

At the height of mine closure activities, the overall visual effects will be similar to those for operations. At some time during closure, mining and processing activities will end, resulting in – amongst other things – the end of the highly visible plumes during cold weather. This analysis assumes that there will be an overlap between the start of closure activities and the ending of processing activities, which will mean high site visibility. Viewpoints to the west, north and east of the site will be particularly adversely affected.

Ten years after closure and the removal of all buildings and supporting infrastructure, the site will be becoming ecologically and visually integrated into its surroundings. The once highly visible and incongruous waste rock dumps and tailings impoundment will be much less so, as the natural-looking (geomorphically designed) final landforms integrate with the surrounding natural landscape, while the site's slowly growing vegetation cover will reinforce this integration further. All views will be improved, compared to the previous phases of on-site activity and particularly those from the E10 north and the key viewpoints in the Ädnamvaara and Luossavaara areas; however, the views will remain significantly adversely affected compared to the baseline. The sight-line between the latter sites will always be impeded by the new landforms to some extent.

Cumulative effects

The main cumulative effects on the landscape relate to:

- Degradation of the perceptions of tranquillity, remoteness and wilderness of the Mountain Birch Forest/ Fjällbjörkskogen LLCA,
- A growing visual and perceptual barrier between the city and the wilderness to the west,
- Landscape fragmentation due to Viscaria interacting with other planned developments around the north Kiruna area,
- Weakening of the sense of place,
- Perceptions of remoteness and wilderness around Máttaráhkká Northern Lights Lodge, and
- Effects on public access.

The main cumulative visual effects relate to:

- Visual connectivity between Kiruna and the wilderness/ western mountains,
- Emissions plumes,
- Dark skies,
- New viewpoints and receptors relating to the city's relocation, and
- Approaches to Kiruna from the north on the E10 at night.

The visual effects are not mutually exclusive and neither are the evident interactions between the landscape and visual cumulative effects.

Great consideration must be given to mitigation, particularly designing-in avoidance during the design phase. Some effects have been addressed to by design mitigation. To date, these include:

- Geomorphic design – natural-looking landform designs for waste rock dumps and the tailings impoundment that also create more naturally functional landforms. The designs should also promote more effective ecological restoration,
- Removal of wind turbines and relocation of powerlines, reducing effects on visual receptors and landscape character, and
- Relocation of the Ädnamvaara Trail to a location further removed from the mine site.

However, although these design mitigations are commendable, further planned avoidance of effects is required and are best designed-out. Some recommendations include:

- Minimising the footprint of disturbance on-site, so less vegetation cover is damaged, which will reduce visual and perceptual effects of the site during the life of mine and aid the ecological recovery of damaged areas.
- Further reducing the visual effects of the waste rock dumps and tailings impoundment, in particular protecting important sightlines identified in the LVIA,
- Reducing emissions plumes, and
- Reducing light pollution and noise.

Creating opportunities for more public access across the Kiruna Mining LLCA, from the town to the wilderness, should also be considered.

ABBREVIATIONS AND ACRONYMS

EIA – environmental impact assessment

LCA – landscape character area/ assessment

LLCA – local landscape character area

LOM – life of mine

LVIA – landscape and visual impact assessment

masl – metres above sea level

TMF – tailings management facility

WRD – waste rock dump

ZTV – Zone of theoretical visibility

1. INTRODUCTION

The Swedish copper exploration and mining company, Copperstone Viscaria AB (Copperstone Viscaria), is preparing an application to the Land and Environment Court in Umeå for an environmental permit to open the former Viscaria copper mine (Viscaria, or the project), at Kiruna, Sweden. Future Terrains and Ecogain were engaged by Copperstone Viscaria to carry out a landscape and visual impact assessment (LVIA) of the project in support of the permit application. Future Terrains and Ecogain have previously worked on projects in the Kiruna area and are familiar with the city, its mining activities, landscape and climate.

The scope of the LVIA was determined by Copperstone-Viscaria and Future Terrains and Ecogain. The permitting authority did not provide specific guidance as to what was required for an LIVA in the context of the Viscaria project, other than an LVIA was required as part of the EIA process.

In the absence of formal Swedish regulation or guidance relating to a methodology for performing an LVIA, we have opted to follow good international industry practice as presented in The Landscape Institute's and the Institute of Environmental Management and Assessment's (IEMA's) Guidelines for Landscape and Visual Impact Assessment of 2013.

1.1 Report structure

This report consists of the following sections:

1. **Introduction** – the rationale and scope of this baseline report.
2. **Project description** – a brief background to the Viscaria project and a summary of the project in relation to the landscape and visual baseline perspective.
3. **Legislation and planning context** – the national, regional and local regulatory and planning context as it pertains to Viscaria and LVIA.
4. **Methodology**
5. **Landscape baseline** – a description of the wider landscape context of the project area, then a detailed analysis of local landscape character areas.
6. **Visual baseline**
7. **Assessment of landscape and visual effects**
8. **Cumulative effects**
9. **Conclusions**
10. **References**

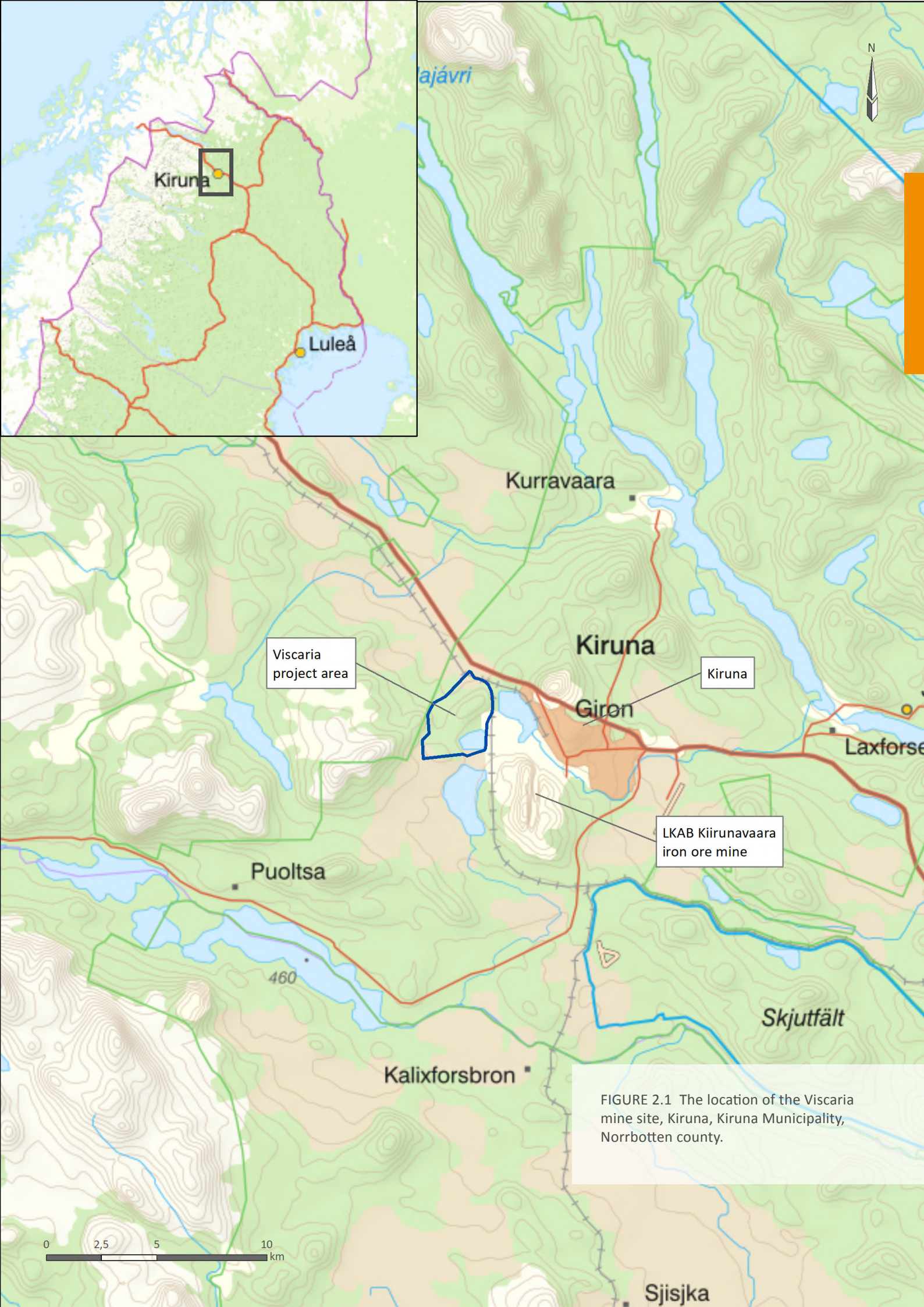


FIGURE 2.1 The location of the Viscaria mine site, Kiruna, Kiruna Municipality, Norrbotten county.

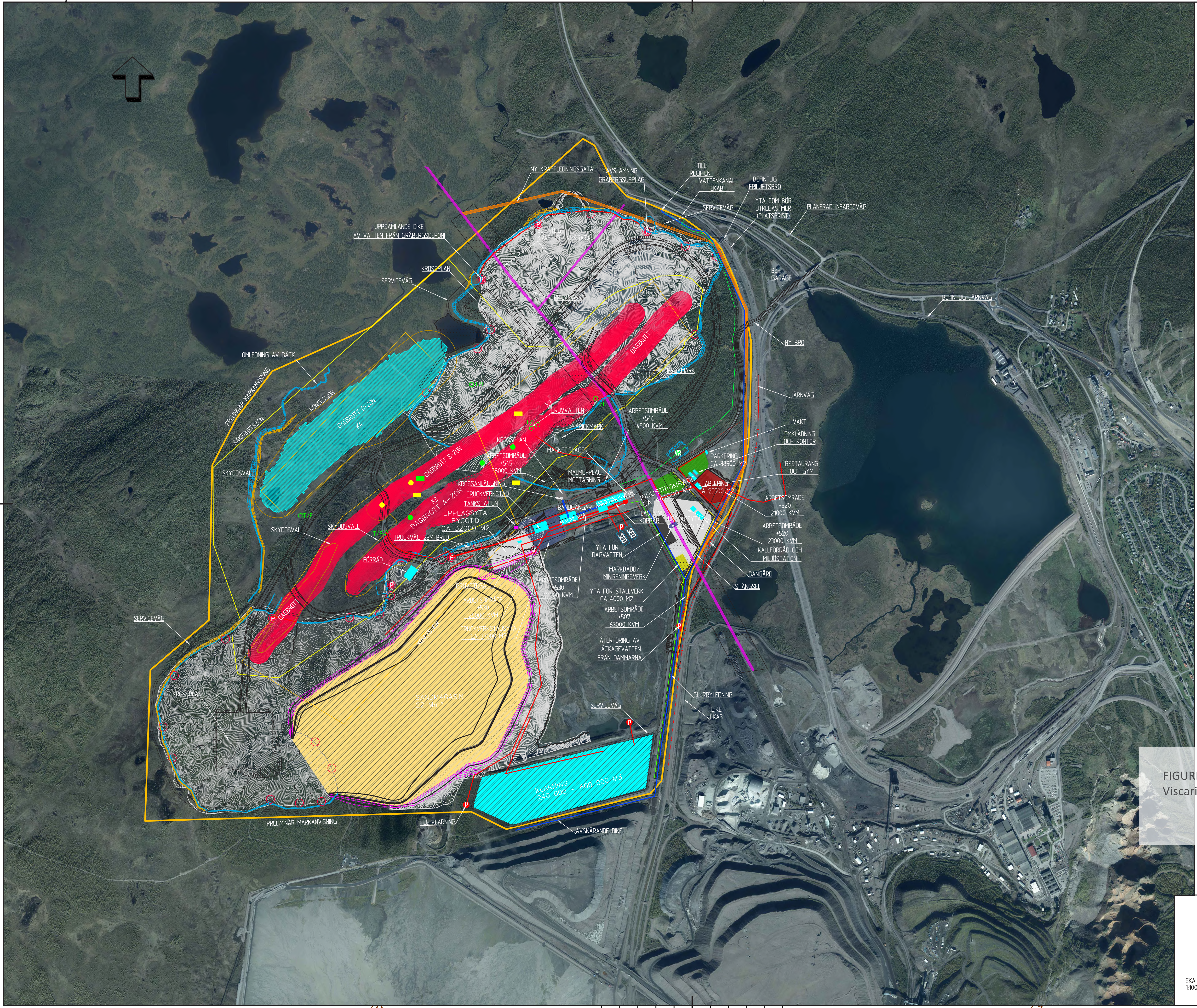


FIGURE 2.2 Proposed layout for the Viscaria copper mine

TECKENFÖRKLARING

MARKANVÄNDNING

- KLARNINGSMAGASIN
- GRÅBERGSDEPONIER
- GRÖNYTOR

VATTENHANTERING

- DIKESSYSTEM
- LEDNINGSSTRÅK
- LEDNINGSSTRÅK
- BV — BUFFERTVOLYM/BRANDVATTENRESERVOAR
- P — PUMPSTATION
- F — FÖRTJOCKARE
- BEFINTLIGT SCHAKT SOM KAN ANVÄNDAS FÖR VATTENUPPFODRING OCH VENTILATION. (STÄNGS INNAN DE TÄCKS MED GRÅBERG)
- EVENTUELLA NYA SCHAKT FÖR VATTEN, VENTILATION M.M.
- GAMLA INGÅNGAR (STÄNGS INNAN DE TÄCKS MED GRÅBERG)
- NY INGÅNG
- SED — SEDIMENTATIONSBASSÄNG
- VR — VATTENRENING
- LOCAL BASE LEVEL

GRUVA

- DAGBROTT
- OT/F — TILL OCH FRÅNLUFT GRUVA

ANMÄRKNINGAR

VATTEN FRÅN PUMPSTATION GRUVA TRYCKSTEGRAS OCH ANSLUTS TILL BUFFERTVOLYMEN.

VATTEN FRÅN SANDMAGASINET SKA STYRAS MOT KLARNINGSMAGASINET (EJ VIA BEFINTLIGT SANDMAGASIN)

MARKNIVÅ VID INDUSTRIOMRÅDET ÄR FASTSTÄLLD TILL +528 (RH 2000).

UPPSAMLANDE OCH AVLEDANDE DIKEN ÄR UNDER UTREDNING.

FRÅN UTOMHUSSTÄLLVERKET DRAS 130 KV-LEDNINGAR TILL 2 ST. TRANSFORMATORER SOM PLACERAS SÅ NÄRA VERKSAMHETERNA SOM MÖJLIGT (CA 500 M² SKA STÄLLAS I ORDNING FÖR DETTA).

20 KV-LEDNINGAR DRAS FRÅN TRANSFORMATORER TILL FÖRDELNINGSSTÄLLVERK I ANRIKNINGSVERKET. DÄRIFRÅN FÖRDELAS MATNINGAR UT TILL PUMPSTATIONER (20 KV).

SERVICEVÄGAR ANLÄGGS LÄNGS DIKEN OCH LEDNINGSSTRÅK, SAMT GRUVFUNKTIONER SÅSOM TILL/FRÅNLUFT.

GEOMORFISK DESIGN AV DEPONIER BYGGER PÅ ATT YTORNA AVVATTNAS MOT LOCAL BASE LEVEL (LBL) SOM ANSLUTER TILL BEFINTLIG TOPOGRAFI.

COPPERSTONE VISCARIA
OMRÅDESLAYOUT V 1.7
2022–01–28

SKALA 1:10000 0 100 200 300 400 500 1000 m

2. PROJECT DESCRIPTION

2.1 Summary project description

The site consists of the previously worked Viscaria copper mine, which opened in 1982 and closed in 1997. The planned area of activity is located immediately northwest of LKAB's Kiruna iron ore mine and about three kilometres west of Kiruna town in Kiruna municipality, Norrbotten County, in the far north of Sweden (Figure 2.1).

Current on-site activities include mineral exploration to further define the orebody and environmental and social investigations relating to the environmental and social impact assessment (ESIA) in support of the application for an environmental permit.

The current mineral resource at Viscaria is estimated at approximately 59 million tonnes of copper ore with an average content of over 1.2 per cent copper and about 5 million tonnes of iron ore (magnetite) with an average content of 26% iron.

The total surface area of the Viscaria project area is 858 ha, with a perimeter length of 11.5 km. The project will consist of the following main components:

- Several open pits trending northeast to southwest across the site. The largest will be about one kilometre long. The pits will be focused in three areas, the A, B and D zones,
- Two main waste rock dumps: the Northern Deposit containing 60 Mt, with an elevation of 605 masl and a footprint of 141 ha, and the Southern Deposit with a capacity of 30 Mt, a height of 630 masl and a footprint of 110 ha,
- Pre-existing, old waste rock dumps,
- Pre-existing old open pits,

- Pre-existing TMF.
- Soil stockpile,
- Moraine bund,
- Primary crusher,
- Processing plant,
- Concentrator,
- Ore stockpiles,
- Copper storage area,
- Magnetite storage area,
- Tailings management facility: capacity 22 Mm^3, elevation 562 masl and footprint 117 ha,
- Clearing pond (240,000 – 600,000 m^3),
- Pre-existing, old tailings management facility,
- Explosives storage,
- Fuel storage,
- Truck workshop,
- Railway and loading area,
- Haul roads,
- Access roads,
- Water treatment plant,
- Sewage treatment plant,
- Administration offices,
- Car parks,
- Services supplies - water, power.

These components are located as shown in Figure 2.2.

The project's main activity phases will include:

1. Construction – enabling works, including preparing access, security, lay-down areas, land clearance, worker facilities, car-parks, equipment maintenance and refuelling areas, signage, removal of six on-site wind turbines and a power line; and construction proper, including preparing the open pits, processing plant, mineral waste areas and the necessary associated infrastructure and ancillary facilities, including utilities supplies, internal roadways and site access roads from outside, including a level-crossing over the railway.

2. Operations – mine development, extraction and processing of the ore materials (including from old mineral wastes), the management and storage of mineral wastes (waste rock and tailings), maintenance of vehicles, infrastructure and services, site management and administration, export of ore materials, importation of materials and equipment, environmental monitoring and management, progressive restoration.

3. Closure and ecological restoration – the cessation of mining activities, removal of infrastructure and re-grading of WRDs prior to ecological restoration.

4. Post-closure monitoring and aftercare – prior to formal relinquishment, there will be a period of years of environmental monitoring and maintenance and aftercare of the remaining access and security infrastructure and ecological management, prior to the relinquishment of the site.

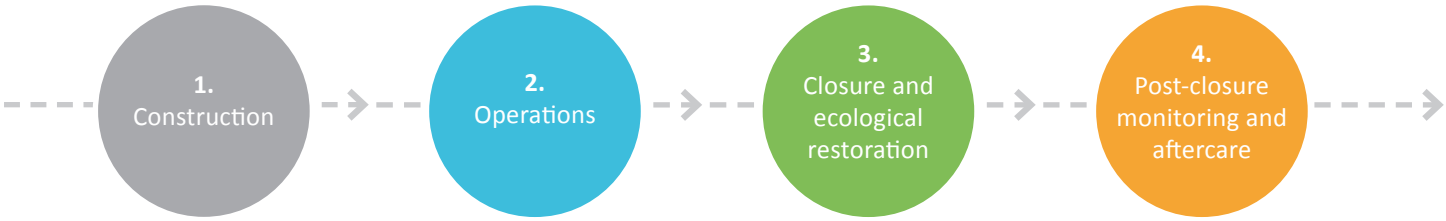


FIGURE 2.3 The projects main activity phases.

3. LEGISLATION AND PLANNING CONTEXT

This section describes the key areas of policy, legislation and regulation as they pertain to landscape and visual assessment of new developments in northern Sweden.

3.1 National legislation

3.1.1 Environmental Code

Prior to enactment of Sweden's Environmental Code in 1998, landscape image protection was a feature of the preceding Nature Conservation Act; however, this was one of the 15 laws that was superseded by the Environmental Code. Landscape image protection aimed to protect the value of the visual experience of a landscape. Some landscape image protection areas remain even after the entry of the Environmental Code, but many have been removed, reorganized or included in other forms of protection under the Environmental Code.

In the Environmental Code, the general rules of consideration in chapter 2 apply, which means that the selection of an area for a specific purpose or activity is achieved with minimum encroachment and inconvenience to human health and the environment and includes the visual perception of the landscape.

3.1.2 European Landscape Convention

Sweden ratified the European Landscape Convention in 2011, which entered into force the same year. This means that Sweden has committed itself to incorporating into national legislation the convention's aims to protect, manage and plan the landscape. In connection with the ratification of the convention, the Swedish Parliament determined that existing legislation was sufficient to meet the convention's expectations, so ratification did not require any new laws to be enacted.

In accordance with the Landscape Convention, Sweden shall, among other things:

- raise awareness of the value and importance of the landscape in civil society, in private organisations and in public authorities,
- promote participation in decisions and processes concerning the landscape locally and regionally, and
- develop a holistic view of the landscape's values and sustainable management of these.

No individual authority has sole responsibility for the implementation of the convention in Sweden. Instead, the responsibility is shared between all authorities, county administrative boards and municipalities. These actors must all work to ensure that a landscape perspective is applied in decisions and processes within their operations. As an example, the municipalities' general plans are a tool with the potential to incorporate the convention's aims into community planning.

Relating to the permitting processes for wind power, powerlines, roads and other development activities that may affect the landscape, the permitting authority sometimes requires landscape analyses. There is no nationally accepted standard for the methodology and contents of a landscape analysis; however, there are different methods used in different contexts, for example, the Swedish Transport Administration's Integrated Landscape Character Analysis is used in landscape analysis for planning roads and railways.

3.2 County/ local planning and permitting context

Neither the County Administrative Board of Norrbotten, nor the municipality of Kiruna, have developed specific guidelines or policies regarding landscape and visual analysis, but the landscape perspective is included in other planning documents regarding, for example, green infrastructure and the cultural environment.

3.3 Designated landscapes policy

There are no specific policies for landscape and visual aspects linked to any of the protected and otherwise designated areas in the vicinity of and/or within the project area.

4. METHODOLOGY

4.1 Introduction

The first step in an LVIA is to determine the landscape and visual baselines. The purpose of a baseline study is to provide the project's landscape and visual contextual information, which is then subsequently reviewed together with the project description to predict the project's effects upon the landscape and visual amenity. Then, these effects can be evaluated and, if necessary, recommendations for mitigation and management of the effects are proposed.

The aim of a landscape baseline "is to provide an understanding of the landscape in the area that may be affected – its constituent elements, its character, and the way this varies spatially, its geographic extent, its history, …, its condition, the way the landscape is experienced, and the value attached to it." The aim of a visual baseline "is to establish the area in which the development may be visible, the different groups of people who may experience views of the development, the places where they will be affected and the nature of the views and visual amenity at those points." Although there are overlaps in perception, it is important to keep the landscape and visual baselines and analyses aspects separate, to a degree, to facilitate understanding.

In the vicinity of the project area, no formal landscape character assessments are available, so this study had to conduct its own, bespoke landscape character assessment prior to being able to run the LVIA. This was informed by good practice, namely: Natural England's An Approach to Landscape Character Assessment.

There is no generic LVIA methodology; the methodology should be bespoke and proportionate to the proposed project and its context. The methodology for the Viscaria LVIA has been primarily informed by the following good practice guidance:

- The Landscape Institute's Guidelines for Landscape and Visual Impact Assessment, third edition (GLVIA3).
- Natural England's An Approach to Landscape Sensitivity Assessment – to Inform Spatial Planning and Land Management.

It is important to note that the landscape and visual impact assessments are separate – although linked – processes, with their own specific methodologies. These methodologies are described in detail in the appendices.

The landscape and visual baselines for the Viscaria project were informed by the following activities:

- Desktop review of existing information,
- Site visits,
- Discussions with stakeholders, and
- Viewshed modelling.

These are described in more detail below.

4.2 Desktop review

Documentary information from various sources was reviewed to better understand the landscape and visual context of the project and the wider landscape and visual amenity within which Viscaria sits. The documentary information included:

- Reports and data provided by Copperstone-Viscaria and through the current EIA process,
- Documents in the public domain,
- Maps in the public domain, and
- Remote imagery – satellite and aerial photography, Google Earth.

4.3 Site visits

Site visits were carried out in mid-summer between 16th to 19th June 2021 and in winter between 28th November and 3rd December. The aims of the site visits were to analyse the project site and its landscape and visual context in the two different seasons and to discuss landscape and visual values with local people (where possible).

4.4 Consultations

Discussions related to the landscape character and visual amenity have been held with various stakeholders and, in an inter-disciplinary manner, with various Viscaria EIA consultants during the course of the landscape and visual baseline assessment. The LVIA team were not able to hold formal discussions with the local municipality or Sami reindeer herding communities, who are key stakeholders in the Viscaria project.

4.5 Determining the study areas

Good practice dictates that a study area around the proposed development should be defined in order to assess the current landscape and visual baselines and project effects upon these baselines. There are no hard and fast rules about how to determine the study area, except that the related methodology and resulting study area need to be agreed with the competent authority and other stakeholders. Visibility assessments may require definition of a separate, bespoke study area.

The study area is the area over which there is a likelihood for significant landscape or visual effects. This does not mean that the development will not be observed beyond the study area, but that its effects are unlikely to be significant beyond this area, given intervening landforms, vegetation cover and the close proximity of other industrial structures and landforms to the project site. However, we also have considered Kiruna's culturally important distant views to four of Sweden's 13 mountain peaks over 2,000 m (Kebnekaise, Kaskasatjåkka, Kaskasapakte and Sielmatjåkka).

Due to a lack of specific guidance from the regional and local authorities for determining the landscape and visual assessment study areas for Viscaria, and given the heights and volumes of the proposed structures described in the project description, this LVIA baseline identifies a provisional study area of 25km radius for the broader assessment of regional landscape character. A smaller study area of 10km radius from the site enables a more fine-grained landscape character baseline assessment to be made of the local context. This is a proportionate approach for reviewing the landscape character of the full study area, balancing the levels of detail at the various scales such that the baseline is appropriate for a robust assessment of landscape effects across the full extent of the study area. The study areas for the Viscaria LVIA are shown in Figure 4.1.

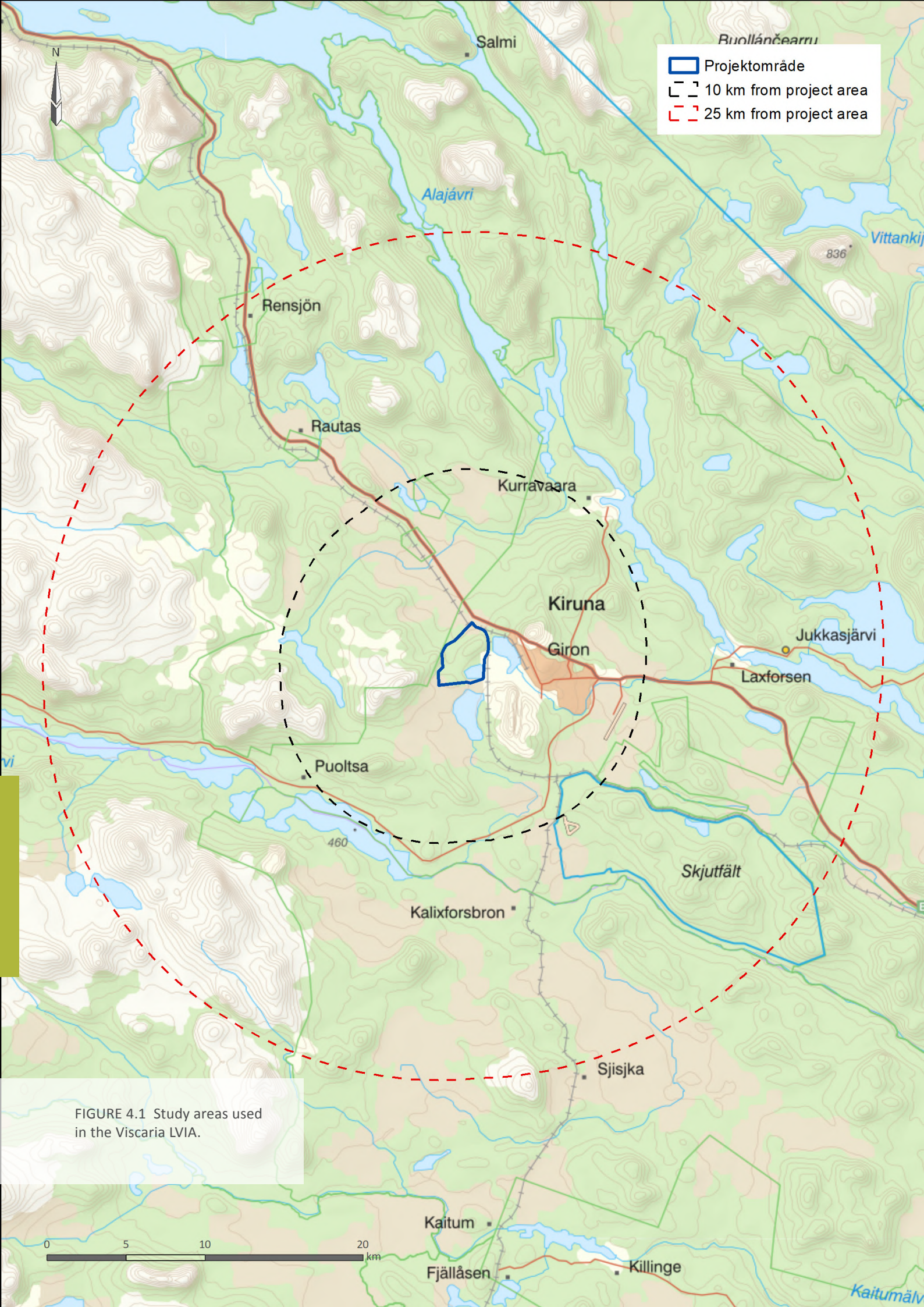


FIGURE 4.1 Study areas used in the Viscaria LVIA.

4.6 Landscape character assessment

The European Landscape Convention (2000) defines "landscape" as:

> *…an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors.*

"Landscape character", as defined by Natural England, is a distinct and recognisable pattern of elements, or characteristics, in the landscape that make one landscape different from another, rather than better or worse. A "landscape character assessment" is the process of identifying and describing variation in the character of the landscape. It seeks to identify and explain the unique combination of elements and features (characteristics) that make landscapes distinctive. This process results in the production of a landscape character assessment. This matters because change is an important aspect of landscape character. The responsible management of that change is essential to ensure that sustainable outcomes are achieved. The decision-makers involved in managing change need to understand the baseline conditions for a landscape and, also, the implications of their conditions upon that baseline. Landscape character assessment is, therefore, an important tool in informing, managing and guiding change.

Landscape receptors include the constituent elements of the landscape, its specific aesthetic or perceptual qualities and the landscape character of different areas. Owing to the lack of detailed previous landscape character studies near to the study area, it was necessary for this study to conduct a bespoke landscape character assessment to identify the main receptors in the vicinity of the project, before the impact analysis could be carried out.

The landscape character baseline used 25km and 10km study areas (see below). For the former, an existing landscape character assessment for Kiruna municipality was updated and adapted to provide a landscape character baseline for the more fine-grained, 10km study area in the Viscaria project landscape character assessment. A detailed description of the landscape character assessment for the project area is proved in appendix 1A.

4.6.1 Determining landscape values

The baseline study attributes landscape values to the different landscape character areas. Landscape value is the relative value that is attached to different landscapes by society. A landscape may be valued by different stakeholders for a variety of reasons. It is important that the value(s) that society places on landscapes and upon their elements, characteristics and visual qualities that combine to create such places, are used to inform the subsequent landscape sensitivity assessment (part of the impact assessment). The landscape value is then used in the impact assessment in analysing the significance of project effects on the landscape character.

4.7 Visual assessment

4.7.1 Zone of theoretical visibility (ZTV)

Prior to the site visit, potentially significant viewpoints were located using a zone of theoretical visibility (ZVT) assessment and by reviewing maps. During the site visit, the views and visual receptors at these locations were assessed to inform the visual baseline for subsequent impact assessment.

A zone of theoretical visibility analysis (ZTV analysis) is used to test the elevations of a development against a 3D terrain model, which is usually a bare earth model. This means that it does take not into account the screening effects of buildings or vegetation, which usually affect the visibility of the development in reality.

A ZTV analysis was carried out to select prospective viewpoints for the visual baseline assessment and to inform determination of the study areas for the landscape character baseline, because there is a strong general relationship between a project's visibility and its impacts on landscape aesthetics and the perception of remoteness/ wilderness.

Given the visibility of the existing mining structures in the Kiruna area, the ZTV analysis was carried out for 10 km and 25 km radius study areas centred on the Viscaria site. The ZTVs were used to identify viewpoints for the visual baseline assessment and to decide the study area. They were also used to inform the extent of the study area for the landscape character baseline, because there is a strong general relationship between a project's visibility and its impacts on scenic beauty and the perception of remoteness/wilderness.

For the baseline assessment, two different ZTVs were carried out, a bare earth ZTV and a ZTV with additional input accounting for buildings, forests and tree clusters.

Bare earth ZTV

A bare earth ZTV implies a worst-case scenario because it identifies all areas from where an object is theoretically visible and does not account for the screening effects of trees, building and other objects. In reality, the mine will not be visible from all locations within the calculated zone of theoretical visibility; for example, at many locations, the mine may be visible only in winter, when the trees have shed their leaves. This approach was used mainly to understand the visual impact on Kiruna town as buildings are moved or demolished as part of the urban relocation. Figure 4.2 illustrates the bare earth ZTV.

ZTV with additional input

To display a more realistic scenario, a second ZTV was carried out that accounted for buildings, forests and tree clusters. As a result, forested areas and areas behind buildings will be excluded from the theoretical visibility. Even though this scenario is a better representation of reality, it is limited by the resolution of the input data. It also does not take into account that visibility may be higher from some forest areas in winter, for example.

The analyses were carried out using GIS software. As input, altitude data from Lantmäteriet with 50-metre resolution was used. For the second ZTV, forest data with six-metre resolution was delivered by Skogsstyrelsen. To represent the mine, project information about the two WRDs and proposed was used. Twenty-five representative points were selected from tops of building and the WRDs. The eye level of the observer was set to 1.7 metres. The analyses were carried out for an area extending to 25 kilometres from the project area. The project information available at the time of the analysis (September 2021) may change as the detailed design phase continues. The ZTVs thus capture the main features of the impact, but neither of them should be seen as an absolute truth. The ZTV, including trees and buildings, is presented in Figure 4.3.

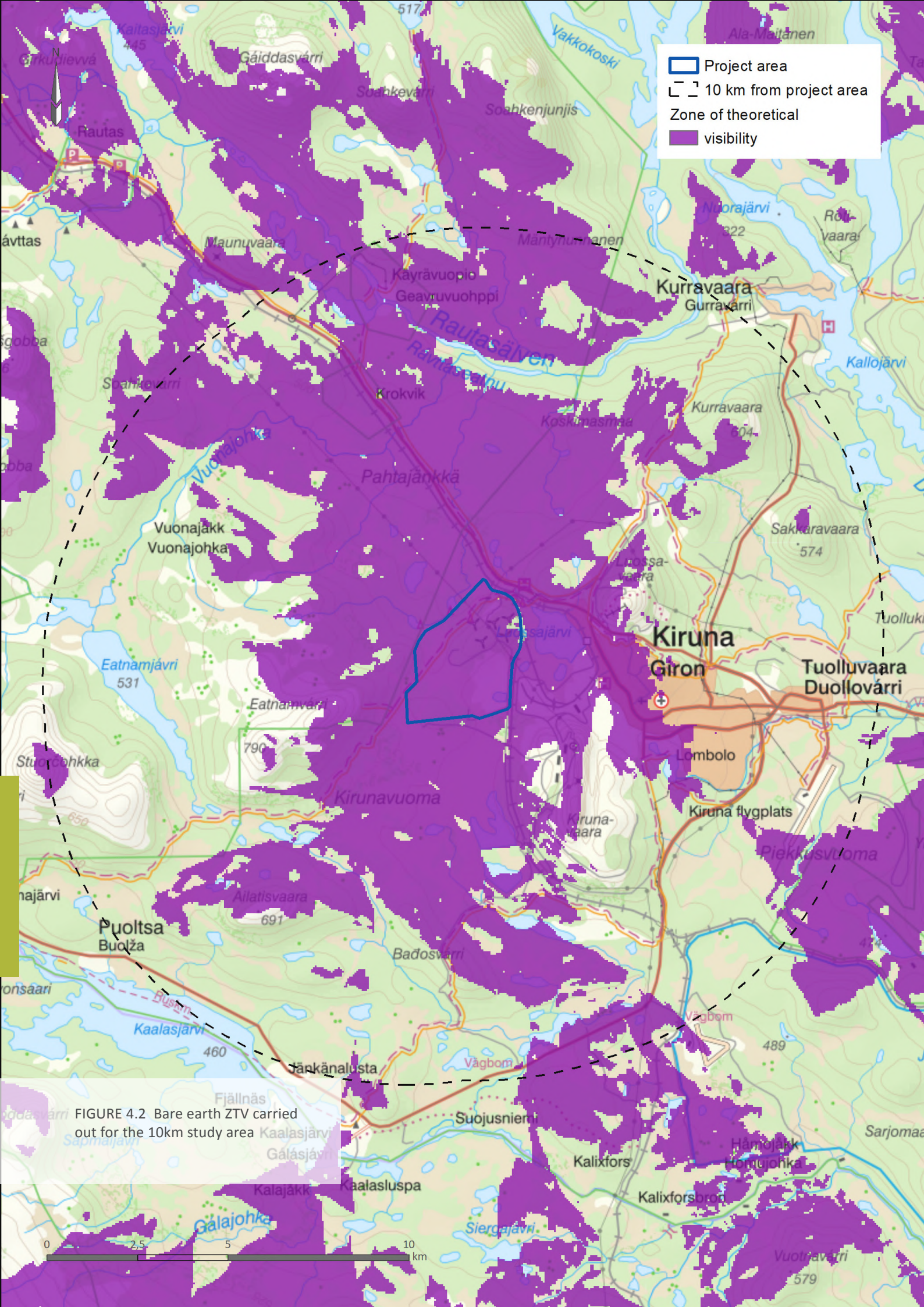


FIGURE 4.2 Bare earth ZTV carried out for the 10km study area

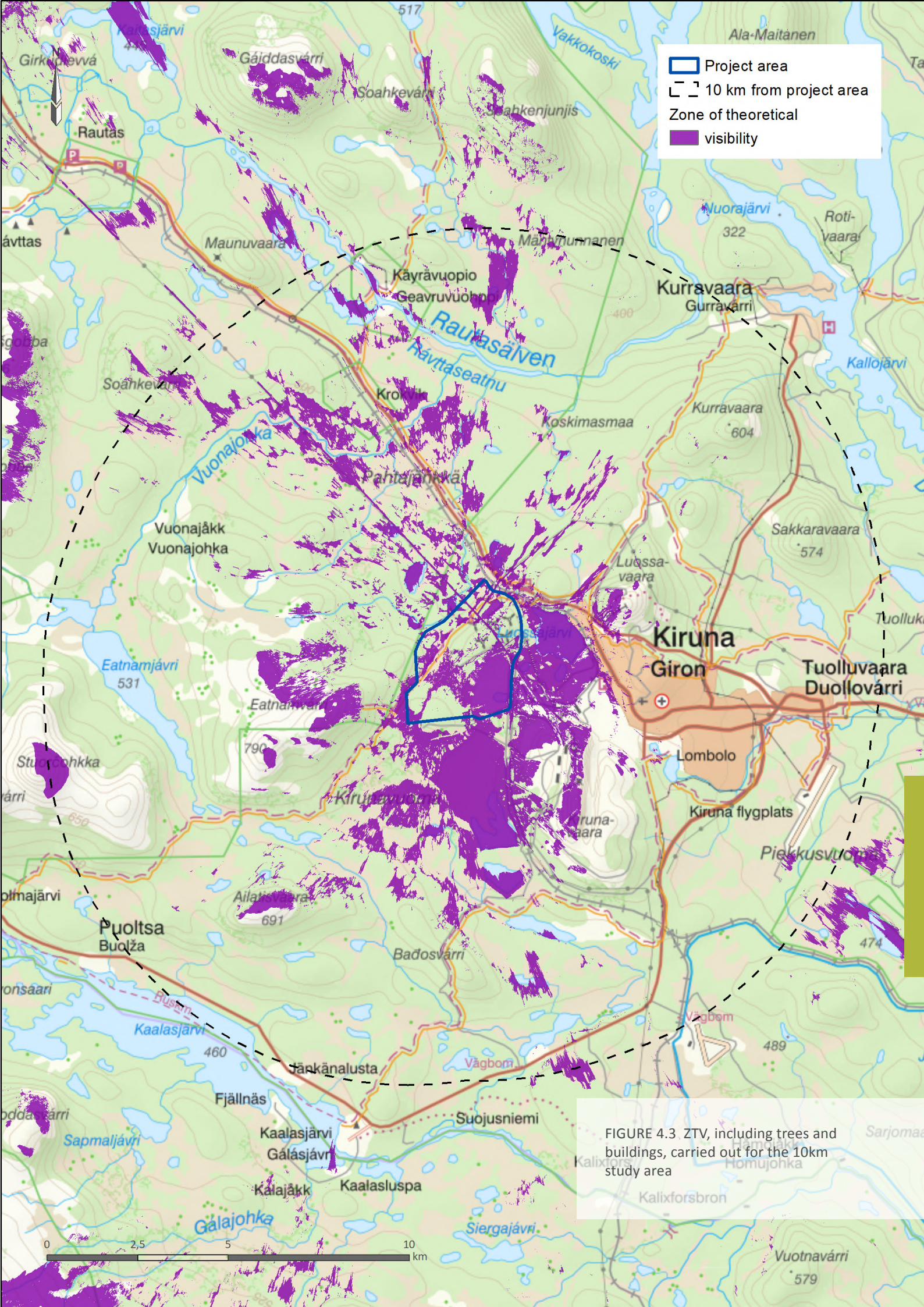


FIGURE 4.3 ZTV, including trees and buildings, carried out for the 10km study area

4.7.2 Viewpoint selection

Viewpoint selection was based on the following criteria:

- Viewpoints should be representative of the likely impacts;
- Viewpoints should show a range of different types of view;
- Viewpoints should be representative of a range of different receptor groups;
- Viewpoints should be representative of a range of distances and directions; and
- Viewpoints should be representative of the varying image of the development within the landscape.

Including consideration of the visual receptors identified above, the selected viewpoints were:

- Public viewpoints – areas of land and buildings providing public access and public trails;
- Transport routes – including views from private vehicles and public transport;
- Places where people live; and
- Places where people work.

Given the cultural importance of views from Kiruna to the distant high mountains to the west and north, these were also considered from some of the viewpoints, although these views extend beyond the ZTV boundary.

It was not possible to gain access to residential properties in order to consider private views, so views from the nearest publicly accessible point at ground level were analysed in several cases, with assumptions made as to the views from floors above ground level.

4.7.3 Visual receptors

Different groups may use, perceive, and value the landscape and its views differently. For the visual impact assessment, it is important to consider different groups of people who may experience views of mine. The following visual receptors were identified during the visual baseline:

- People who live in the area;
- People who work in the area;
- People passing through on transport infrastructure;
- Visitors to promoted landscapes and attractions;
- People engaged in recreation of different types; and (in the case of northern Sweden)
- The Sami reindeer herding communities of the Laevas and Gabna villages.

It was not possible to engage with the Sami reindeer herding communities in relation to the LVIA for the Viscaria project.

4.8 Photomontages

To further illustrate the visual effects, photomontages were created for the views from five key viewpoints. These viewpoints were selected because they represent locations that are frequently visited for different purposes, and the site is highly visible from them according to the ZTV. The photomontages are based on a worst-case scenario, meaning that they illustrate maximum heights of WRDs and before their ecological restoration, and the maximum operational extents of the open pit and TMFs. In the LVIA, although views to the high mountains 70 km distant were considered, it is difficult to meaningfully represent these on a conventional photomontage.

4.9 Impact assessment

The impact assessment processes determine the significances of the predicted project effects on the landscape and visual baselines. The methodologies differ for both and are detailed, but logical, and follow good international industry practice. The details of the impact assessment methodologies are provided in appendix 2 and are summarised in Figures 4.4 and 4.5.

4.10 Dark skies/ lighting impact assessment

The night-time (including winter dark period) is an important and sensitive aspect of the landscape character visual amenity of the project area and its context. Given the sensitivities around dark skies and tourism and the values associated with easy viewing of the aurora borealis in the area, a preliminary artificial lighting impact assessment has been carried out as a supplementary report to this main LVIA report.

4.11 Limitations and assumptions

Owing to ongoing restrictions to travel and face-to-face gathering in response to the Covid-19 pandemic, some aspects of the LVIA methodology were compromised, including limited time in the field. One of the project workers was unable to travel to Kiruna (from the UK) until travel restrictions were lifted in November 2021, which meant limited daylength and periods of poor visibility caused by snow events. Covid restrictions also hindered face-to-face meetings with individuals and groups hindered stakeholder consultations to an extent.

It is usual for the competent authority to provide their expectations of the LVIA and advise on its scope and the extent of study areas and landscape and visual sensitivities and key consultees. However, this information was not forthcoming for the Viscaria LVIA.

During the LVIA process, it was possible to engage and consult with the Sami reindeer herding communities. It is recognised that they are important stakeholders in this regard.

A landscape impact assessment usually uses previous landscape character assessments as a pre-existing baseline for the impact analysis. These were not available for the Viscaria LVIA, necessitating a bespoke local landscape character assessment.

At the time of writing, details for some aspects of the final project description have not been finalised. Consequently, in this LVIA, we have taken a precautionary approach based on a worst-case scenario in terms of assessing maximum heights, scales, locations and massing of the project elements.

For the visual baseline, representative viewpoints were taken from publicly accessible locations; for residential receptors the closest publicly accessible locations were used as representative viewpoints with assumptions made as to views from upper floors. This may be required as a follow-up study.

The precise future route of the popular Ädnamvaara Trail, which is to be relocated by Copperstone, was not known at the time of the site visits, so it was not possible to carry out visual assessments on this route. This will be required at a later stage, once the route is known.

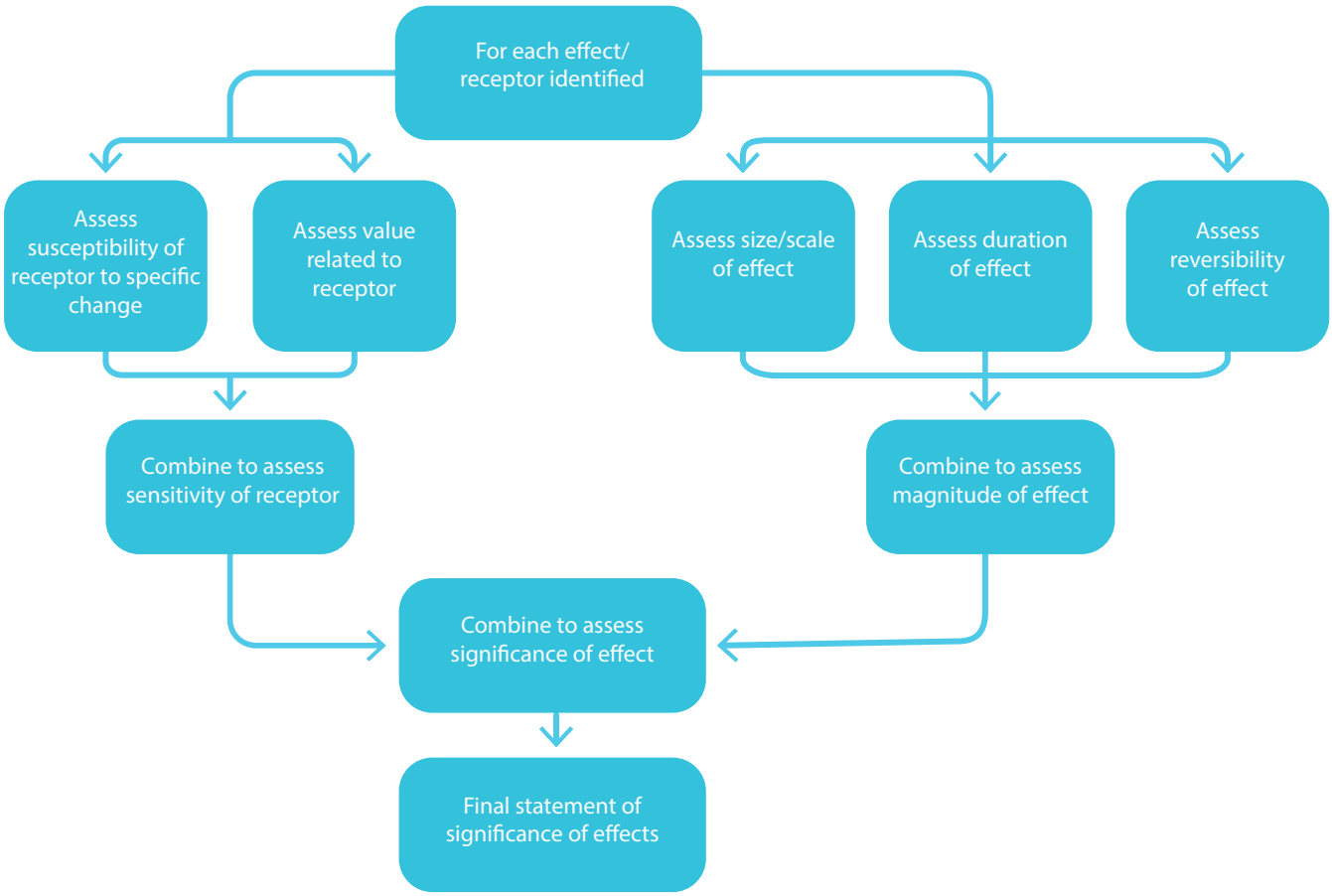


FIGURE 4.4 Methodology for determining the significance of landscape effects

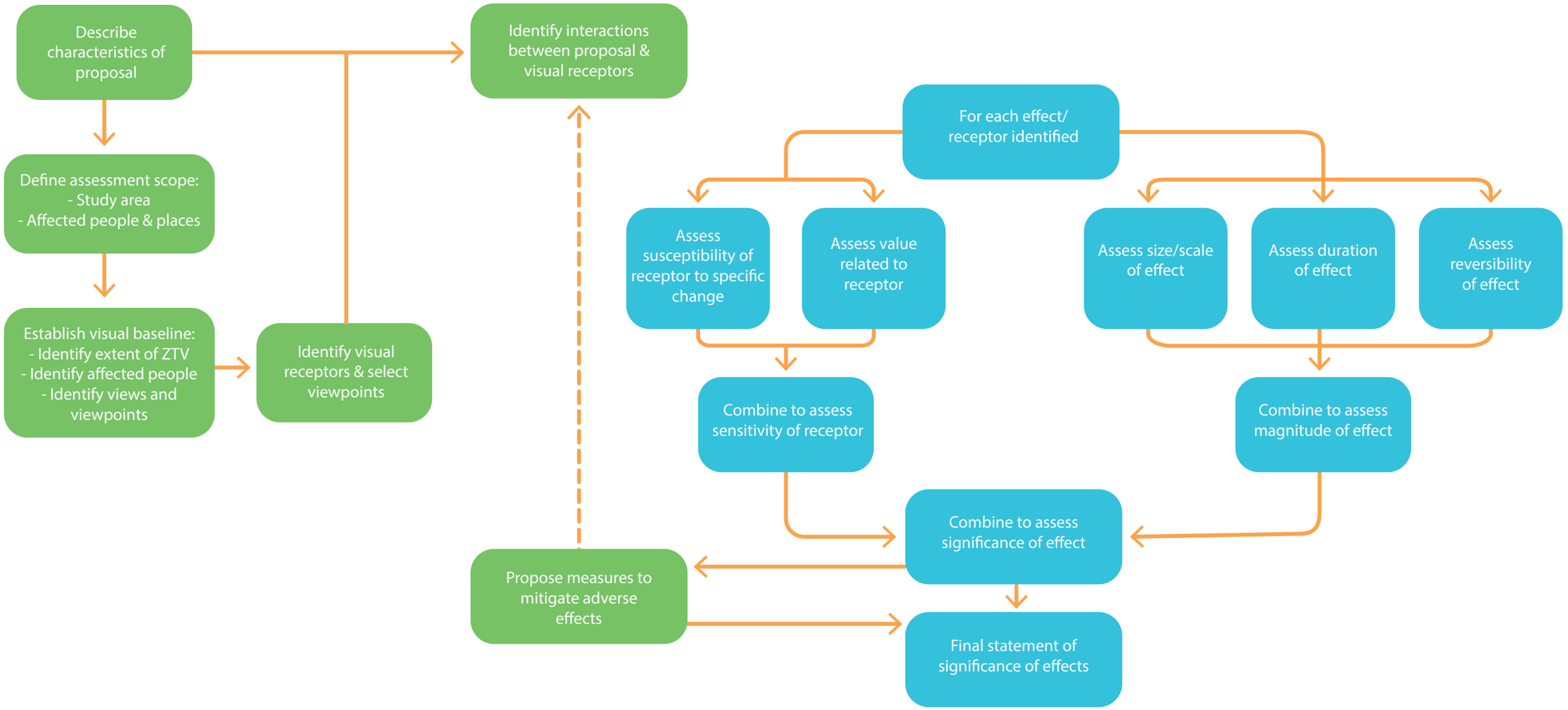


FIGURE 4.5 Methodology for determining the significance of visual effects.

5. LANDSCAPE BASELINE

The LVIA requires a landscape baseline assessment upon which to conduct the landscape impact analysis. Landscape character is the key part of the baseline, but there no existing formal landscape character assessment for the Viscaria site and its context. Consequently this study carried out a bespoke and detailed landscape character assessment as a major part of the landscape baseline. Initially, an assessment of the available information relating to landscape character at a regional to local level was carried out. This information, coupled with field-based analysis, led to the development of local landscape character areas (LLCAs). The approach is summarised in Figure 5.1. The detailed landscape character assessment is provided in appendix 1A. The most locally relevant aspects pertaining to the subsequent impact assessment phase of analysis are described below.

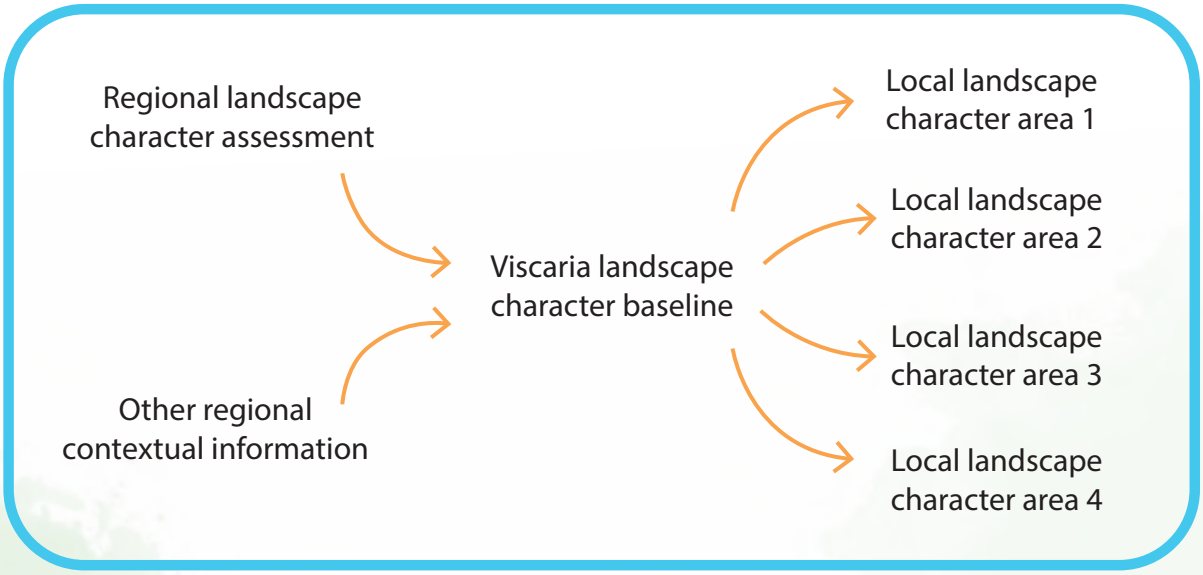


FIGURE 5.1 Summary of the Viscaria landscape character baseline process.

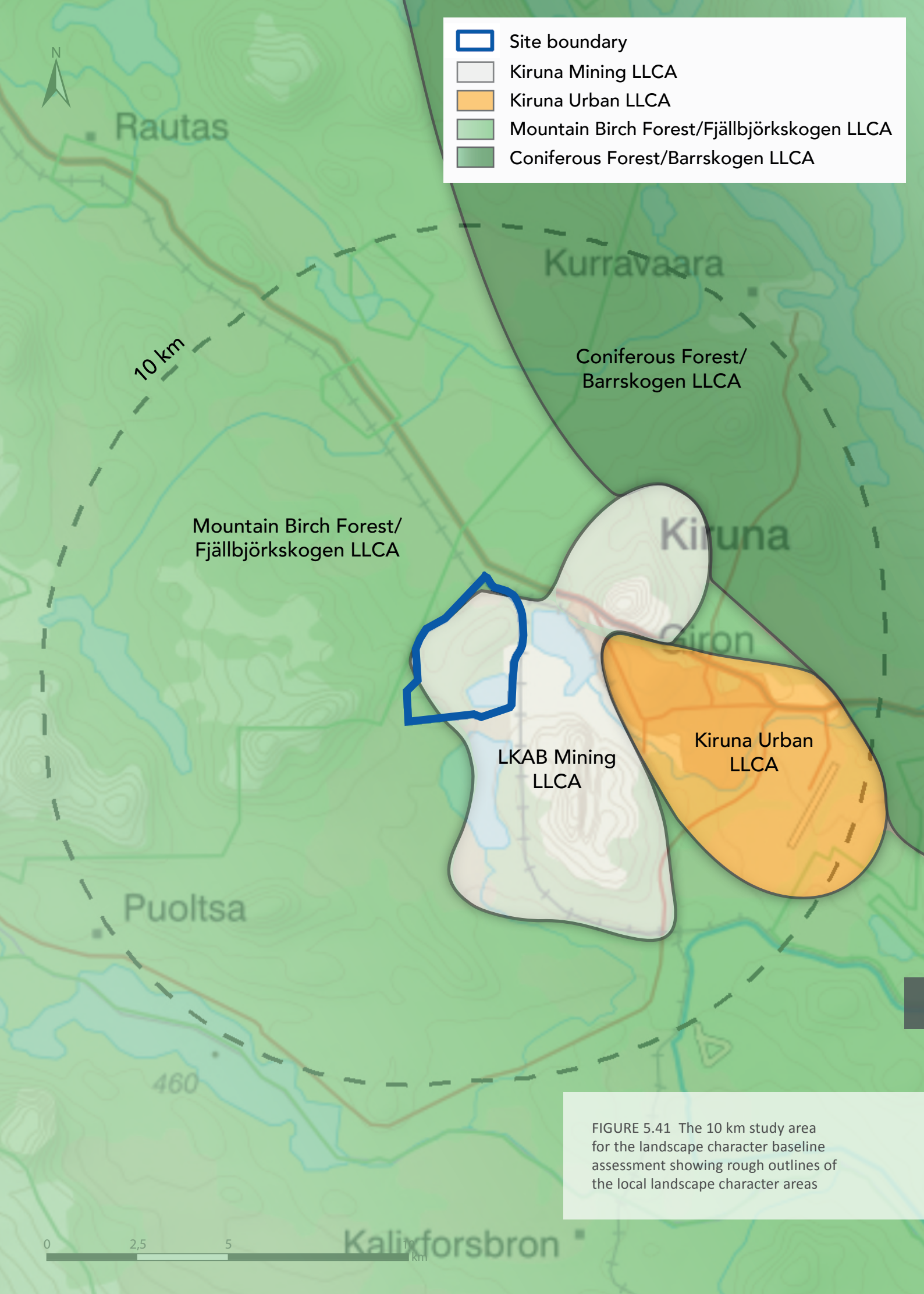


FIGURE 5.41 The 10 km study area for the landscape character baseline assessment showing rough outlines of the local landscape character areas

5.1 Viscaria landscape character study area – local landscape character areas

Because there has been relatively little previous work carried out into the characteristics of the landscapes of Kiruna city and its environs, this LVIA took a first principles approach to landscape characterisations at a local level (the detailed analysis is presented in appendix 1A). To assist development of the Viscaria landscape baseline and the subsequent impact analysis, the study area was divided into four local landscape character areas, namely:

- **Kiruna Mining LLCA,**
- **Kiruna Urban LLCA,**
- **Mountain Birch Forest/ Fjällbjörkskogen LLCA, and**
- **Coniferous Forest/ Barrskogen LLCA.**

The area encompassed by the LLCAs are illustrated in Figure 5.41. A summary of the characteristics of each LLCA is provided in tabular form below encompassing the following aspects:

- Natural characteristics,
- Cultural/ social characteristics,
- Aesthetics and perceptual characteristics,
- Landscape condition, and
- Visual characteristics.

Under each LLCA, the specific landscape character elements of relevance to the LVIA study are summarily illustrated and a landscape value is ascribed to the LLCA. The methodology for determining landscape value is described in Appendix 2.

5.1.1 Kiruna Mining LLCA

The Kiruna Mining LLCA includes the landscape features of operating mines and of closed mines that are still recognisably mine sites from the predominant site characteristics. Within the study area, mining landscapes are associated with LKAB's operating Kiirunavaara mine and the closed Luossavaara mine and the currently closed Viscaria mine. Specific attributes, landscape character elements and its overall value are presented in Table 5.1.

5.1.2 Kiruna Urban LLCA

This LLCA is specific to Kiruna town (however, it may well apply (with modifications) to other mining towns in the Malmfälten regional landscape character area of the Kiruna municipality study, particularly if adapted as a more generic landscape character type). Table 5.2 presents the key attributes, elements and the overall value of the Kiruna Urban LLCA.

5.1.3 Mountain Birch Forest/ Fjällbjörkskogen LLCA

This landscape character type derives from the regional mountain birch forest landscape character area defined in the Kiruna municipality study above. It is included here as a local landscape character area to reflect its modified nature due to its proximity to the population centre and industry of the study area. Table 5.3 summarises the analysis and presents a deduction of the value of the LLCA.

5.1.4 Coniferous Forest/ Barrskogen LLCA

As for the Birch Forest LLCA, the Coniferous Forest LLCA is a locally-modified version of the regional landscape character classification that reflects the influence of the industry and town in the study area. The landscape character analysis of this LLCA is provided in Table 5.4, with an attribution of value too.

TABLE 5.1 Summary description of the Kiruna Mining LLCA and its overall value.

Kiruna Mining LLCA	
Attributes	
Natural characteristics	• The distinctive ridge-shape of Kiirunavaara dominates the entire area – particularly from the north, south and east • Landscape character defined by its unnatural, engineered appearance • There may be pockets of natural vegetation or areas of ecologically restored or naturally re-colonised land, which may provide some biodiversity value, but generally little vegetated land cover
Cultural/ social characteristics	• Kiruna town and the mining industry grew simultaneously – the culture of each is reflected in the other. The mining area, along with the town, is nationally recognised to be of cultural significance. • The mining land use defines the town • Public access to active mining lands is limited; but for the closed mine sites at Luossavaara and Viscaria, access is permitted
Aesthetics & perceptual characteristics	• A dynamic landscape of change; the shape and location of key features may change regularly • Hard, angular, geometric landforms; dark rock • The north end of Kiirunavaara is augmented by old, benched WRDs, which dominate views of the site from the old town • Movement of vehicles, flashing and stationary lights at night • Snow cover reduces perceptual separate of the unnatural features from the surrounding landscape • Noise and from vibration from mining activities, including occasionally from the deformation zone • Occasionally rocks can be seen and heard rolling down the side of a new crack or pit in the deformation zone
Landscape condition	• Extensive areas of heavily degraded, fractured and denuded land, including open pits, waste rock dumps, tailings impoundments, mining infrastructure, processing plant and other industrial buildings and offices • Kiirunavaara has a linear, open pit on the eastern flank of the hill, trending north northeast to south southwest, which is approximately 2.5km long and no longer mined. It has been partly backfilled with waste rock. Waste rock has been dumped widely on the northern, western and southern flanks of the hill, with some small tips on the top • Luossavaara's linear open pit runs for about 1 km north-south on the eastern flank, just below the summit, with attendant waste rock dumps to the east • Extensive deformation zone of active subsidence creating an unstable, dysfunctional landscape of deep pits and cracks that sterilises large areas from other land uses • Waste rock dumps and open pits of the closed mines at Viscaria and Luossavaara have not been rehabilitated and restored, so remain largely denuded, visible and open to erosion

Kiruna Mining LLCA	
Attributes	
Visual characteristics	• LKAB's mining areas (Kiirunavaara and Luossavaara) are visible from almost everywhere within the study area (and beyond it) and from many kilometres on elevated, open land outside of it • Views from the summits of Kiirunavaara and Luossavaara are panoramic and unobstructed by trees or high densities of other hills and mountains, but only Luossavaara is publicly accessible. Views outward include the whole extent of Kiruna town, the LKAB mining areas, Viscaria mine site and the wilderness areas beyond, which merge into the horizon • The WRDs are distinctive landforms and highly visible and intrusive. As well as those of LKAB's active Kiirunavaara mine, the artificiality of the dumps of the long-closed Luossavaara and Viscaria mines dominates their local surroundings • Under winter snow cover, the contrasting colours and textures of the waste rock dumps with other landscape features are diminished, becoming more monochrome, and also less prominent in the landscape (picked out, still, by their unnatural shapes), particularly in conditions of poor visibility • Emissions plumes of mining and processing activities are highly visible in colder conditions, creating clouds and low-level mists in low windspeeds. • Extensive waste rock dumps – usually bare of vegetation. Typically benched, angular and geometric • At night and in winter, lighting of the LKAB operations detracts from the dark skies that would otherwise be visible to the east of Kiruna
Landscape character elements	
• Unnatural features • Open pits on Luossavaara and Kiirunavaara and at Viscaria • Kiirunavaara • Luossavaara • High, angular, geometric, benched waste rock dumps • Expansive, low-lying tailings impoundments • Processing plans, industrial buildings and working areas • Emissions plumes • Deformation zone	
Value	
The Kiruna Mining LLCA is characterised as a highly dynamic, denuded and degraded, unnatural mining landscape (that is closely associated with the Kiruna Urban LLCA). As a contradiction, although it is of low value ecologically it contains areas of former mining activity that are now quite well vegetated and add to the LLCA's character. Also, it is of high value culturally and is nationally designated as such, along with Kiruna town. There is a strong sense of place and cultural identity, with a distinctive skyline and landforms that dominate the surroundings, and social acceptance among local people. The dynamism of its landforms offers a low degree of vulnerability. On balance, the LLCA is deemed to be of **medium value**.	

TABLE 5.2 Summary description of the Kiruna Urban LLCA and its overall value.

Kiruna Urban LLCA	
Attributes	
Natural characteristics	• Original town constructed on slope with a southwest to south perspective to maximise direct sunlight • Partial protection to old town from cold northern winds offered by the mass of Luossavaara and from west by Kiirunavaara • Luossavaara is a key natural feature of the town • Topography of the LLCA is dominated by Luossavaara (and also Kiirunavaara of the Kiruna Mining LLCA) • Old Town to immediate east of the partially drained Luossajärvi lake
Cultural/ social characteristics	• Urban character is complex and defined by association with LKAB and mining, the town's different historical layers and its relocation activities • National designation for cultural significance • The layout of the old town is characteristic, with its company area and the old town centre • Substantial differences in character between the old and new urban areas • Town is small and easy to get around, however, the changing topography and relocation activities makes it more complicated to move around and understand the local urban geography • Town is heavily impacted by the relocation, affecting the sense of place and cultural identity of the residents • Key historic buildings are being preserved and relocated, albeit re-set within new and different urban contexts • Public open spaces used mostly during snow season, which gives a different character to the spaces • Luossavaara has a downhill ski slope and a road to the summit and is a popular place for recreation and for viewing the aurora borealis.
Aesthetics & perceptual characteristics	• The town is small and its connectivity is good (it's easy to get around); but the town relocation and changing topography make understanding the local geography a little more complicated • Kiruna combines several different characters and contrasts between the historical layers, the old and new areas of the town, and the mining area, the urban area and the surrounding Arctic landscapes • Affection for old town is arguably not reflected by perceptions of the new urban areas and its modern architecture
Landscape condition	• Older parts of the town that will moved/ demolished are becoming run-down • Relocation of E10 road has caused environmental fragmentation and degradation on the town's northern perimeter • The physical, intellectual and cultural connections between old and new Kiruna are difficult to comprehend • Luossavaara is heavily degraded by former open pit mining activities and waste rock dumps

Kiruna Urban LLCA	
Attributes	
Visual characteristics	• The skyline of LKAB's mine site dominates most views from the town, beyond which are views of the Arctic wilderness landscape and distant mountains, including Kebnekaise • From the town centre, including the Gruvstadsparken, views are mostly to the west and southwest towards the mining industrial skyline • Towards the north/ northwest, the bulk of Luossavaara dominates views from the town, but also offers panoramic views over the town and into the distance in all directions • Towards the Viscaria site, the view is of lower, softer and greener land, offering wilderness beyond
Landscape character elements	
• Layout of old town – Company Area • Old town architecture, wooden company buildings, including old town hall • Wooden church and bell tower • New town and modern architecture • Different historical layers within the town • The Gruvstadsparken • The new parts of the urban area, built within the same century, but narrating socio-economic progression	
Value	
The Kiruna Urban LLCA is characterised as a culturally significant and dynamic townscape and architecture developed in response to the environmental, social and economic challenges of developing a major industrial town in a remote Arctic location. It is nationally recognised for its cultural significance. However, it is also a dynamic town and is – paradoxically – simultaneously conserving, reinventing and relocating its townscape and community through the necessity induced by encroaching mining subsidence. Its frontier spirit and closeness to extensive, wild terrain augments the already strong sense of place and cultural identity, which is heavily influenced by the other LLCAs described here. The LLCA is deemed to be of **medium value**.	

TABLE 5.3 Summary description of the Mountain Birch Forest/ Fjällbjörkskogen LLCA and its overall value.

Mountain Birch Forest/ Fjällbjörkskogen LLCA	
Attributes	
Natural characteristics	• The wider landscape is open, relatively flat and framed by the mountain massifs to the west. • Includes the occasional, rounded hill, such as Ädnamvaara, which emerges above the treeline • Generally occurs below 500 masl, above which mountain heath and bare rock take over. • The LLCA is characterised by short in stature mountain birch trees, with varying degrees of densely growing and more sparsely growing forest. The forest varies between drier heather birch forest, with a field layer dominated by small, shrubby plants and meadow birch forest and swamp forest with a field layer dominated by high herbs on well-drained to moist soils. The landscape also has large, open bogs and lakes. • The LLCA is located across two major catchments: the northern, western and eastern parts of the LLCA drain into the Torn River and the southern parts into the Kalix River.
Cultural/ social characteristics	• Much of the area is recognised as Sami cultural land. The area today constitutes important reindeer grazing land for Gabna and Laeva's Sami villages. • The landscape is used for outdoor life and recreation in both summer and winter. Snowmobile, skiing and hiking trails run through the area, with wind shelters and rest areas. • The nature area is important for Arctic wilderness tourism and dark skies. Tourism providers market activities such as fishing, Aurora Borealis watching, dog sledding and snowmobile tours. • Trails between Kiruna and Ädnamvaara cross the LLCA. The close proximity to nature and its easy accessibility are of great importance to many Kiruna residents. • There is a popular cabin on Ädnamvaara, which is a spring – autumn café, and classrooms for visits by schools • Ädnamvaara offers an ideal vantage point for viewing the aurora borealis and panoramic views across the Arctic wilderness and of the Kiruna mining area from the southwest • Almost the entire Fjällbjörkskogen around Kiruna is of national interest for outdoor life and comprises, for the most part, designated areas, such as Natura 2000 sites, areas of national interest in nature conservation and nature reserves.
Aesthetics & perceptual characteristics	• The LLCA has an open, expansive expression of untamed nature on a monumental scale. • Timeless and stable. • The wildness is tangible and the remoteness all-consuming. • Fresh greens to the horizon in summer; more browns and greys in winter. • Winter snow cover transforms the landscape, blurring the division between the different aesthetics and lessening detractive features. • Tranquillity grows rapidly as the urban and mining LLCAs are left behind and strengthens further with snow cover, which deaden sound.

Mountain Birch Forest/ Fjällbjörkskogen LLCA	
Attributes	
	• Emergence from the forest, above the treeline on Ädnamvaara, offers strong feelings of openness, freedom and tranquillity, with far-reaching views in most directions across natural landscapes. • Natural sounds feature strongly, such as wind through the trees, bird song, running water. Such sounds are much diminished with winter snow cover. • In the vicinity of Ädnamvaara, relatively close to the east and north sides of LKAB's mining concession, continuous background noise produced by LKAB's mining and processing activities are discordant with the natural landscape, particularly when looking away from LKAB's operations.
Landscape condition	• Very high degree of natural land cover continuity and intactness. • Occasionally this continuity is impinged by a road or powerline, or even a railway. • Increasing degradation noticeable, then dominating, as the Kiruna urban and mining LLCAs are approached, which, conversely, quickly diminish as they are left behind
Visual characteristics	• Views inwards from, for example, Kiirunavaara and Luossavaara, are of unbroken forest and wetland to the distant high mountains to the north, west and southwest, and merging into the Coniferous Forest LLCA to the east • Views outward to the east and south are dominated by LKAB's angular mining landscape and the city of Kiruna. To the north and west, the high mountains dominate views, including of Kebnekaise. • There is a valued direct line of sight east from Ädnamvaara to Luossavaara • Denser forest is perceived as closed, while the sparser forest areas are more open allowing more views outwards towards the mountains and the Kiruna Mining LLCA • The mountain birch trees are tall enough to obscure outward views • From higher points and by roads and powerlines, wider views of the surrounding landscape are possible • Wetland areas offer wider, more open views of surrounding hills
Landscape character elements	
• Open, expansive, continuous natural landscape of extensive bogs and mountain birch forests • Tranquil, remote wilderness • Ädnamvaara • Views of the high mountains to the west and north • Public access trails • Dark skies • Association with Sami reindeer herding communities	
Value	
The Mountain Birch Forest/ Fjällbjörkskogen LLCA is characterised as a pristine, tranquil Arctic wilderness, dominated by expansive mountain birch forest and wetlands. It is easily accessible within the vicinity of Kiruna and is an essential of the local tourism provision and a cultural and recreational foundation for the sense of identity of local people. The views from Ädnamvaara are exceptional. It is designated internationally and nationally for the integrity of its ecological systems and biodiversity. It is formally recognised as traditional Sami lands. The LLCA is deemed to be of **high value**.	

TABLE 5.4 Summary description of the Coniferous Forest/ Barrskogen LLCA and its overall value.

Coniferous Forest/ Barrskogen LLCA	
Attributes	
Natural characteristics	• Topography is variably flat and low, rounded, rolling hills with the occasional higher peak. • Mountainous topography is less significant in this LLCA than in the birch forest LLCA • Generally continuous natural vegetation to the horizon, predominantly of coniferous trees and wetland areas • The LLCA is within the drainage area for Torne River. • Starts below approximately 500 masl, at the altitudinal limit of the coniferous forest • The forest is characterized by coniferous trees of varying age and density, although mountain birch also occurs. The ground layer generally consists mainly of small shrubby plants such as blueberries and crowberries.
Cultural/ social characteristics	• This LLCA consists of Sami traditional land and provides long-established and important reindeer grazing land for the Gabna and Laeva's Sami villages • A small part of the LLCA is protected as the Rautas Nature Reserve and Natura 2000 site and is also of national interest for outdoor life and recreation • The LLCA is important for outdoor recreation and tourism for both residents and visitors. It is easily accessible from Kiruna with good roads and many trails used for running, orienteering, skiing and snowmobiles. Several running and skiing tracks start from Matojärvi sports ground and Camp Ripan in northern Kiruna • There are scattered residencies disseminated across the landscape, mainly concentrated along river valleys and close to lakes
Aesthetics & perceptual characteristics	• The LLCA has an open, expansive expression of untamed nature on a monuThe LLCA is perceived to be pristine wilderness, with high levels of tranquillity and feelings of remoteness, which are even stronger in the winter with snow covering • Despite the alien mining landscapes visible from the LLCA, perceptions of wilderness are strong • Perceptions of landscape change in winter with snow cover, as landscape features become less distinct and continuous. Snow also increases tranquillity and quietness. • The coniferous trees provide reassurance and shelter from winter’s winds and low temperatures
Landscape condition	• This LLCA is lightly affected by human activities and the impacts of these rapidly diminish on leaving the vicinity of the Kiruna urban-industrial complex • The landscape is partly fragmented and degraded close to areas of human habitation and industry, but diminishes markedly as one leaves such areas

Coniferous Forest/ Barrskogen LLCA	
Attributes	
Visual characteristics	• The forest trees limit the views and there are few viewpoints at lower landscape elevations • Occasional hills emerge above the treeline affording exceptional panoramic viewpoints over unbroken forest and wetlands to distant mountains in the north, west and south and to forest merging into the horizon in the east • Wetland areas allow wider views outwards • Views are limited by forest vegetation, but just like in the mountain birch forest, roads, power lines, ponds and other more open areas lead to longer views. • Winter snow cover creates a simpler, more subtle and monochrome landscape, with diminished differences between features and between different LLCAs
Landscape character elements	
• Generally low elevation with a few low, rounded hills • Evergreen trees provide some colour in the landscape on monochrome winter days • Coniferous forest with small shrubby plants in the field layer • Open, expansive, continuous natural landscape of wetlands and evergreen forests • Tranquil, remote wilderness • Views of the high mountains to the west and north • Public access trailDark skies • • Association with Sami reindeer herding communities	
Value	
As for the Birch Forest/ Fjällbjörkskogen LLCA, the Coniferous Forest/ Barrskogen LLCA is characterised as a pristine, tranquil Arctic, forested wilderness, dominated by evergreen, coniferous trees. Both LLCAs are continuous with one another. It is easily accessible within the vicinity of Kiruna and is an essential of the local tourism provision and a cultural and recreational foundation for the sense of identity of local people. It is designated internationally and nationally for the integrity of its ecological systems and biodiversity. It is formally recognised as traditional Sami lands. The LLCA is deemed to be of **high value**.	

6. VISUAL BASELINE

6.1 Introduction

Many aspects of the visual amenity and character of the study area and its broader context are highly valued by residents and visitors alike and are promoted widely. Visually the area is highly diverse, offering views of natural wilderness, a variety of urban settings and heavily degraded land. This diversity is exacerbated by the marked visual differences relating to the intense seasonality; the vistas change rapidly and often.

6.2 Viewpoint selection and values

Following the methodology for selecting viewpoints outlined in section 4, the visual baseline was determined by:

- Establishing the area in which the mine many be visible;
- Determining the different groups of people who may experience views of the mine;
- Identifying the places where they will be affected; and
- Determining the nature of the views and visual amenity at those points.

Viewpoints were selected based on a combination of analysis of the ZTVs, pre-existing local knowledge, analysis of maps for public access trails and transport routes, conversations with people on the ground and an understanding of the local landscape character (Figure 4.3).

An important aspect of the views, which fall outside the ZTV, are the views from Kiruna towards the distant high mountains to the west and north. These are considered as a factor in appropriate parts of the landscape and the visual assessments.

During the site visits, other potential viewpoints were visited on the ground. Where there was no view of the site from these locations, they were discounted from the subsequent stages in the visual assessment. Other potential viewpoints, such as those along the Ädnamvaara Trail, which skirts the northern and western perimeter of the site, were discounted because the trail will be relocated to

A summary of the viewpoints and a brief rationale for their selection is provided in Table 6.1 and these locations are shown on Figure 6.1. Certain viewpoints were selected for the visualisation of the project development. These are indicated in Table 6.1 too. Certain viewpoints were assessed at ground level, where site visibility was sometimes very poor, but views from the upper floors of surrounding residential buildings would have good views of the site. In such instances, a photograph from the viewpoint was not taken.

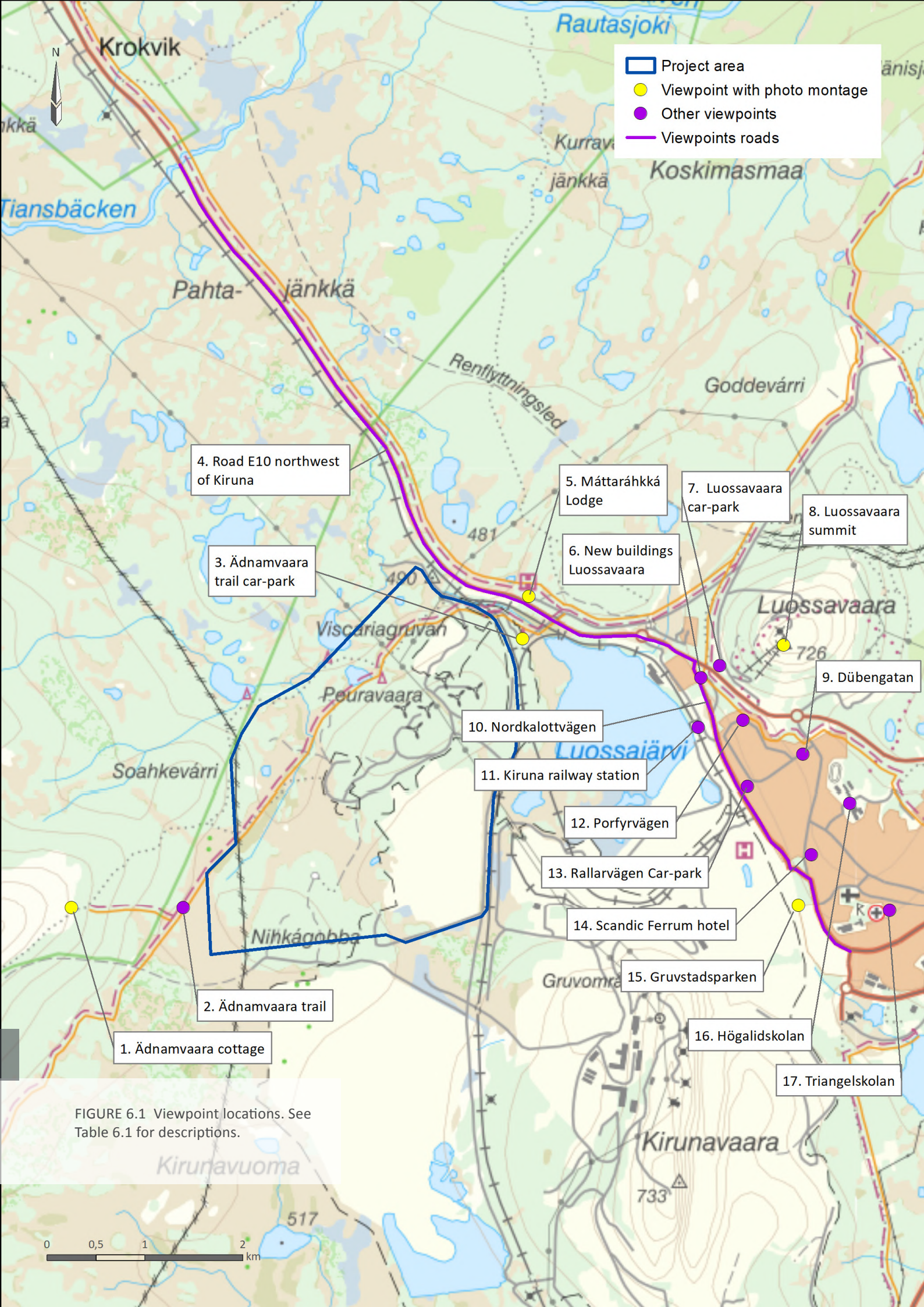


FIGURE 6.1 Viewpoint locations. See Table 6.1 for descriptions.

TABLE 6.1 The selected viewpoints and their description and ascribed values and the rationale for their selection. Note, not all viewpoints have a corresponding image. Those viewpoints selected for a visualisation study (photomontage) are indicated in the table with a '*'.

ID	Viewpoint Name (Figure no.)	Description & Value	Reason for Selection	Direction to Viscaria	Distance to Viscaria
1	**Ädnamvaara Cottage*** (Figure A1.27)	A widely promoted recreational destination, easily accessible year-round from northern Kiruna via the Ädnamvaara Trail. Visited for exceptional panoramic views to east across to Luossavaara (a key sightline), Kiruna city and LKAB's mining area and to north and west and south over Arctic wilderness to Kebnekaise and the high mountains. Promoted for views. Houses a café in spring and summer. Deemed to be of **high value**.	Selected to illustrate view available to visitors to this wilderness site above the treeline, outside the immediate confines of Kiruna city.	East	1.4 km
2	**Ädnamvaara Trail** (Figure 6.2)	Viewpoint from trail on valley floor, beyond Viscaria site perimeter, at base of Ädnamvaara with unobstructed views to southwestern part of site. Deemed to be of **high value.**	Selected for view towards site on part of the trail not crossing the site and at base of Ädnamvaara hill	East	500 m
3	**Ädnamvaara Trail car-park*** (Figure 6.3)	The trailhead for the Ädnamvaara Trail and adjacent to site. View is degraded by wind turbines, fence and foreground carpark. Not a viewing destination in its own right, but viewers are motivated to use it by easy access to the nearby Arctic wilderness and its views year-round. Deemed to be of **low value.**	Selected for view to site, which is immediately adjacent. Start/end of Ädnamvaara Trail into wilderness.	West	200 m
4	**E10 north of Kiruna** (Figure 6.4)	A major route to Kiruna from the mountains and national parks to the north and west and to the Norwegian and Finnish borders. Aesthetically beautiful as passes through Arctic wilderness (Mountain Birch Forest/ Fjällbjörkskogen LLCA). Heading towards Kiruna, intermittent views of site along road from 10km out, with increasing frequency as site gets closer. Intermittency of view is generally caused by the forest. Both resident and tourist travellers pass through at speed. Site visibility is increased by presence of wind turbines on Peuravaara Hill, intermittently visible for several kilometres. E10 (and railway) passes adjacent to northern perimeter of site. Approaching site, views become dominated by its wind turbines and an old, benched waste rock dump. Deemed to be of **medium value.**	Selected to illustrate views along the E10 road to north of Kiruna, with intermittent views of site from about 10km north, increasing as site approaches.	South	Varies: ~10km to 200m

ID	Viewpoint Name (Figure no.)	Description & Value	Reason for Selection	Direction to Viscaria	Distance to Viscaria
5	**Máttaráhkká Northern Lights Lodge*** (Figure 6.5)	Accommodation for national and international tourists visiting to experience the Arctic wilderness throughout the year. Snow-mobile, dog-sled, cross-country skiing and fishing tours start from here. The main lodge building faces the site; roof is a popular location for relaxing and viewing the aurora borealis, marketed as viewing from the hot tub. Deemed to be of **medium value.**	Selected to illustrate view of site from main lodge building. Very close to northern perimeter of site.	Southwest	450 m
6	**Maria Taavenikkus Gata (new residential area)** (Figure 6.6)	New apartment complex with mostly uninterrupted views across Luossajärvi to the site and Ädnamvaara and the mountains beyond. View extends to southeast over LKAB's mining area. The view will be important to the people who live there. Deemed to be of **high value.**	Selected for view from new apartment complex with unobstructed views across to the site and beyond.	West	1.9 km
7	**Luossavaara carpark** (Figure 6.7)	Locals and tourists visit this easily accessible location to enjoy and photograph the view year-round, as well as walking up to Luossavaara summit. Views over Kiruna city, LKAB, Viscaria site. Direct sightline to Ädnamvaara mountain and cottage. Deemed to be of **high value**.	Selected to illustrate the view from this popular and easily accessible recreational area.	West	2.15 km
8	**Luossavaara summit*** (Figure 6.8)	Popular year-round recreational location on the northern edge of Kiruna for residents and visitors, easily accessible by road, trail, or chairlift, depending on the time of year. Home to a ski slope. The 724m-high summit offers 360-degree panoramic views over the city, LKAB mining area and Kiirunavaara, the Viscaria site and the wilderness beyond in every direction and Kebnekaise and high mountains in the distant west and north. Easily accessible in summer too, including along the promoted Midnight Sun Trail. Direct sightline to Ädnamvaara mountain and cottage, which passes directly over the Viscaria site. Deemed to be of **high value.**	Selected to illustrate views from the summit of this popular recreational location on the edge of Kiruna.	West	3 km
9	**Dübengatan** (No photo available)	Views from suburban residential area of apartment blocks on hilltop overlooking the site. Many residences will have mainly partial views of the site and LKAB and beyond to the mountains. Deemed to be of **medium value**.	Selected as a viewpoint in a mainly residential area of apartment blocks on hill-top overlooking site.	West	3 km

ID	Viewpoint Name (Figure no.)	Description & Value	Reason for Selection	Direction to Viscaria	Distance to Viscaria
10	**Nordkalottvägen** (No photo available)	Views along this road heading north-west, with mainly unrestricted views of the site. Views from southern end of road are dominated by LKAB and the deformation zone. The southern end of the road will be removed in the coming years in response to the encroaching LKAB subsidence The northern end views become intermittent due to trees, railway infrastructure and occasional buildings. The eastern side of road is lined with residential buildings with mainly unobstructed views of the site and LKAB's mining landscape (a national cultural designation). Deemed to be of **medium value**.	Selected to represent views along an urban road running between the mining area and Kiruna city.	West	1.6 km at northern end 2.8 km at southern end
11	**Kiruna railway station** (Figure 6.9)	Views directly across Luossajärvi to Viscaria for those travellers arriving or leaving Kiruna by train. A view which is not unattractive, but is not the main reason for the receptor being there. View adversely affected by railway infrastructure and trains. LKAB mining landscape is a national cultural designation. The city plans to move the railway station, but the timing and new location are not yet known. View deemed to be of **medium value**.	Selected as a key entry/ exit point into Kiruna for residents, workers and visitors.	West	1.9 km
12	**Porfyrvägen** (Figure 6.10)	Views from suburban residential area of Kiruna on hillside facing the site across Luossajärvi. Some residences will have unobstructed views, many will have partial views of the site and the LKAB mining landscape (a national cultural designation) and beyond to the mountains. Deemed to be of **medium value**.	Selected as a viewpoint in a mainly residential area with views across to the site.	West	2.4 km
13	**Rallarvägen carpark** (No photo available, viewpoint obscured by trees)	Views from small rise above Luossajärvi; well-spaced, old residential area. Some residences will have unobstructed views, many will have partial views of the site and LKAB and beyond to the mountains. This location will be on the edge of the deformation zone in 2035, as predicted by LKAB. Deemed to be of **medium value**.	Selected to represent a mainly residential area of old houses close to Luossajärvi with views across to site	West	2.45 km

ID	Viewpoint Name (Figure no.)	Description & Value	Reason for Selection	Direction to Viscaria	Distance to Viscaria
14	**Scandic Ferrum hotel** (Figure 6.11)	Views from hotel east over deformation zone to LKAB and northeast over Viscaria site to mountains beyond. Hotel promotes long-distance views of Kebnekaise. Viewpoint is outside at ground level. Other adjacent visual receptors include residents at home and workers in adjacent areas. The viewpoint is likely to be removed by 2029/30 due to the encroaching LKAB subsidence. Deemed to be of **medium value.**	Selected because hotel promotes views of Kebnekaise, also views from hotel will improve as deformation zone approaches removing intervening trees and buildings. Hotel to be demolished as deformation zone move eastwards	Northwest	3.3 km
15	**Gruvstadsparken** (Figure 6.12)	Viewpoint across deformation zone to LKAB, which dominates view, and distant view to site. LKAB mining area is nationally designated for its cultural importance. Purpose built and easily accessible viewpoint to view the encroaching deformation zone in a park developed as a moving buffer zone between the deformation and the retreating city. The viewpoint is likely to be removed by 2029/30 due to the encroaching LKAB subsidence. Deemed to be of **medium value.**	Selected as purpose-built viewpoint for viewing the mining landscape of LKAB and the deformation zone.	Northwest	3.2 km
16	**Högalidskolan** (Figure 6.13)	Viewpoint from suburban school carpark on hill to illustrate views from school, STF Malmfältens Folkhögskola and residential properties close by. Many will have partial views over Kiruna towards the site. Deemed to be of **low value.**	Selected to examine view from hill with school, close to STF Malmfältens Folkhögskola and residential areas.	West	3.5 km
17	**Triangelskolan** (No photo available, viewpoint obscured by trees)	Viewpoint in suburbs close to school, hospital and residential suburban area. Current views of site obstructed by intervening buildings Currently deemed to be of **negligible value**. By 2029-2032, this location will be on the edge of the deformation zone, as predicted by LKAB. Views to site will then be clearer, but over a deformed landscape and past the prominent LKAB workings. Predicted to be of **low value.**	Selected as a viewpoint because the area will be on the edge of the deformation zone in 2035, based on LKAB predictions, so will have clear views of site in distance. Suburban residential area, near hospital.	Northwest	4.2 km

FIGURE 6.2 View of Viscaria site from Ädnamvaara Trail viewpoint.

FIGURE 6.3 View of site from Ädnamvaara Trail car-park.

FIGURE 6.4 View of site from E10 approximately 5km north of Viscaria.

FIGURE 6.5 View of the site from the roof of the Máttaráhkká Northern Lights Lodge.

FIGURE 6.6 View of the site from Maria Taavenikkus Gata (new residential area).

FIGURE 6.7 View of the site from Luossavaara car-park in poor visibility conditions in late November 2021.

FIGURE 6.8 View of the site from the summit of Luossavaara.

FIGURE 6.9 View of site from Kiruna railway station in poor visibility in early December 2021.

FIGURE 6.10 View of site from Porfyrvägen in early December 2021.

FIGURE 6.11 View of site from the ground in front of the Scandic Ferrum hotel in early December 2021.

FIGURE 6.12 View from the Gruvstadsparken viewpoint towards the site.

FIGURE 6.13 View of site over residential area, from Högalidskolan.

7. ASSESSMENT OF LANDSCAPE AND VISUAL EFFECTS

7.1 Introduction

Based on the project description, the project effects, as they pertain to landscape and visual aspects, are outlined below. The project effects are summarised under the four main phases of the mining life cycle: construction, operations, closure and post-closure, then the magnitudes and significances of the residual project effects is determined. The detailed methodologies for determining the magnitudes and significances of project effects are provided in Appendix 2.

7.2 Viscaria Project Landscape and Visual Effects

The foreseeable, potentially significant, landscape and visual effects related to a hard rock, surface mining operation such as that planned at Viscaria are:

- **Movement of vehicles and machinery** – bright colours, reflections and movement of machinery will draw the eye away from the more natural landscape aesthetic and undermine the perception of 'wilderness'.
- **Presence of people** – the proximity of large numbers of workers will affect an area perceived as being close to 'wilderness', remote and tranquil.
- **Noise** – project-related noise will interfere with natural sounds caused by the use of machinery and vehicles, including reversing vehicle alarms, exploration drilling, open pit blasting, dumping of waste rock and ore, generators, affecting perceptions of tranquillity (and negative effects on reindeer and wildlife).
- **Vibration** – caused by large passing vehicles and, particularly, blasting in an open pit (and underground). Blasting vibrations can be particularly intrusive in an area perceived as wild and tranquil.

- **Lights** – flashing and constant – currently the Viscaria project area adjacent to LKAB is dark (unlike LKAB), providing a visibly dark element at night and in the Arctic winter months. This will change as the project is built and lights become emitted from the site. This will impact the perception of wilderness by local landscape-users and views of the night sky, including the aurora borealis.
- **Reflections** – glint and glare from glass and shiny surfaces, both moving and stationary, can increase site visibility, which will create a visual intrusion and degrade the values of some LLCAs.
- **Odours** – potential for unnatural odours, foreign to the local landscape, caused by processing chemicals, exhaust emissions, fuel spillage, decomposing waste materials and sewage discharge.
- **Removal of pre-existing infrastructure** – buildings and other structures currently on-site are removed prior to construction of the new development. If these are environmentally, culturally or visually significant, then impacts on the perceptions of the local landscape and visual envelope could occur. The wind turbines on Peuravaara will be removed during construction and the existing powerlines will be relocated off-site during operations.
- **Vegetation removal** – gaps in vegetation continuity between the site and its surrounding context, including changes in colour and texture.
- **Soil clearance** – dust and changes in landscape colour and texture and obvious discontinuity with the surrounding landscape and visual context.
- **Unnatural landforms** – typically large-scale, geometric structures constructed of mineral wastes (waste rock dumps, tailings management facility), soil stockpiles and ore stockpiles, which are out of character with the local topography and are highly visible. Copperstone plans geomorphic designs for its WRDs and TMF, which will reduce their adverse effects.

- **Vertical structures** – cranes, buildings, powerlines, often with lights, which are visually intrusive and are out of character with softer natural landscape elements.
- **Linear structures** – fence-lines, pipelines, ditches, powerlines, haul and access roads, conveyors, which cut through the gently undulating landscape, their visible intrusiveness enhanced by their regularity and linearity.
- **Signage** – around site entrances and along roadways may be visually intrusive and affect perceptions of remoteness.
- **Emissions plumes** – smoke, gases and water vapour emitted from point sources, such as flues, chimney stacks and, if underground workings are present, ventilation shafts. In the cold Arctic air, their elevation and their movement exacerbate their visibility from a distance and can affect views. The visibility of plumes increases in cold weather. Plumes will be produced primarily during the operational phase.
- **Dust** – generated from transport on unsealed roads, dumping of mineral materials (waste rock, soils, ore), exposed rock/ tailings surfaces, rock crushing activities and conveying. Point sources can be as visible as emissions plumes. Fugitive emissions can create a general discoloured haze in low velocity wind conditions that can be visible from a large distance. Locally, dust can settle and discolour the surroundings, creating perceptions of pollution and detracting from landscape character.
- **Discolouration of water courses/ bodies** – run-off contaminated with sediment and/or chemicals or fuel may contaminate surrounding water features. Such pollution will lead to a perception of environmental damage in a wild, protected landscape.
- **Re-vegetation/ planting schemes** – plants/ trees planted in unnatural patterns or locally inappropriate colours could be visually intrusive and may limit the potential for ecological recovery, with repercussions for landscape character. Vegetation growth is very slow in the Arctic environment, so planted/ restored landscapes can take many years to have a meaningful beneficial effect on the landscape and views.

Each effect will not be considered alone by the landscape observer or user, but will form an ensemble of effects that interact to create an overall effect. Such effects will vary in severity according to the stage in the mine lifecycle, but also with the varying duration of time during day- and night-time and between winter and summer.

As stated in the methodology, project landscape and visual effects were determined for the following stages in the LOM:

- **Construction** – assuming peak construction activity;
- **Operations (year 5)** – the period of the maximum extent of ore production and extent and of site landscape and visual effects, prior to most of the mitigations being applied;
- **Closure** – assuming the peak of mine closure activity, and
- **Post-closure (year 10)** – how the site will appear 10 years after mine closure.

These are broken down further during the analysis of effects below.

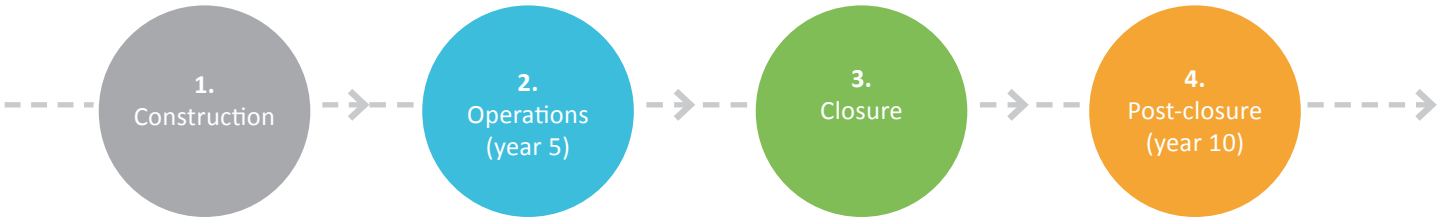


FIGURE 7.1 Project landscape and visual effects were determined for four stages in the LOM.

7.2.1 Effect Mitigations

There are two key types of mitigation for landscape and visual effects presented in this LVIA :

- **Primary mitigation:** modifications to the location or design of the development made during the pre-application phase that are an inherent part of the project and do not require additional action to be taken.
- **Secondary:** actions that will require further activity in order to achieve the anticipated outcome, either as a permitting requirement or through inclusion in the EIA.

There are several examples of primary mitigation included in the project design that aim to avoid or minimise adverse project impacts. Any remaining effects (after primary mitigation are then subjected to appropriate secondary mitigation measures during development and management of the project during its construction, operations, closure and post-closure activities. Both types of mitigation are outlined in Table 7.1 (note that these mitigations are not recommendations, but consist of suggested possible actions that are typical and generally applicable to projects elsewhere in mitigating the effects identified).

7.3 Sensitivity of Landscape and Visual Receptors

In order to determine the significance of project effects on the landscape and visual receptors, the sensitivity of a receptor to an effect and the magnitude of the effect need to be combined (Figures 4.4 and 4.5).

The baseline section of this report describes the landscape and visual receptors identified and, as explained in the methodology section, the sensitivity of these receptors has been determined based on judgements of their value and susceptibility in relation to the proposed Viscaria development (the methodology is provided in Appendix 2). Deductions of the sensitivity of landscape receptors are presented in Table 7.2, while the sensitivity of visual receptors is determined in Table 7.3.

TABLE 7.1 Suggested primary and secondary mitigation of Viscaria project landscape and visual effects (underlined mitigations are those known to be included in the project design)

Landscape/ visual effect	Primary mitigation	Secondary mitigation
Movement of vehicles and machinery; presence and movement of machinery and vehicles, particularly with bright colours	• Design physical screening from bunds/ embankments • Maintain existing vegetation for screening purposes	• Plant evergreen trees in key locations to provide visual screening
Presence of people	• Plan and create public access to part of the site to build/ maintain interest • Post-closure land-use: create public access to enable public to experience this part of Kiruna Mining LLCA	• Limit access to undisturbed parts of site close to Mountain Birch Forest/ Fjällbjörkskogen LLCA
Noise; vehicle reversing alarms, exploration drilling, open pit blasting, dumping of rock/ ore, generators	• Design haul/ access routes away from site perimeters and within pits/ high bunds/ embankments • Create acoustic barriers around noisy equipment/ areas, or near sensitive receptors, e.g. bunds from waste rock/ moraine/ soil; existing tree cover; temporary structures • Plan secondary containment around mills, etc. • Enclose conveyors	• Implement noise management plan • Switch-off equipment/ vehicles when not in use, including engine idling • Use noise attenuation technology available from vehicle suppliers • Use white noise vehicle reversing alarms • Minimise hard acceleration on vehicles • Reduce vehicle speeds • Use well-maintained vehicles • Minimise ore/ rock drop heights from conveyors/ trucks
Vibration; large passing vehicles and, particularly, blasting in an open pit (and underground)	• Design haul/ access routes away from site perimeters and within pits/ high bunds/ embankments	• Minimise use of explosives • Time blasting to the least sensitive time of the day
Lights; flashing and constant, fixed, moving and stationary points of light and light spill	• Avoid unnecessary lighting – use only lighting that is really needed • Design lighting plan to minimise light spill • Design orientation of long sides of buildings away from key visual receptors	• Vehicles to use headlight anti-glare technology • Follow best practice controls for lighting emissions • Use white, low-energy LED lamps (ensure LED lights possess necessary filter to avoid negative effects on nocturnal insects) • Ensure all outdoor lights are fully shielded and directed downwards • Use PIR movement sensor lamps • Cover windows at night, e.g. blinds/ curtains

Landscape/ visual effect	Primary mitigation	Secondary mitigation
Reflections; glint/ glare caused by sun reflecting off glass windows in buildings or vehicles	• Design orientation of long sides of buildings away from key visual receptors Design visual screens • Keep existing vegetation wherever possible as visual screen	• To be determined
Odours; unnatural odours from processing chemicals, exhaust emissions, fuel spillage, decomposing waste materials, sewage treatment	• Design-in odour controls to avoid leakage/ escape, considering proximity to 'wilderness'	• Follow best practice in managing hazardous chemicals • Plan and implement spill responses
Removal of pre-existing infrastructure, e.g. wind turbines, powerlines, trails, fencing	• Relocate Ädnamvaara Trail away from site boundary • Remove wind turbines (thus reducing a visual intrusion) • Relocate powerlines to enable northern WRD to progress (thus reducing a visual intrusion)	Relocate powerlines to enable northern WRD to progress (thus reducing a visual intrusion)
Vegetation removal, e.g. during site development/ construction	• Minimise footprint of disturbance • Leave mature vegetation in situ to the degree possible, especially along roadways, site perimeter, around infrastructure to act as a visual and acoustic barrier and reduce ecological and visual impact of vegetation destruction • Progressive restoration from earliest opportunity	• 'Rescue'/ transplant small trees from vegetation removal for re-use in restoration to create an early positive revegetation impact • Transplant rescued small trees from vegetation removal at a temporary 'storage area'/ nursery for later use in restoration
Soil clearance – dust and changes in landscape colour and texture. Obvious discontinuity.	• Minimise footprint of disturbance, e.g. efficient access/haulage road network • Stockpile soils/ moraines as bunds/ embankments	• Re-vegetate stockpiled soil materials • Spread soils onto previously worked areas and re-vegetate as soon as possible
Unnatural landforms; (waste rock dumps, tailings management facility), soil stockpiles and ore stockpiles, which are out of character with the local topography and highly visible.	• Design geomorphic reclamation of WRDs and TMF for more natural and hydrologically functional landforms • Where WRDs will be located, design and construct visual/ acoustic screening bunds/ embankments of waste rock in 'natural' shapes in early stages near sensitive receptors, which are then subsequently incorporated into the WRD proper • Plan backfilling of open pits to reduce WRD dimensions and effects of open pits after closure • Plan soil/ moraine/ ore stockpiles as 'natural' landforms (avoid linearity and repetitive geometry)	• Re-vegetate stockpiled soil materials, even if stockpiles are temporary

Landscape/ visual effect	Primary mitigation	Secondary mitigation
Vertical structures – cranes, buildings, powerlines, often with lights	• Design buildings to avoid obvious linearity and angles to reduce visibility • Minimise building heights • Building/ vertical structures should be in a neutral colour appropriate to the landscape to reduce visibility • Orientate long sides of buildings away from key visual receptors • Minimise height of flues, buildings	• Break-up outlines of structures with vegetation and/or different shaped structures/ landforms
Linear structures – fence-lines, pipelines, ditches, powerlines, haul and access roads, conveyors	• Design fences, embankments/ bunds, ditches, roads, etc. with curves/ more naturally shapes • Design drainage ditches with curves, not straight lines	• Break-up outlines of structures with vegetation and/or different shaped structures • Establish vegetation on all bunds/ embankments (including translocated trees, etc., obtained during vegetation clearance activities)
Signage – around site, e.g. at entrances, access/ haulage roads	NA	• Minimise amount of signage required
Emissions plumes	• Research and design-in available technologies for mitigating emissions plumes from flues	NA
Dust – generated from transport on unsealed roads, dumping of mineral materials (waste rock, soils, ore), exposed rock/ tailings surfaces, rock crushing activities and conveying.	• Minimise footprint of surface disturbance • Maintain natural vegetation cover to the degree possible • Pave high traffic areas	• Wet active dust generation areas • Minimise ore/ rock drop heights from conveyors/ trucks • Reduce vehicle speeds • Cover haulage trucks • Wet unpaved areas • Apply dust suppressants/ crusting agents to unpaved roads • Enclose conveyors • Reduce/ stop dust generating activities in windy weather • Re-vegetate bare areas as early as possible
Discolouration of water courses/ bodies – run-off contaminated with sediment and/or chemicals or fuel may contaminate surrounding water features	• Install sediment traps • Install oil traps • Design best practice hazardous chemicals storage facilities • Water treatment plants	• Follow best practice in managing hazardous chemicals • Implement spill response plan • Manage run-off and sedimentation

Landscape/ visual effect	Primary mitigation	Secondary mitigation
Re-vegetation/ planting schemes	• Plan progressive restoration wherever possible, as early as possible, including during construction!	• Implement temporary plantings, e.g. on soil/ moraine stockpiles as soon as possible • Final land surface microtopography should be complex, not smooth • Create denser than normal plantings to reduce effects of slow-growing vegetation on land cover (manage this density in the future) • Use in-situ vegetation from site as donor sites for restoration areas • Avoid unnatural planting patterns or locally inappropriate colours and species • Avoid planting in unnatural patterns/ grids

TABLE 7.2 Determining the sensitivity of landscape receptors

Landscape receptor	Value	Susceptibility	Sensitivity
Kiruna Mining LLCA	The LLCA is a highly dynamic and degraded mining landscape. It contains some well-vegetated former mining areas that add to its character and merge parts of this LLCA into the more natural neighbouring LLCA of Mountain Birch Forest/ Fjällbjörkskogen LLCA. It is of high value culturally and is nationally designated as such. There is a strong sense of place and cultural identity, with a distinctive skyline and landforms that dominate the surroundings, and social acceptance among local people. The dynamism of its landforms offers a low degree of vulnerability. The LLCA is deemed to be of **medium value.**	The LLCA is heavily affected by former and existing mining activities, with related landscape effects on topography, aesthetics, views and cultural associations. It is deemed to be of **low susceptibility.**	The LLCA is considered to be of low sensitivity resulting from its medium value and **low susceptibility.**
Kiruna Urban LLCA	The LLCA is a culturally significant and dynamic townscape, with architecture developed in response to the environmental, social and economic challenges of developing a large mining community in a remote Arctic location. It is nationally recognised for its cultural significance and is, paradoxically, simultaneously conserving, reinventing and relocating its townscape and community through the necessity induced by encroaching mining subsidence. Its frontier spirit and closeness to extensive, wild Arctic terrain augments the already strong sense of place and cultural identity, which is heavily influenced by the other LLCAs described here. The LLCA is deemed to be of **medium value.**	The city is being relocated, which involves demolition and translocation of many buildings and reconstruction of a new city centre. It is deemed to be of **low susceptibility**.	The LLCA is considered to be of low sensitivity resulting from its medium value and **low susceptibility.**
Mountain Birch Forest/ Fjällbjörkskogen LLCA	The LLCA is a tranquil Arctic wilderness, dominated by expansive mountain birch forest and open wetlands. It is easily accessible from Kiruna and is an essential of the local tourism provision and a cultural and recreational foundation for the sense of identity of local people. The views from Ädnamvaara are exceptional. It is designated internationally and nationally for the integrity of its ecological systems and biodiversity. It is formally recognised as traditional Sami lands. The LLCA is deemed to be of **high value.**	The LLCA is adjacent to the site and LKAB's mining area, with attendant noise and aesthetic and visual effects affecting part of the LLCA. It is deemed to be of **medium susceptibility.**	The LLCA is considered to be of medium sensitivity resulting from its high value and **medium susceptibility.**
Coniferous Forest/ Barrskogen LLCA	The LLCA is characterised as a pristine, tranquil, Arctic wilderness, dominated by coniferous trees. The Mountain Birch Forest/ Fjällbjörkskogen LLCA and Coniferous Forest/ Barrskogen LLCA are continuous with one another. It is easily accessible from Kiruna and is an essential of the local tourism provision and a cultural and recreational foundation for the sense of identity of local people. It is designated internationally and nationally for the integrity of its ecological systems and biodiversity. It is formally recognised as traditional Sami lands. The LLCA is deemed to be of **high value.**	The LLCA imparts a strong sense of remote, tranquil forest wilderness. It is a minimum of 5 km from the Viscaria site. There is some development in the LCA, such as occasional roads and small communities. It is deemed to be of **medium susceptibility.**	The LLCA is considered to be of medium sensitivity resulting from its high value and **medium susceptibility.**

TABLE 7.3 Determining the sensitivity of visual receptors

ID	Viewpoint location	Value	Susceptibility	Sensitivity
1	**Ädnamvaara Cottage**	A widely promoted recreational destination, easily accessible year-round from northern Kiruna via the Ädnamvaara Trail. Visited for exceptional panoramic views to east across to Luossavaara (a key sightline), Kiruna city and LKAB's mining area and to north and west and south over Arctic wilderness to Kebnekaise and the high mountains. Promoted for views. Houses a café in spring and summer. Deemed to be of **high value**.	Visitors come here for the views, including residents and tourists. Deemed to be of **high susceptibility**.	Based on its high value and high susceptibility, the viewpoint is considered to be of **high sensitivity**.
2	**Ädnamvaara Trail**	Viewpoint from trail on valley floor, beyond Viscaria site perimeter, at base of Ädnamvaara with unobstructed views to southwestern part of site. Deemed to be of **high value.**	Visitors come here for the wilderness and the views, including residents and tourists. Deemed to be of **high susceptibility**.	Based on its high value and high susceptibility, the viewpoint is considered to be of **high sensitivity.**
3	**Ädnamvaara Trail car-park**	The trailhead for the Ädnamvaara Trail and adjacent to site. View is degraded by wind turbines, fence and foreground carpark. Not a viewing destination in its own right, but viewers are motivated to use it by easy access to the nearby Arctic wilderness and its views year-round. Deemed to be of **low value.**	Of low interest to visitors, who use the location as starting point for recreational trails. Deemed to be of **low susceptibility.**	Based on its low value and susceptibility, the viewpoint is considered to be of **low sensitivity.**
4	**E10 north of Kiruna**	A major route to Kiruna from the mountains and national parks to the north and west and to the Norwegian and Finnish borders. Aesthetically beautiful as passes through Arctic wilderness (Mountain Birch Forest/ Fjällbjörkskogen LLCA). Heading towards Kiruna, intermittent views of site along road from 10km out, with increasing frequency as site gets closer. Intermittency of view is generally caused by the forest. Both resident and tourist travellers pass through at speed. Site visibility is increased by presence of wind turbines on Peuravaara Hill, intermittently visible for several kilometres. E10 (and railway) passes adjacent to northern perimeter of site. Approaching site, views become dominated by its wind turbines and an old, benched waste rock dump. Deemed to be of **medium value.**	Travellers consist of workers/ commuters, tourists, recreationists, some of whom will be there en-route to enjoy the wild landscapes. Views from the road/ train are not the main reason for being there. Deemed to be of **medium susceptibility.**	Based on its medium value and medium susceptibility, the viewpoint is considered to be of **medium sensitivity.**
5	**Máttaráhkká Northern Lights Lodge**	Accommodation for national and international tourists visiting to experience the Arctic wilderness throughout the year. Snow-mobile, dog-sled, cross-country skiing and fishing tours start from here. The main lodge building faces the site; roof is a popular location for relaxing and viewing the aurora borealis, marketed as viewing from the hot tub. Deemed to be of **medium value.**	View impacted by wind turbines on site. Also, close to E10 road. At night, vehicle lights visible from E10 and LKAB lights. Deemed to be of **medium susceptibility**.	Based on its medium value and medium susceptibility, the viewpoint is considered to be of **medium sensitivity**.
6	**Maria Taavenikkus Gata (new residential area)**	New apartment complex with mostly uninterrupted views across Luossajärvi to the site and Ädnamvaara and the mountains beyond. View extends to southeast over LKAB's mining area. The view will be important to the people who live there. Deemed to be of **high value.**	View experienced primarily by residents at home. Deemed to be of **high susceptibility**.	Based on its high value and high susceptibility, the viewpoint is considered to be of **high sensitivity**.

ID	Viewpoint location	Value	Susceptibility	Sensitivity
7	**Luossavaara car-park**	Locals and tourists visit this easily accessible location to enjoy and photograph the view year-round, as well as walking up to Luossavaara summit. Views over Kiruna city, LKAB, Viscaria site. Direct sightline to Ädnamvaara mountain and cottage. Deemed to be of **high value**.	Visitors come here for the views (as well as other outdoor recreational activities), including residents and tourists. Deemed to be of **high susceptibility.**	Based on its high value and high susceptibility, the viewpoint is considered to be of **high sensitivity**.
8	**Luossavaara summit***	Popular year-round recreational location on the northern edge of Kiruna for residents and visitors, easily accessible by road, trail, or chairlift, depending on the time of year. Home to a ski slope. The 724m-high summit offers 360-degree panoramic views over the city, LKAB mining area and Kiirunavaara, the Viscaria site and the wilderness beyond in every direction and Kebnekaise and high mountains in the distant west and north. Easily accessible in summer too, including along the promoted Midnight Sun Trail. Direct sightline to Ädnamvaara mountain and cottage, which passes directly over the Viscaria site. Deemed to be of **high value.**	Visitors come here for the views (as well as other outdoor recreational activities), including residents and tourists. Deemed to be of **high susceptibility**.	Based on its high value and high susceptibility, the viewpoint is considered to be of high sensitivity.
9	**Dübengatan** (No photo available)	Views from suburban residential area of apartment blocks on hilltop overlooking the site. Many residences will have mainly partial views of the site and LKAB and beyond to the mountains. Deemed to be of **medium value**.	View experienced primarily by residents at home. Deemed to be of **medium susceptibility**.	Based on its medium value and high susceptibility, the viewpoint is considered to be of medium sensitivity.
10	**Nordkalottvägen** (No photo available)	Views along this road heading north-west, with mainly unrestricted views of the site. Views from southern end of road are dominated by LKAB and the deformation zone. The southern end of the road will be removed in the coming years in response to the encroaching LKAB subsidence The northern end views become intermittent due to trees, railway infrastructure and occasional buildings. The eastern side of road is lined with residential buildings with mainly unobstructed views of the site and LKAB's mining landscape (a national cultural designation). Deemed to be of **medium value**.	Views experienced mainly be commuting workers and residents. Deemed to be of **medium susceptibility**.	Based on its medium value and high susceptibility, the viewpoint is considered to be of **medium sensitivity**.
11	**Kiruna railway station** (Figure 6.9)	Views directly across Luossajärvi to Viscaria for those travellers arriving or leaving Kiruna by train. A view which is not unattractive, but is not the main reason for the receptor being there. View adversely affected by railway infrastructure and trains. LKAB mining landscape is a national cultural designation. The city plans to move the railway station, but the timing and new location are not yet known. View deemed to be of **medium value**.	View incidentally experienced by rail passengers. Deemed to be of **low susceptibility**.	Based on its low value and susceptibility, the viewpoint is considered to be of **low sensitivity**.

ID	Viewpoint location	Value	Susceptibility	Sensitivity
12	**Porfyrvägen** (Figure 6.10)	Views from suburban residential area of Kiruna on hillside facing the site across Luossajärvi. Some residences will have unobstructed views, many will have partial views of the site and the LKAB mining landscape (a national cultural designation) and beyond to the mountains. Deemed to be of **medium value**.	View experienced primarily by residents at home. Deemed to be of **high susceptibility**.	Based on its medium value and high susceptibility, the viewpoint is considered to be of **medium sensitivity**.
13	**Rallarvägen carpark** (No photo available, viewpoint obscured by trees)	Views from small rise above Luossajärvi; well-spaced, old residential area. Some residences will have unobstructed views, many will have partial views of the site and LKAB and beyond to the mountains. This location will be on the edge of the deformation zone in 2035, as predicted by LKAB. Deemed to be of **medium value**.	View experienced primarily by residents at home. Deemed to be of **medium susceptibility**.	Based on its medium value and high susceptibility, the viewpoint is considered to be of **medium sensitivity**.
14	**Scandic Ferrum hotel** (Figure 6.11)	Views from hotel east over deformation zone to LKAB and northeast over Viscaria site to mountains beyond. Hotel promotes long-distance views of Kebnekaise. Viewpoint is outside at ground level. Other adjacent visual receptors include residents at home and workers in adjacent areas. The viewpoint is likely to be removed by 2029/30 due to the encroaching LKAB subsidence. Deemed to be of **medium value.**	Viewers will be travellers and workers who are not focussed on appreciation of the view, and some residents. Viewpoint deemed to be of medium to **low susceptibility.**	Based on its medium value and medium to low susceptibility, the viewpoint is considered to be of **medium sensitivity.**
15	**Gruvstadsparken** (Figure 6.12)	Viewpoint across deformation zone to LKAB, which dominates view, and distant view to site. LKAB mining area is nationally designated for its cultural importance. Purpose built and easily accessible viewpoint to view the encroaching deformation zone in a park developed as a moving buffer zone between the deformation and the retreating city. The viewpoint is likely to be removed by 2029/30 due to the encroaching LKAB subsidence. Deemed to be of **medium value.**	Viewers visit for the view, but the view is of a dynamic mining/ subsiding landscape. Viewpoint deemed to be of **low susceptibility.**	Based on its medium value and low susceptibility, the viewpoint is considered to be of **low sensitivity.**
16	**Högalidskolan** (Figure 6.13)	Viewpoint from suburban school carpark on hill to illustrate views from school, STF Malmfältens Folkhögskola and residential properties close by. Many will have partial views over Kiruna towards the site. Deemed to be of **low value.**	View experienced by workers, travellers and residents. Deemed to be of **low susceptibility.**	Based on its low value and susceptibility, the viewpoint is considered to be of **low sensitivity.**
17	**Triangelskolan** (No photo available, viewpoint obscured by trees)	Viewpoint in suburbs close to school, hospital and residential suburban area. Current views of site obstructed by intervening buildings Currently deemed to be of **negligible value**.	Viewers will be mainly residents. Site will be visible past LKAB and over deformation zone. Deemed to be of **low susceptibility.**	Based on its negligible value and low susceptibility, the viewpoint is considered to be of **negligible sensitivity.**
		By 2029-2032, this location will be on the edge of the deformation zone, as predicted by LKAB. Views to site will then be clearer, but over a deformed landscape and past the prominent LKAB workings. Predicted to be of **low value.**	Viewers likely to be mainly residents. Site will be visible past LKAB and over deformation zone. Deemed to be of **low susceptibility.**	Based on its low value and susceptibility, the viewpoint is considered to be of **low sensitivity.**

7.4 Assessment of Project Effects

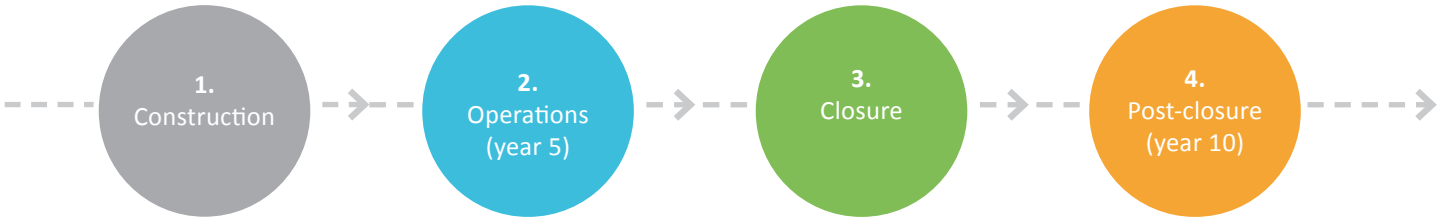
This section discusses the predicted residual project effects, inclusive of primary mitigation, on the landscape and visual receptors and ascribes levels of significance to them at different stages in the LOM, namely:

- **Construction,**
- **Operations (year 5),**
- **Closure, and**
- **Post-closure (year 10).**

The assessment assumes that the primary mitigations developed during the design stage of the project will be implemented (Table 7.1), but only where these primary mitigations are known.

The full impact assessment considerations are presented in Appendix 3. The sections below consider only the significant project effects, which are those deemed to be moderate/ minor and adverse or worse.

When considering the visual effects, the cumulative impact of the deformation zone moving eastwards, coupled with demolition/ relocation of buildings and therefore the opening up of new views towards the site from viewpoints at the edge of the deformation zone was addressed with one viewpoint, Triangelskolen. This was included twice in the analysis, once to consider effects on the current baseline view, and a second time to estimate the cumulative effect of the removal of currently obstructive buildings in response to the encroaching deformation zone on the same visual receptors. This is a particularly difficult exercise, given the lack of detail available on relocation/ demolition timelines, etc. This predictive analysis of the visual impacts of Viscaria should be carried out at a later stage when more detail is available on the phasing of the Viscaria project and the of the demolition/ relocation project.



7.4.1 Construction Effects

The site

The planning details of the construction phase are not yet known, so this analysis assumes the period of maximum construction effects.

At site level, the main landscape and visual effects arising from the construction phase will be: removal of the wind turbines; clearance of vegetation, soil and moraine leading to changing surface colours and textures on the site; stockpiling of soils and moraines creating new landscape features; the movement of machinery and vehicles on-site and into and out of the site, including moving and flashing lights and reflections; noise from vehicle movements and machinery; the presence of people will increase suddenly on-site in an area of relatively few people; dust generation; the erection of vertical, moving structures (cranes); buildings under construction will become more prominent as construction progresses. Noticeable access and haul road infrastructure will also be created creating new linear features and patterns on the landscape and other linear structures, such as fence lines, will be created.

Vegetation will be cleared and lay-down areas prepared along with a construction camp, vehicle maintenance and parking areas. Office and administration buildings will be constructed near the centre of the site, close to the northern side of the old TMF. Clearance of vegetation and soils and moraines and levelling of the ground will occur prior to construction of buildings and infrastructure and in the locations destined to become the new TMF and the northern and southern WRDs. Soils and moraines will be stockpiled for use in reclamation later in the project, but the precise stockpile locations have not yet been determined.

There will be increased traffic using public routes, via the E10, to and from the site. This will include transporters carrying heavy construction equipment and materials, fuel, processing and mining equipment, and personal vehicles carrying workers.

Large areas of the site will be directly affected, as will related, adjacent off-site areas to improve main site access, such as over the E10 at the north of the site. Current thinking is that the western section of the perimeter may not be developed to minimise the footprint of disturbance on an area that has seen relatively little disturbance during previous mining activities.

Removal of the wind turbines on Peuravaara ridge will have a beneficial landscape and visual effect across the LLCAs, reducing visual intrusion from the north – particularly along the E10, and to the west, making the site less noticeable and increasing perception of a 'natural' landscape until construction and operational activities begin.

The impacts at site level would relate primarily to the land-use change, from a re-vegetated former mine to an active construction with attendant noise and visual impacts and the development of new structures, as described…

Landscape receptors

A large part of the site is covered with mountain birch forest and appears similar in character to – and is continuous with – the forest of the Mountain Birch Forest/ Fjällbjörkskogen LLCA.

The Kiruna Mining LLCA will be directly affected by the construction phase as the project site is located within it. The baseline site integrates the Kiruna Mining LLCA, the Kiruna Urban LLCA and the Mountain Birch Forest/ Fjällbjörkskogen LLCA from and aesthetic perspective, but also ecologically and in terms of public access. The site is also highly visible from these three LLCAs and, to a lesser extent, from the Coniferous Forest/ Barrskogen LLCA.

The Ädnamvaara Trail, which skirts the north and west of the site, will be relocated further west into the Mountain Birch Forest/ Fjällbjörkskogen LLCA, along a route still to be determined. This will have a localised effect of removing trees along the course of the trail and may lead to localised fragmentation and disturbance through movement and noise as people are directed further into this LLCA.

The Viscaria site is located some distance from the closest part of the Coniferous Forest/ Barrskogen LLCA. Construction effects are likely to be mainly indirect, resulting from increased traffic in the Kiruna area and possible distant lighting effects and views of effects at site level from certain areas of the LLCA.

The residual effects of construction on the individual LLCAs and their corresponding levels of significance have been determined and are presented in Table 7.4.

Visual Receptors

Early in the construction phase the existing wind turbines will be removed. These are highly visible on the E10 north of Kiruna, when driving towards the city. Their removal will initially reduce the visibility of the site to this visual receptor. This situation may last for a couple of years, until development of the northern WRD begins, during the early years of operations.

From the north, the most visual aspect of construction will the removal of the wind turbines, which will have a neutral to beneficial effect on views from, for example, Ädnamvaara Trail car-park, the E10 north of Kiruna and Máttaráhkká Northern Lights Lodge.

With increasing elevation and distance from the northern perimeter, particularly from the Ädnamvaara and Luossavaara areas, most of the site will be visible, which means all of the construction activity, including: movement, to lights, to ground clearance and new structures will be visible across most of the site. The significant visual residual effects from the different viewpoints are presented in Table 7.5.

7.4.2 Operations (Year 5) Effects

The site

Based on the project description and phasing plans, operations will reach their maximum on-site disturbance in year 5, with consequential effects on landscape and visual impacts. Ore production will be at its highest, as will site disturbance, including the full development of the open pits and TMF and both WRDs will be in operation. Dust production during dry periods will impact the immediate site surroundings and vehicle traffic into and out of the site will be at its maximum. Plumes will continue to be visible in cold weather.

The southern WRD will be at its greatest extent and visibility, but yet to be graded into its final geomorphic design and restored with vegetation. The geomorphic design means that waste rock will be placed in benches, as in a typical WRD, but with varying widths to the benches and varying heights to the lifts. The WRD sides will not be straight with sharp angles, but relatively curved and sinuous. Grading to produce the final geomorphic finish cannot be completed until deposition on the WRD is complete. After grading, a cover of moraine and soil materials will be applied.

Progressive ecological restoration will be in its early stages and limited at best. The southern WRD will therefore be imposing in size, shape, texture and colour.

Any visual benefits to the aspect of the site from removing the powerlines in year five will be outweighed by the rapid growth thereafter of the northern WRD and increased vehicle movements, noise, dust and lights in that part of the site. In year 5, therefore, the northern WRD will create rapidly growing visual and landscape effects at the north of the site, including attendant vehicle movements, (flashing) lights, and noise.

The extent of the TMF will be obvious from many viewpoints and will be at its maximum extent.

Landscape receptors

Generally, this is the period of maximum adverse effect on the landscape receptors. The northern WRD will start to be developed in the early years of operations, but will not progress towards its intended final dimensions until the powerlines, which cross the site, are relocated to follow the railway track through the Mountain Birch Forest/ Fjällbjörkskogen LLCA. This relocation will have direct effects, such as tree removal, the introduction of linear features, and habitat fragmentation and cumulative effects with the existing infrastructure in this location.

The residual effects of operations (year 5) on the individual LLCAs and the corresponding levels of significance have been determined and are presented in Table 7.6.

Visual Receptors

The site will be at its most visually intrusive in year five of operations. The southern WRD, open pits, TMF and northern WRD will all be highly visible and active. The activity on the northern WRD will increase visibility from the E10, Máttaráhkká Northern Lights Lodge and Ädnamvaara Trail car-park. Few areas will have been reclaimed and ecologically restored by this time. The powerlines across the northern part of the site will be relocated off-site, marking a negligible improvement in the site's visual perspective. Emissions plumes will be highly visible in cold weather. The important sight-line for visual receptors between Luossavaara and Ädnamvaara will be degraded. The significant residual visual effects from the different viewpoints are presented in Table 7.7.

7.4.3 Effects of Mine Closure

The site

The plans for the mine closure phase are not yet known in detail, so the effects have been determined for the period of maximum activity during this phase. Mitigation activities carried out throughout the life of mine, such as backfilling of open pits with waste rock (and, possibly, benign tailings) and progressive restoration, will reduce the amount of activity required during the mine closure phase and, therefore the related effects of this phase.

Key landscape-related activities to be carried out will include: demolishing buildings and flues, removal of plant and processing equipment, removal of storage tanks, breaking up of concrete foundations and sealed roadways, removing infrastructure (except that required for access and site security in the closure and post-closure phases), re-grading and ecological restoration of the geomorphically-designed WRDs, capping and restoring the TMF, removal of most linear and vertical structures, removal of most signage. The introduction of new linear patterns, such as from tree planting in straight lines, or visually intrusive new fences, should be avoided. Overall there will be fewer people on-site.

Such activities may require explosives and heavy equipment, extensive earth movement, movement across site with flashing lights and noise, dust generation, changes in landform and surface texture and colour, few linear and vertical features. Noticeable will be the reduction in noise and vibration due to the ending of blasting, rock crushing and grinding. The visually intrusive emissions plumes will also end.

The end state of the mine closure phase will be a safe and stable site, with reduced visual impacts and more natural-looking and stable geomorphic landforms, with a slow-growing, self-sustaining vegetation cover and appropriate public access.

Landscape receptors

The residual effects of mine closure activities on the individual LLCAs and the corresponding levels of significance have been determined and are presented in Table 7.8.

Visual Receptors

At the height of on-site closure activities, the overall visual effects will be similar to those for operations (year 5). At some time during closure, mining and processing activities will end, resulting in – amongst other things – the end of the highly visible plumes during cold weather. This analysis assumes that there will be an overlap between the start of closure activities and the ending of processing activities, which will mean high site visibility. The significant residual visual effects from the different viewpoints are presented in Table 7.9.

7.4.4 Post-Closure (Year 10) Effects

The site

For many years – even decades – after closure, there will be ongoing on-site activities, which will be mainly limited to post-closure monitoring and maintenance/ aftercare of the closed and restored site. This will require regular, but infrequent site visits by a small number of specialists. They will monitor features like water quality, ecological recovery, TMF and WRD stability. There will also be a need to maintain appropriate access to key parts of the site, and security features, such as fencing and gates and restore eroded areas and re-plant, if necessary. If public access is to be allowed on the restored site, this will need to be maintained too, with due regard to public health and safety.

The stark impact of the WRDs, particularly the southern WRD and the TMF, from Ädnamvaara, will diminish as the landforms become softer on re-grading and, the texture and colour become more appropriate and, over the longer term, vegetation re-establishes.

In the Arctic conditions, vegetation growth is very slow, so it will take many years/ decades for the site to become unnoticeably re-integrated ecologically into its surroundings ecosystems; the reduced vegetation compared to the site's surroundings will be visible for many years/ decades and particularly in summer. However, for long periods of the year the site will be covered with snow, which will facilitate visual integration into the surrounding landscapes, particularly given the geomorphic design – and therefore more natural-looking landforms of many prominent site features.

The site's restored landscape will dramatically reduce its detrimental impact on the Mountain Birch Forest/ Fjällbjörkskogen LLCA. The final site will be devoid of wind turbines and powerlines, which exist currently as a baseline condition on-site. Perceptions of wildness, tranquillity and remoteness will re-build as the noise, visual impacts and movement end.

Landscape receptors

The residual effects of post-closure activities on the individual LLCAs and the corresponding levels of significance have been determined and are presented in Table 7.10.

Visual Receptors

Ten years after closure and the removal of all buildings and supporting infrastructure, the site will be becoming ecologically and visually integrated into its surroundings. The once highly visible and incongruous WRDs and TMF will be much less so, as their geomorphic design provides a strong basis for landform integration, while the site's slowly-growing vegetation cover will reinforce this integration further. All views will be improved and particularly those from the E10 north and the key viewpoints in the Ädnamvaara and Luossavaara areas. The sight-line between the latter sites will always be impeded by the new landforms to some extent. The significant residual visual effects from the different viewpoints are presented in Table 7.11.

TABLE 7.4 Summary of significant residual construction effects on landscape receptors (effects are considered to be significant if they are determined to be moderate/minor or above and adverse)

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Construction	
		Effect Magnitude	Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Moving machinery and vehicles** will affect the appearance of stillness and tranquillity in this part of the LLCA	Medium	Moderate/ Minor/ Adverse
	Noise from activities will affect the sense of peace in this part of the LLCA	Medium	Moderate/ Minor/ Adverse
	Moving and stationary lighting will be highly visible and affect the 'natural' aesthetic in a part of the LLCA that is relatively dark and connects with other dark areas	Large	Moderate/ Adverse
	Vegetation removal on 'natural' appearance of landscape and integration and continuity with 'wilder' landscapes	Large	Moderate/ Adverse
	Soil clearance on land surface colour and texture creating discontinuity with surrounding landscape	Large	Moderate/ Adverse
	Vertical structures will increase site visibility and reduce natural appearance, but removal of wind turbines will have beneficial effect on these site properties too	Medium	Moderate/ Minor/ Adverse
	Linear structures will highlight fragmentation of land and detract from natural, sinuous shapes	Medium	Moderate/ Minor/ Adverse
	Dust will cause local discolouration of land/ water features and clear skies near the site	Medium	Moderate/ Minor/ Adverse
Kiruna Urban LLCA Value: medium Sensitivity: low	**Moving and stationary lighting** will be highly visible and affect the 'natural' aesthetic in a part of the LLCA that is relatively dark and connects with other dark areas and is highly visible from a large part of Kiruna	Medium	Moderate/ Minor/ Adverse
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Moving machinery and vehicles** will affect the appearance of stillness and tranquillity in this LLCA in the area near the site and Ädnamvaara. Movement may affect reindeer herding.	Medium	Moderate/ Adverse
	Presence of people will increase in the area of this LLCA near the site, which will reduce the perception of solitude and remoteness	Small	Moderate/ Minor/ Adverse
	Noise from activities will affect the sense of tranquillity in this part of the LLCA. Noise may affect reindeer herding.	Large	Major/ Moderate/ Adverse
	Moving and stationary lighting will be highly visible and affect the 'natural' night-time/ winter aesthetic and perceptions of remoteness and the dark skies in this LLCA. Reindeer may be affected by lighting	Large	Major/ Moderate/ Adverse

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Construction	
		Effect Magnitude	Significance
	Reflections will increase site visibility in daylight and undermine sense of tranquillity and remoteness	Small	Moderate/ Minor/ Adverse
	Vegetation removal on the site will affect continuity of vegetation cover across a larger area from this LLCA	Medium	Moderate/ Adverse
	Soil clearance will increase unnatural appearance of site, thus perception of 'natural' landscape and remoteness in this LLCA	Medium	Moderate/ Adverse
	Unnatural landforms, such as moraine and soil stockpiles and bunds will be created, thus departing from the site's topographic continuity with surrounding landscapes, and draw the eye to unnatural shapes and linearity.	Small	Moderate/ Minor/ Adverse
	Linear structures will highlight fragmentation of neighbouring land and detract from natural, sinuous shapes	Small	Moderate/ Minor/ Adverse
	Dust will cause local discolouration of land/ water features and clear skies near the site detracting from perceived purity of natural landscape	Small	Moderate/ Minor/ Adverse
	Discolouration of water courses/ bodies will detract from the natural purity of waters in this LLCA	Small	Moderate/ Minor/ Adverse
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Moving and stationary lighting** will be visible and affect the 'natural' night-time/ winter aesthetic and perceptions of remoteness and the dark skies in parts this LLCA.	Small	Moderate/ Minor/ Adverse

TABLE 7.5 Summary of significant residual construction effects on visual receptors

Viewpoint		Construction	
ID	Name (Sensitivity)	Overall Magnitude	Significance
1	**Ädnamvaara cottage** (High sensitivity)	Large	Major/Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Major/Adverse
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Major/Adverse
7	**Luossavaara carpark** (High sensitivity)	Large	Major/Adverse
8	**Luossavaara summit** (High sensitivity)	Large	Major/Adverse
9	**Dübengatan** (Medium sensitivity)	Medium	Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Large	Moderate/ Adverse
12	**Porfyrvägen** (Medium sensitivity)	Medium	Moderate/ Adverse
13	**Rallarvägen carpark** (Medium sensitivity)	Medium	Moderate/ Adverse
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Moderate/ Adverse

TABLE 7.6 Summary of the significant residual effects of operations (year 5) on landscape receptors (effects are considered to be significant if they are determined to be moderate/ minor or above and adverse)

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Operations (Year 5)	
		Effect Magnitude	Effect Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Noise** from activities will affect the sense of peace in this part of the LLCA	Medium	Moderate/ Minor/ Adverse
	Vibration, primarily from blasting and heavy vehicles moving, will adversely affect perceptions of the closeness of nature	Medium	Moderate/ Minor/ Adverse
	Moving and stationary lighting will be highly visible and affect the 'natural' aesthetic in a part of the LLCA that is relatively dark and connects with other dark areas	Large	Moderate/ Adverse
	Vegetation removal will be at its maximum at the height of operations, affecting the 'natural' appearance of the landscape and integration and continuity with 'wilder' landscapes	Large	Moderate/ Adverse
	Soil clearance effects land surface colour and texture will be at their maximum, creating discontinuity with surrounding landscapes and visibility from outside the site	Large	Moderate/ Adverse
	Unnatural landforms, primarily WRDs and the TMF will be at their maximum extents and prior to significant reclamation and revegetation	Large	Moderate/ Adverse
	Vertical structures will increase site visibility and reduce natural appearance	Medium	Moderate/ Minor/ Adverse
	Linear structures will highlight fragmentation of land and detract from natural, sinuous shapes	Medium	Moderate/ Minor/ Adverse
	Emissions plumes from point sources related to industrial activities will be at their maximum and particularly impactful in cold weather	Large	Moderate/ Adverse
	Dust will cause local discolouration of land/ water features and clear skies near the site	Medium	Moderate/ Minor/ Adverse
Kiruna Urban LLCA Value: medium Sensitivity: low	**Moving and stationary lighting** will be highly visible and affect the 'natural' aesthetic in a part of the LLCA that is relatively dark and connects with other dark areas and is highly visible from a large part of Kiruna	Medium	Moderate/ Minor/ Adverse
	Unnatural landforms: the WRDs and TMF will be prominent, unnatural features when viewed from the city and degrade the sense of closeness to the wild landscapes beyond	Large	Moderate/ Adverse
	Emissions plumes from point sources will be at their maximum and particularly visible in cold weather, and degrade views to the mountain landscapes beyond	Large	Moderate/ Adverse

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Operations (Year 5)	
		Effect Magnitude	Effect Significance
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Moving machinery and vehicles** will affect the appearance of stillness and tranquillity in this LLCA in the area near the site and Ädnamvaara. Movement may affect reindeer herding.	Medium	Moderate/ Adverse
	Presence of people will increase in the area of this LLCA near the site, which will reduce the perception of solitude and remoteness	Small	Moderate/ Minor/ Adverse
	Noise from activities will affect the sense of tranquillity in this part of the LLCA. Noise may affect reindeer herding.	Large	Major/ Moderate/ Adverse
	Vibration, primarily from blasting and heavy vehicles moving, will adversely affect perceptions of closeness to nature/ wilderness, and tranquillity	Medium	Moderate/ Adverse
	Moving and stationary lighting will be highly visible and affect the 'natural' night-time/ winter aesthetic and perceptions of remoteness and the dark skies in this LLCA. Reindeer may be affected by lighting	Large	Major/ Moderate/ Adverse
	Reflections will increase site visibility in daylight and undermine sense of tranquillity and remoteness	Small	Moderate/ Minor/ Adverse
	Odours, will detract from natural scents of the LLCA, thus impacting sense of closeness to nature/ wildness	Small	Moderate/ Minor/ Adverse
	Vegetation removal on the site will affect continuity of vegetation cover across a larger area from this LLCA	Medium	Moderate/ Adverse
	Soil clearance will increase unnatural appearance of site, thus perception of 'natural' landscape and remoteness in this LLCA	Medium	Moderate/ Adverse
	Unnatural landforms, such as the WRDs and TMFs, and moraine and soil stockpiles and bunds will be most apparent, impacting views from this LLCA and restricting perceptions of wilderness and scenic beauty.	Large	Major/ Moderate/ Adverse
	Vertical structures will reduce natural appearance or surroundings and impact perceptions of remoteness	Small	Moderate/ Minor/ Adverse
	Linear structures will highlight fragmentation of neighbouring land and detract from natural, sinuous shapes	Small	Moderate/ Minor/ Adverse
	Emissions plumes from point sources related to industrial activities will be at their maximum, obscuring views and clarity of the sky and impacting perceptions of environmental purity	Large	Major/ Moderate/ Adverse
	Dust will cause local discolouration of land/ water features and clear skies near the site detracting from perceived purity of natural landscape	Small	Moderate/ Minor/ Adverse
	Discolouration of water courses/ bodies will detract from the natural purity of waters in this LLCA	Small	Moderate/ Minor/ Adverse

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Operations (Year 5)	
		Effect Magnitude	Effect Significance
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Moving and stationary lighting** will be visible and affect the 'natural' night-time/ winter aesthetic and perceptions of remoteness and the dark skies in parts this LLCA.	Small	Moderate/ Minor/ Adverse
	Unnatural landforms, particularly the WRDs, will be most apparent, impacting some views from this LLCA and affecting perceptions of wilderness and scenic beauty.	Small	Moderate/ Minor/ Adverse
	Emissions plumes will be visible in the distance from parts of the LLCA nearest the site	Small	Moderate/ Minor/ Adverse

TABLE 7.7 Summary of significant residual operations (year 5) effects on visual receptors. Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been greyed out with a darker grey.

Viewpoint		Operations (Year 5)	
ID	Name (Sensitivity)	Overall Magnitude	Significance
1	**Ädnamvaara cottage** (High sensitivity)	Large	Major/Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Major/Adverse
3	**Ädnamvaara car-parkl** (Low sensitivity)	Large	Moderate/ Adverse
4	**E10 north of Kiruna** (Medium sensitivity)	Large	Major/ Moderate/ Adverse
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Moderate/ Adverse
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Major/Adverse
7	**Luossavaara carpark** (High sensitivity)	Large	Major/Adverse
8	**Luossavaara summit** (High sensitivity)	Large	Major/Adverse
9	**Dübengatan** (Medium sensitivity)	Medium	Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Large	Major/ Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Large	Moderate/ Adverse
12	**Porfyrvägen** (Medium sensitivity)	Medium	Moderate/ Adverse
13	**Rallarvägen carpark** (Medium sensitivity)	Large	Major/ Moderate/ Adverse
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Moderate/ Adverse
15	**Gruvstadsparken** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse
16	**Högalidskolan** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse
17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Negligible
	Triangelskolan (Predicted: low sensitivity)	Medium	Moderate/ Minor/ Adverse

TABLE 7.8 Summary of the significant residual effects of operations (year 5) on landscape receptors (effects are considered to be significant if they are determined to be moderate/ minor or above and adverse)

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Mine Closure	
		Effect Magnitude	Effect Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Moving machinery and vehicles** will affect the appearance of stillness and tranquillity in this part of the LLCA	Medium	Moderate/ Minor/ Adverse
	Moving and stationary lighting will be highly visible and affect the 'natural' aesthetic in a part of the LLCA that is relatively dark and connects with other dark areas	Large	Moderate/ Adverse
	Vegetation removal will be at its maximum at the height of operations, affecting the 'natural' appearance of the landscape and integration and continuity with 'wilder' landscapes	Large	Moderate/ Adverse
	Soil clearance effects land surface colour and texture will be at their maximum, creating discontinuity with surrounding landscapes and visibility from outside the site	Medium	Moderate/ Minor/Adverse
	Unnatural landforms, primarily WRDs and the TMF will be at their maximum extents and prior to significant reclamation and revegetation	Large	Moderate/ Adverse
	Vertical structures will increase site visibility and reduce natural appearance	Medium	Moderate/ Minor/ Adverse
	Linear structures will highlight fragmentation of land and detract from natural, sinuous shapes	Medium	Moderate/ Minor/ Adverse
	Dust will cause local discolouration of land/ water features and clear skies near the site	Medium	Moderate/ Minor/ Adverse
Kiruna Urban LLCA Value: medium Sensitivity: low	**Moving and stationary lighting** will be highly visible and affect the 'natural' aesthetic in a part of the LLCA that is relatively dark and connects with other dark areas and is highly visible from a large part of Kiruna	Medium	Moderate/ Minor/ Adverse
	Unnatural landforms: the WRDs and TMF will be prominent, unnatural features when viewed from the city and degrade the sense of closeness to the wild landscapes beyond	Large	Moderate/ Adverse

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Mine Closure	
		Effect Magnitude	Effect Significance
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Moving machinery and vehicles** will affect the appearance of stillness and tranquillity in this LLCA in the area near the site and Ädnamvaara. Movement may affect reindeer herding.	Medium	Moderate/ Adverse
	Presence of people will increase in the area of this LLCA near the site, which will reduce the perception of solitude and remoteness	Small	Moderate/ Minor/Adverse
	Noise from activities will affect the sense of tranquillity in this part of the LLCA. Noise may affect reindeer herding.	Medium	Moderate/ Adverse
	Vibration, primarily from blasting and heavy vehicles moving, will adversely affect perceptions of closeness to nature/ wilderness, and tranquillity	Medium	Moderate/ Adverse
	Moving and stationary lighting will be highly visible and affect the 'natural' night-time/ winter aesthetic and perceptions of remoteness and the dark skies in this LLCA. Reindeer may be affected by lighting	Large	Major/ Moderate/ Adverse
	Reflections will increase site visibility in daylight and undermine sense of tranquillity and remoteness	Small	Moderate/ Minor/Adverse
	Vegetation removal on the site will affect continuity of vegetation cover across a larger area from this LLCA	Medium	Moderate/ Adverse
	Soil clearance will increase unnatural appearance of site, thus perception of 'natural' landscape and remoteness in this LLCA	Small	Moderate/ Minor/ Adverse
	Unnatural landforms, such as the WRDs and TMFs, and moraine and soil stockpiles and bunds will be most apparent, impacting views from this LLCA and restricting perceptions of wilderness and scenic beauty.	Large	Major/ Moderate/ Adverse
	Vertical structures will reduce natural appearance or surroundings and impact perceptions of remoteness	Small	Moderate/ Minor/ Adverse
	Linear structures will highlight fragmentation of neighbouring land and detract from natural, sinuous shapes	Small	Moderate/ Minor/ Adverse
	Dust will cause local discolouration of land/ water features and clear skies near the site detracting from perceived purity of natural landscape	Small	Moderate/ Minor/ Adverse
	Discolouration of water courses/ bodies will detract from the natural purity of waters in this LLCA	Small	Moderate/ Minor/ Adverse
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Moving and stationary lighting** will be visible and affect the 'natural' night-time/ winter aesthetic and perceptions of remoteness and the dark skies in parts this LLCA.	Small	Moderate/ Minor/ Adverse
	Unnatural landforms, particularly the WRDs, will be most apparent, impacting some views from this LLCA and affecting perceptions of wilderness and scenic beauty.	Small	Moderate/ Minor/ Adverse

TABLE 7.9 Summary of significant residual closure effects on visual receptors. Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been greyed out with a darker grey.

Viewpoint		Mine Closure	
ID	Name (Sensitivity)	Overall Magnitude	Significance
1	**Ädnamvaara cottage** (High sensitivity)	Large	Major/Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Major/Adverse
3	**Ädnamvaara car-parkl** (Low sensitivity)	Large	Moderate/ Adverse
4	**E10 north of Kiruna** (Medium sensitivity)	Large	Major/ Moderate/ Adverse
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Moderate/ Adverse
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Major/Adverse
7	**Luossavaara carpark** (High sensitivity)	Large	Major/Adverse
8	**Luossavaara summit** (High sensitivity)	Large	Major/Adverse
9	**Dübengatan** (Medium sensitivity)	Medium	Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Large	Major/ Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Large	Moderate/ Adverse
12	**Porfyrvägen** (Medium sensitivity)	Medium	Moderate/ Adverse
13	**Rallarvägen carpark** (Medium sensitivity)	Large	Major/ Moderate/ Adverse
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Moderate/ Adverse
15	**Gruvstadsparken** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse
16	**Högalidskolan** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse
17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Negligible
	Triangelskolan (Predicted: low sensitivity)	Medium	Moderate/ Minor/ Adverse

TABLE 7.10 Summary of the significant residual effects of post-closure (Year 10) on landscape receptors (effects are considered to be significant if they are determined to be moderate/ minor or above)

Landscape Receptor Value & Sensitivity	Description of Construction Effects	Post Closure (Year 10)	
		Effect Magnitude	Effect Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Unnatural landforms**, primarily WRDs and the TMF will be at their maximum extents and prior to significant reclamation and revegetation	Large	Moderate/ Adverse
Kiruna Urban LLCA Value: medium Sensitivity: low	No significant post-closure (year 10) landscape effects were determined for this LLCA.		
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Moving machinery and vehicles** will affect the appearance of stillness and tranquillity in this LLCA in the area near the site and Ädnamvaara. Movement may affect reindeer herding.	Small	Moderate/ Minor/Adverse
	Vegetation removal on the site will affect continuity of vegetation cover across a larger area from this LLCA	Small	Moderate/ Minor/Adverse
	Unnatural landforms, such as the WRDs and TMFs, and moraine and soil stockpiles and bunds will be most apparent, impacting views from this LLCA and restricting perceptions of wilderness and scenic beauty.	Small	Moderate/ Minor/Adverse
	Linear structures will highlight fragmentation of neighbouring land and detract from natural, sinuous shapes	Small	Moderate/ Minor/ Adverse
	Discolouration of water courses/ bodies will detract from the natural purity of waters in this LLCA	Small	Moderate/ Minor/ Adverse
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	No significant post-closure (year 10) landscape effects were determined for this LLCA.		

TABLE 7.11 Summary of significant residual closure (year 10) effects on visual receptors. Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been greyed out in darker grey.

Viewpoint		Post Closure (Year 10)	
ID	Name (Sensitivity)	Overall Magnitude	Significance
1	**Ädnamvaara cottage** (High sensitivity)	Large	Major/ Moderate/ Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Major/ Moderate/ Adverse
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Major/ Moderate/ Adverse
7	**Luossavaara carpark** (High sensitivity)	Large	Major/ Moderate/ Adverse
8	**Luossavaara summit** (High sensitivity)	Large	Major/ Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Moderate/ Adverse
13	**Rallarvägen carpark** (Medium sensitivity)	Medium	Moderate/ Adverse

7.5 Photomontages

The photomontages show the maximum extent of operations from five key viewpoints. Note that the effect will be exacerbated by emissions plumes, which are not shown. The photomontages are discussed briefly below:

- **Ädnamvaara Cottage** (Figures 7.1 and 7.2): From the viewpoint just north of the cottage, the mining site will be highly visible and will dominate the view to the northeast. The northern and southern WRDs and the TMF, buildings and open pits will be highly visible. The sight-lines between the cottage and Kiruna and Luossajärvi will be obstructed to some degree as a minimum. Kiirunavaara and Luossavaara will however still be visible, although the sight-line to the latter will be affected to a yet-to-be quantified degree.
- **Ädnamvaara Trail Car-Park** (Figures 7.3 and 7.4): The wind turbines on Peuravaara will be removed during construction, which is a beneficial visual effect. At the height of operations, the northern WRD will be highly visible from the car-park. Until vegetation has been established on the deposit, it will contrast to Peuravaara and other parts of the surrounding landscape in terms of colour, texture and shape. It is important to remember that a vegetation cover will take very many years to grow in the Arctic climate.
- **Máttaráhkká Northern Lights Lodge** (Figures 7.5 and 7.6). The wind turbines on Peuravaara will be removed during construction, which is a beneficial visual effect, although less-so than for the Ädnamvaara Trail Car-Park, which is closer. The northern WRD will be visible from Máttaráhkká Lodge and, due to the angle of the visual receptor, more of it will be visible than from the Ädnamvaara Trail Car-Park. The deposit will obscure the view of a more distant mountain top.

- **Luossavaara Summit** (Figures 7.7 and 7.8). The whole site is visible from this viewpoint and it sits directly in the Ädnamvaara/ Luossavaara sight-line. The shapes, landforms, colours and textures will all make the site highly visible and will reduce the scope of views towards the wilderness and mountains beyond, although these should still be visible, and augment the views of disturbed and developed land that already exists at LKAB and Kiruna.
- **Gruvstadsparken** (Figures 7.9 and 7.10). The Viscaria WRDs will compose a new silhouette towards the west and its buildings will be highly visible. To a small degree, some of the high mountains in the far west that are visible today will be obscured. From this location, the wind turbines on Peuravaara are prominent features of the silhouette today, but will not be there beyond the construction phase.

FIGURE 7.1 Baseline view from Ädnamvaara Cottage.

FIGURE 7.2 Predicted view from Ädnamvaara Cottage at the maximum extent of Viscaria's operations.

FIGURE 7.2 Baseline view from Ädnamvaara Trail Car Park.

FIGURE 7.4 Predicted view from Ädnamvaara Trail Car Park at the maximum extent of Viscaria's operations.

FIGURE 7.5 Baseline view from the roof of Máttaráhkká Northern Lights Lodge.

FIGURE 7.6 Predicted view from the roof of Máttaráhkká Northern Lights Lodge at the maximum extent of Viscaria's operations.

FIGURE 7.7 Baseline view from Luossavaara summit.

FIGURE 7.8 Predicted view from Luossavaara Summit at the maximum extent of Viscaria's operations.

FIGURE 7.9 Baseline view from Gruvstadsparken.

FIGURE 7.10 Predicted view from Gruvstadsparken at the maximum extent of Viscaria's operations.

8. CUMULATIVE EFFECTS

According to GLVIA3, cumulative effects are the additional changes caused by a proposed development in conjunction with other similar developments, or as the combined effect of a set of developments, taken together. In most cases the focus of a cumulative effects assessment is on the additional effect of the project in conjunction with other developments of a similar type; however, in Kiruna, there are substantial industrial and development projects underway, or planned, in which the effects they cause will be of interest from the perspective of landscape or visual receptors.

This section briefly discusses the potential cumulative landscape and visual effects as determined during the LVIA and uses the same 10km study area. Only those effects considered to be likely and significant are described.

8.1 Cumulative Landscape Effects

Cumulative landscape effects are effects that can impact on either the physical fabric of character of the landscape, or any special values attached to it. These are briefly discussed below.

The context of the Viscaria site as a former mine site adjacent to a heavily degraded mining landscape reduces perception of the effects of the development when compared to exploitation in a truly remote wilderness location. That said, the site is located on the boundary between intense landscape degradation and highly valued wilderness. This makes the cumulative analysis complex and interesting. Some potential effects identified include:

- **Wilderness, tranquillity, remoteness.** Perceptions of tranquillity and remoteness result from a combination of visual and auditory (and other) sensory experiences. In the highly valued Mountain Birch Forest/ Fjällbjörkskogen LLCA, these perceptions are already degraded by the unnatural angular landforms of LKAB's mining area and the constant industrial noise that is an auditory backdrop within a few kilometres of the site. Viscaria's largely re-vegetated

landscape currently blends with this LLCA and provides continuity almost to the edge of Kiruna. As the site develops, this transition zone will become more akin to LKAB's mining landscape forming an apparently impenetrable barrier of degraded and unnatural landscape between the LLCA and the town. Viscaria's mining and processing activities will add to this noise, further diminishing the perception of Ädnamvaara as an easily accessible wilderness; this may no longer feel quite so wild, tranquil and on the edge of remoteness.

- **Landscape aesthetic.** The 'filling in' of the Viscaria site with mining infrastructure, buildings and waste deposits will expand the de facto barrier of mine WRDs from LKAB and Viscaria, which, when coupled with buildings and emissions plumes, may engender among people in Kiruna a sense of increasing separation between the city and the wilderness, which could lead to erosion of the sense of place. The constant visual backdrop of distant mountains and forests will no longer be so easily connected to – either physically or emotionally. This experience will be felt most by those living in the north of Kiruna, particularly at low elevations, and when – for example - driving along the Nordkalottvägen road.
- **Landscape fragmentation.** Development at the Viscaria site will mean relocating public access trails, reindeer fences, powerlines and, perhaps, even access routes into the site. Also, at some time in the future, the railway station and part of the railway will be relocated, and new residential developments are being built in the north of the city. In combination, these activities will interact to increase landscape fragmentation to the north and northwest of Kiruna. This could affect public access and reindeer herding in the area. People wishing to access the wilderness will use new trails further into the forest, with potential effects on biodiversity. The landscape in this area could look and feel more contained, with increasing barriers to movement across it and visually less continuous.

- **Sense of place.** As a large part of the city's population moves further east, there is a risk to the sense of place experienced by local people, as the geographical disconnect with the mining industry extends by a few kilometres. Some people will work with LKAB and Copperstone, but for the many who don't the current sensory (i.e. visual and auditory) mining backdrop to city life that strengthens this sense of place could be weakened as the sensory connections weaken. Over the long term, this could lead to increasing apathy against the industry.
- **Máttaráhkká Northern Lights Lodge.** The lodge is located in the forest close to the E10 road to the north of Kiruna. From the front, the view of Peuravaara is of wind turbines and to the rear are the ski slopes of Luossavaara, which are brightly lit in the winter. It is also very close to the road to Viscaria's main entrance. The cumulative effects of the mine re-opening will increase disturbance the lodge's residents through more traffic on the E10, heavy vehicles on the Viscaria access road, increased noise from on-site activities, visual intrusion from the movement of vehicles in the north of the site, and a new WRD with potential for dust and visual intrusion. The WRD will be unnatural in appearance for many years before it is re-graded to a geomorphic design and re-vegetated. Night-time lighting on-site will also combine with the above to undermine the sense of relative tranquillity and remoteness for visitors to the lodge.
- **Public access.** This will be degraded by the development and easy access to the wilderness directly to the west of Kiruna will become more difficult, entailing longer detours from current routes, which are going to be moved. This lack of access is a cumulative effect of LKAB and Viscaria. Consideration should be given to providing a public access route across the Kiruna Mining LLCA, from one side to the other, including either through LKAB or Viscaria landholdings, or both. This would also work to build understanding of the local mining industry among local landscape users

8.2 Cumulative Visual Effects

Cumulative visual effects are those caused by combined visibility, which occurs where the observer is able to see two or more developments from one viewpoint and/or sequential effects which occur when the observer has to move to another viewpoint to see different developments. Visually, the project site and its surrounding context are complex and multi-dimensional.

In the Kiruna area, the views to the high mountains and wilderness are highly valued by local people, in spite of the views of unnatural, degraded lands caused by mining. Some of the cumulative visual effects identified in the LVIA are:

- **Visual connectivity between Kiruna and the wilderness/ western mountains.** Viscaria's current undeveloped status provides a convenient gap in the industrial landscape with visual connectivity between the Mountain Birch Forest/ Fjällbjörkskogen LLCA and the city. The cumulative effect of both mines working in close proximity and the new landforms and buildings will tend to fill the visual gap, obscuring the lines of sight between city and wilderness, particularly from lower elevations.
- **Emissions plumes.** In cold weather the emissions plumes from LKAB are very obvious and already intrude on clear views from key viewpoints in the city, Luossavaara and Ädnamvaara. Further plumes emanating from Viscaria will extend the visual intrusion to the extent that on some days it may not be possible to see the western mountains from, for example, Maria Taavenikkus Gata, Luossavaara car-park, or from Ädnamvaara to Luossavaara.
- **Dark skies.** Views of the aurora borealis and dark Arctic night skies from the Kiruna area are promoted to the tourism industry, both nationally and internationally. The sky over Viscaria constitutes a large, dark patch between the light-affected skies over LKAB, Kiruna and the floodlit Luossavaara ski-slope. Cumulatively, the Viscaria development risks diminishing the dark sky resource for residents and visitors to Kiruna by light pollution emanating from this site.

- **New viewpoints and new visual receptors relating to the city relocation.** As the deformation zone moves eastwards and the closest buildings to it are removed, new views will be opened up to old residences and workplaces. These are difficult to analyse and model in relation to the project phasing and timeframe and how it integrates with the city demolition and relocation programme, but viewpoints with no – or only partial – views of the site may have unobstructed clear views of it in a few years' time. This is a cumulative effect, but it is difficult to determine whether it is adverse, neutral or beneficial, as the new, wider views that include Viscaria may be more highly valued than the original views from viewpoints obstructed by foreground buildings.
- **Approaching Kiruna from the north on the E10 at night.** Driving south on the E10 towards Kiruna in the dark in winter, eyes are drawn upwards to the brightly floodlit ski-slopes on Luossavaara, which dominate the area. On the eastern side of the road, it is relatively dark, because the undeveloped Viscaria site masks most direct light pollution from LKAB. This will change as Viscaria develops, with lights then filling this dark void and cumulatively impacting on the night-time visual experience as one approaches Kiruna.

9. CONCLUSIONS

The former Viscaria mine site is now largely revegetated with a landscape character that transitions between the wilderness on one side and intense, degraded mining lands and urban development on the other. A further cultural and depth of time aspect to the landscape character derives from the occupation of the land by the Sami for thousands of years. They also husband reindeer, which are also sensitive to mining-related disturbance.

The site is highly visible from many parts of Kiruna and the surrounding wild landscapes and access routes from the north. The extensive, heavily degraded, adjacent mining landscape of LKAB provides a stark visual contrast to the qualities of the current Viscaria site. It also offers a visual 'pathway' towards the wilderness and mountains beyond Kiirunavaara and LKAB for most visual receptors. Viscaria is prominent from many locations; the space it occupies is a valued 'gap' through which the residents of and visitors to Kiruna can access – physically or emotionally – the wilderness on their doorstep.

In winter and at night, the dark skies and lack of lighting over Viscaria enhance this perceptual corridor to the wilderness and enables views of the aurora borealis, which are promoted to visitors.

Of the four LLCAs determined for this LVIA, the most sensitive to the Viscaria development is the Birch forest/ Fjällbjörkskogen LLCA. This is the easily accessible gateway to the wilderness for many Kiruna residents and visitors. Its landscape character will be degraded by the project development to the extent where a 'wilderness' experience in the Ädnamvaara area will be diminished.

Significant residual, adverse visual and landscape effects will occur during construction in all four LLCAs, but particularly the Kiruna Mining LLCA and the Mountain Birch Forest/ Fjällbjörkskogen LLCA. The effects on the latter are of particular concern. These effects will include: a change in landcover, colour and texture; the appearance of new structures; noise and lighting pollution; and movement and the presence of people. Visual effects will particularly affect visual receptors within 5 km to the west, north and east of the site.

Many of the construction phase's residual adverse, visual and landscape effects will transfer into the operations phase. Particular new effects will result from the growing WRDs and TMF, lighting intrusions and emissions plumes. Most affected will be the Mountain Birch Forest/ Fjällbjörkskogen LLCA and the visual receptors mentioned above, including impacts on the landscape character and visual obstructions and intrusions.

The severity of effects will start to decline during the mine closure phase as, for example, emissions plumes disappear and prominent landforms become re-shaped into more natural-looking features. The site will still emanate light and noise and the reclaimed land will have little noticeable vegetation to assist visual integration into its surroundings.

Ten years after closure, there will be remaining – but small – landscape effects, primarily on the Mountain Birch Forest/ Fjällbjörkskogen LLCA, but some important effects on visual receptors will remain resulting mainly from the dimensions of the new landforms.

The main cumulative effects on the landscape relate to:

- Degradation of the perceptions of tranquillity, remoteness and wilderness of the Mountain Birch Forest/ Fjällbjörkskogen LLCA,
- A growing visual and perceptual barrier between the city and the wilderness to the west,
- Landscape fragmentation around the northern area of Kiruna,
- Weakening of the sense of place,
- Perceptions of remoteness and wilderness around Máttaráhkká Northern Lights Lodge, and
- Effects on public access

The main cumulative visual effects relate to:

- Visual connectivity between Kiruna and the wilderness/ western mountains,
- Emissions plumes,
- Dark skies,
- New viewpoints and receptors relating to the city's relocation, and
- Approaches to Kiruna from the north on the E10 at night.

The visual effects are not mutually exclusive and neither are the evident interactions between the landscape and visual cumulative effects.

Great consideration must be given to mitigation, particularly designing-in avoidance during the design phase. Some effects have already been addressed by design mitigation. To date, these include:

- Geomorphic designs for WRDs and TMFs to create a more natural appearance and more functional landform. The designs should also promote more effective ecological restoration,
- Removal of wind turbines and relocation of powerlines, reducing effects on visual receptors and landscape character, and
- Relocation of the Ädnamvaara Trail to a location further removed from the mine site.

However, although these design mitigations are commendable, further planned avoidance of effects is required and are best designed-out, if possible. Some recommendations include:

- Minimising the footprint of disturbance on-site, so less vegetation cover is damaged, which will reduce visual and perceptual effects of the site during the life of mine and aid quicker ecologically recovery of damaged areas.
- Further reducing the visual effects of the WRDs and TMF, in particular protecting important sight-lines identified in the LVIA, e.g. between Luossavaara car-park and Ädnamvaara.
- Reducing emissions plumes,
- Reducing light pollution and noise, and
- Creating opportunities for more public access across the Kiruna Mining LLCA, from the town to the wilderness.

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LANDSCAPE AND VISUAL IMPACT

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APPENDICES

APPENDIX B2:1

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CONTENTS

APPENDIX 1A: LANDSCAPE CHARACTER ASSESSMENT FOR THE VISCARIA PROJECT

As there is no existing landscape character study for the Kiruna area, the LVIA team had to carry out an appropriate investigation to determine the landscape character features and values of the area upon which an impact analysis was then carried out. This appendix provides a detailed account of the landscape character assessment for the Viscaria site.

General Landscape Context

The Nordic Council of Ministers has divided the Nordic region into 76 natural geographical regions. The division is based on biological and geological factors in the landscape and also takes into account topography, climate and land-use. There are twenty-nine of the natural geographical regions in Sweden. Kiruna and the project are located within the region of Northern Coniferous-Lapland. The regions of Nordland, Troms and Lapland's high mountain region and Finnmark's and Lapland's continental forest and mountain ranges are neighbouring geographical regions (Figure A1.1).

Northern Coniferous-Lapland is characterised by undulating plains with hills and smaller areas of foothills and high mountain areas. The western parts of the region, around Kiruna, are mainly covered with moraine and drumlins are common. The vegetation consists of varied coniferous forests, mountain birch forests, bogs and alpine vegetation. The coniferous forests around Kiruna are dominated by spruce (Picea abies), while pine (Pinus sylvestris) is more common further east. Wetland areas can be extensive.

The high mountain regions of Nordland, Troms and Lapland are characterized by mountains with tree lines at low altitudes, steep, rugged, high mountains and glaciers. The ground cover vegetation is thin or non-existent in some parts of the region. The vegetation period is short, and the vegetation is dominated by alpine vegetation.

The continental forest and mountain ranges of Finnmark and Lapland are characterized by extensive mountain birch forests with elements of pine and mountain heath. The topography is characterized by mountainous terrain reaching 700 masl. Between the low mountains there are open, wide, flat-bottomed valleys.

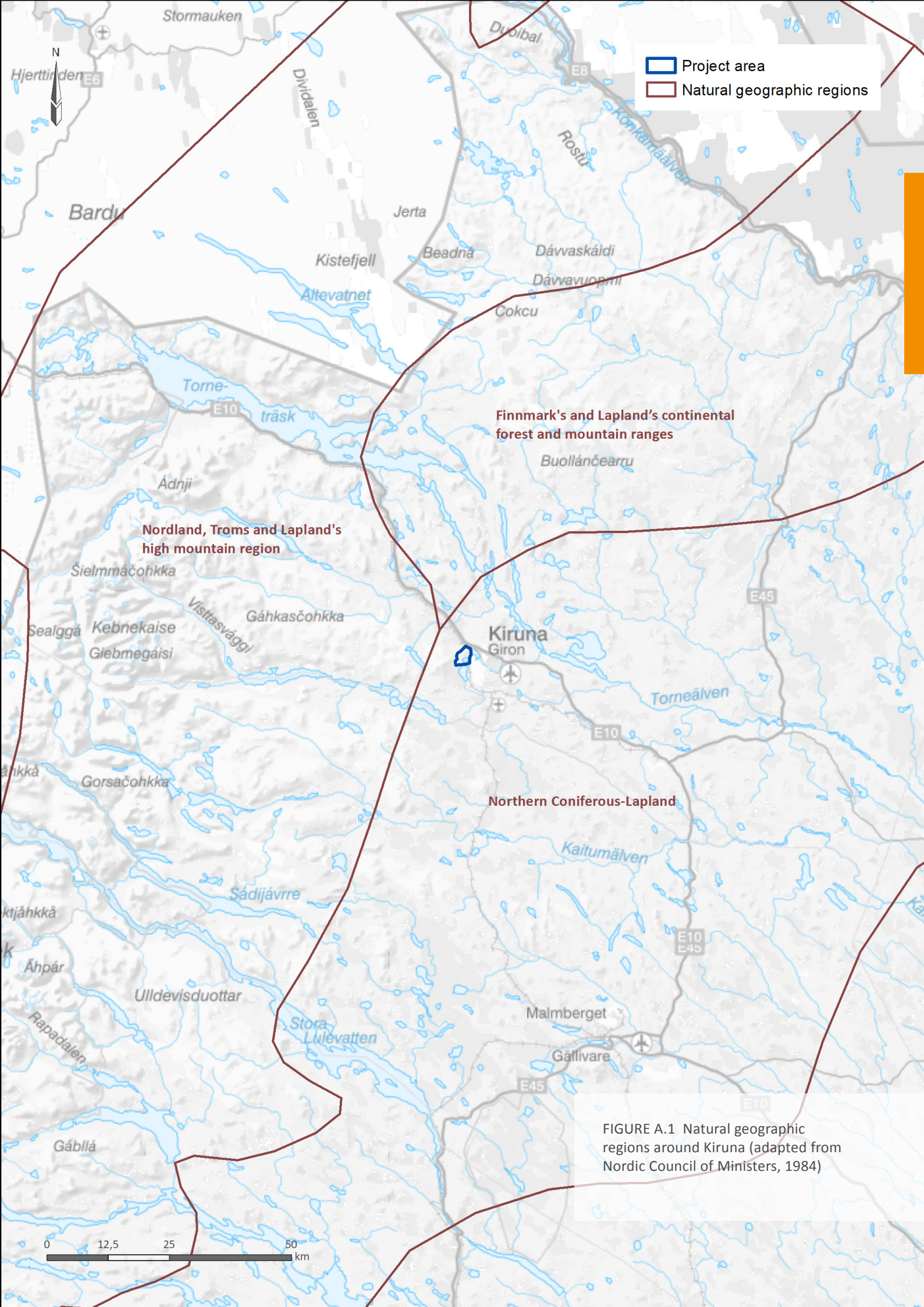

FIGURE A.1 Natural geographic regions around Kiruna (adapted from Nordic Council of Ministers, 1984)

Climate change in northern Sweden

It is important to understand and, ultimately, account for the predicted effects of climate change on the landscape of the area/ region that will be affected by the Viscaria development. Such knowledge will enable climate-sensitive landscape design and management mitigations to the planned effects of the project. Not only will (direct and indirect) climate change effects interact with each other, they will interact too with the dynamic landscape of the Kiruna area and with LKAB's continuing operations, the planned Viscaria mine development and the translocation of the town itself. These will affect how people engage with and experience the landscape and how people's perceptions of it will change with – for example – changes in forest type and tree cover, reduced periods of snow cover, new land-uses, different animals and bird song, etc. Appendix 1B provides a summary of the climate change effects that are happening and will continue to happen over the coming decades in northern Sweden.

Norrbotten County

Copperstone Viscaria AB's prospective copper mine is located on the north-western edge of the historic mining town of Kiruna in Norrbotten county, Sweden. Norrbotten is Sweden's largest and northernmost county; its 97,239km2 comprises almost a quarter of the country's land area.

Much of Norrbotten lies above the Arctic Circle and it is the coldest part of Sweden, although the extreme climate is moderated by the effects of the warm Gulf Stream ocean current of the north Atlantic Ocean, which drifts up the coast of Norway. Featuring both Sweden's highest mountain, Kebnekaise, and its deepest lake, Hornavan, the county is renowned for its remote and empty Arctic landscapes largely devoid of extensive development, which impart strong feelings of remoteness, wilderness and tranquillity. This landscape quality is recognised in the county's eight national parks and other protected areas. UNESCO has recognised Laponia as a World Heritage Site for its outstanding natural values. Three of Sweden's four rivers of national interest occur in Norrbotten County.

The region's first people, ancestors of the Sami, arrived in the northern part of Scandinavia, including what is now Norrbotten and the Kiruna area, about 9,000 years ago, as the inland ice cap retreated. The Sami culture and the Finnish-speaking culture have co-existed and interacted

in the area for all of recorded history. The Sami's reliance on reindeer herding over thousands of years has created a unique Sami cultural identity and sense of place in Norrbotten.

The church in Jukkasjärvi, on the river Torne 17 kilometres from Kiruna, was completed in 1607 and the Jukkasjärvi parish celebrated its 400th anniversary in 2007. The first "Swedes" arrived in the Kiruna area near Masugnsbyn, where the first iron ore mine began in 1647.

Today, its Arctic location and climate make this one of the most sparsely populated regions of Europe, with a population almost quarter of a million people found mainly in coastal towns. The populations of many of the inland towns, including Kiruna, are declining.

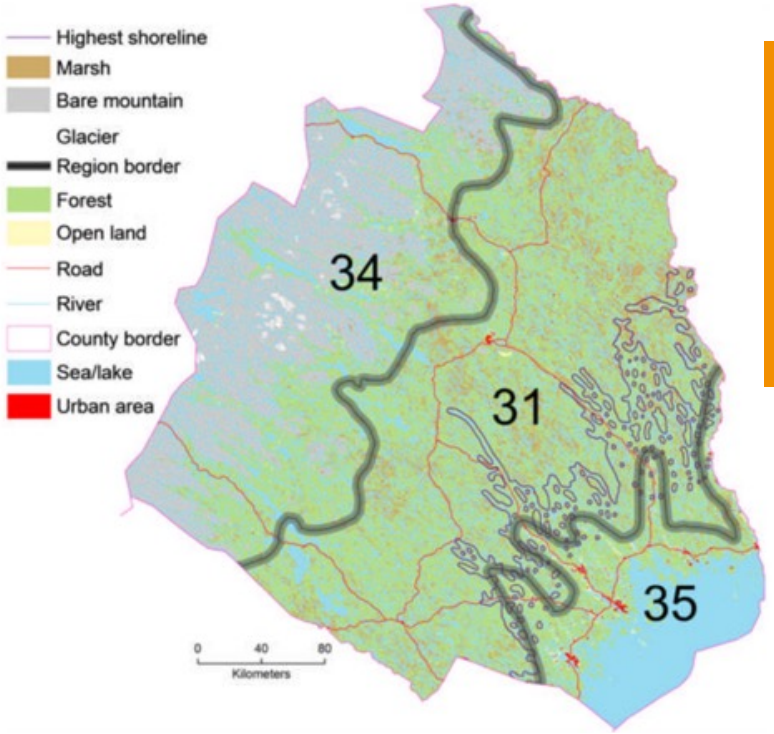

FIGURE A1.2 The three regions of Norrbotten County, northern Sweden, as defined by landscape character. The highest shoreline (transgression line) is indicated by the thin grey line

Over 90% of the land is natural, undeveloped landscape. The main land-use is timber production, with only a very small proportion of the county devoted to farming, mineral extraction and urban development. Mineral extraction, particularly for iron, has been a driving force in the development of inland urban centres. The county produces 11% of the national electricity supply, primarily from hydropower.

Regionally Norrbotten has been classified into three very general landscape character regions based on large-scale characteristic physical and cultural parameters, which include drumlins, river valleys, settlement agglomerations and their geographical positions, land-use, transportation patterns, vegetation, population density, livelihood patterns and forests (Figure A1.2). Unforested mountains dominate in the west, while forest, bogs and mires dominate the other two regions. In the eastern region near the coast and in the valleys lie some rural settlements.

Kiruna municipality

Kiruna municipality is the northernmost municipality in Norrbotten county. It borders Pajala municipality to the east, Gällivare municipality to the south, Norway to the west and Finland to the north. Its 23,000 people inhabit some 20,553 km2, most of whom live in the town of Kiruna.

Large parts of the municipality are protected areas with the state owning about 75% of the land – mainly the mountainous areas, but also some productive forest to the east. Although forest productivity is low due to the high latitude, there is a large supply of timber due to the extensive expanses of forest and low population density.

Reindeer husbandry is carried out across all of the municipality's area, which is located above the Lappmark border and mostly above the Cultivation Limit. The Lappmark is the northern Scandinavian area which historically has been inhabited by the Sami. The Lappmark border was established for administrative reasons in the mid-18th century. The Cultivation Limit is another administrative border that was established to protect the interests of the reindeer husbandry and to prevent the establishment of unprofitable agriculture. Today, the Cultivation Limit is part of Swedish legislation on reindeer husbandry, hunting and fishing.

There are four river catchment areas in the municipality:

1. The Kalix river in the far south, which forms the border with Gällivare municipality,
2. The Torneträsk of the Torne river which connects with the Rautas and Vittangi rivers,
3. The Råstojaure with the Lainio River, and
4. In the far north of the municipality, the Könkämä river and Muonio river form the border with Finland before flowing into the Kalix and Torne rivers.

Kiruna Municipality Regional Landscape Character Assessment

Alongside the afore-mentioned natural geographic regions of the Nordic Council of Ministers, Kiruna municipality commissioned a general, high-level landscape character analysis in 2011, which aimed to form a basis to assist spatial planning for wind power installations (for example, the analysis did not consider areas that are designated as unbroken mountain areas according to the Environmental Code 5:4, as these are not considered appropriate for wind power installations). Taken together, the landscape of the Kiruna municipality is characterized by the following features and special qualities:

- Magnificence,
- High mountains,
- Extensive bogs,
- Industrial remains, mining remains,
- Sami reindeer herding communities and related culture,
- Settler spirit,
- Extensive areas without roads, and
- Feelings of wilderness, remoteness.

The landscape across the municipality was divided into eight landscape character areas, excluding areas designated as Mountain Areas of National Interest, because it was previously determined that such areas are not suitable for wind power installations (Figure A1.3). The eight landscape areas are listed below, with those of relevance to the Viscaria LVIA in bold text:

1. Torneträsk,
2. **Fjällbjörkskogen (Birch Forest) by Kiruna,**
3. **Barrskogen (Coniferous Forest) by Kiruna,**
4. **Malmfälten/ Orefields,**
5. The Marshes between the Lainio River and the Torne River,
6. The Upper race of the Lainio River,
7. The North String, and
8. The Woodlands at Pessinki.

The project area sits close to the southern border of the Kiruna municipality, so part of the wider study area occurs in Gällivare municipality. The LVIA team searched for a similar landscape character analysis for Gällivare municipality to fill this gap, but one was not forthcoming.

Summary descriptions of the relevant three landscape character areas (LCAs) from the Kiruna Municipality report are provided below and, for the purposes of this project, have been called regional LCAs in order to distinguish them from the local LCAs subsequently identified in this project.

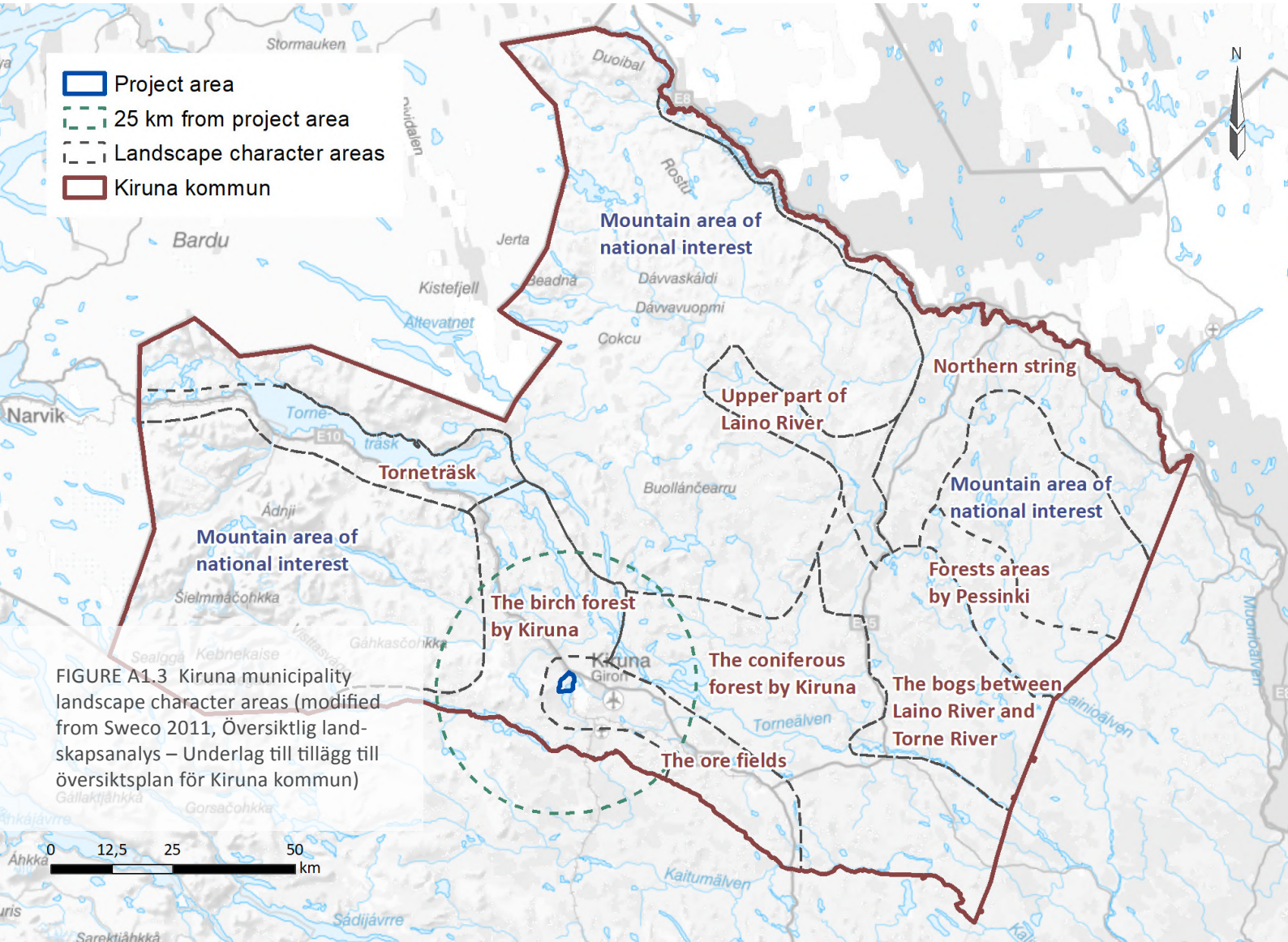

FIGURE A1.3 Kiruna municipality landscape character areas (modified from Sweco 2011, Översiktlig landskapsanalys – Underlag till tillägg till översiktsplan för Kiruna kommun)

Fjällbjörkskogen vid Kiruna/ Mountain Birch Forest at Kiruna

The strongest features of the Mountain Birch Forest at Kiruna LCA are its relatively flat, expansive open landscape, its outlook towards the mountains and the low, windswept vegetation and extensive bogs "like a sparse carpet". The LCA is more influenced by the proximity of the high mountains than by the proximity of Kiruna town. It is bounded to the east at by the Coniferous forest, which grows below 500 masl, and also by the Malmfälten, and to the north by the Torneträsk and the Mountain Area of National Interest.

Almost the entire LCA is of national interest for outdoor pursuits and consists mostly of designated high-value natural environments and protected areas, such as Natura 2000 sites, areas of national interest and nature reserves.

The LCA is used for reindeer grazing land over the long winter period by the Gabna and Leava Sami villages. The Talma Sami village in the northeast also has reindeer pastures in the area.

Barrskogen vid Kiruna/ Coniferous Forest at Kiruna

The Coniferous Forest at Kiruna LCA is bounded in the west by the Mountain Birch Forest at Kiruna and to approximately 500 masl. Elsewhere, its boundaries are determined by the Ore Fields LCA and the Bogs between the Lainio River and the Torne River LCA and the Mountain Area of National Interest.

The landscape is relatively low-lying, when compared to the mountain areas, but there are some hills present in the LCA. The LCA has been influenced by human development in some areas. Generally, broader landscape views are limited by the forest trees, but in those areas adjacent to developments such as roads, powerlines, buildings and settlements, the views are more open. The presence of the high mountains is felt less compared to the Mountain Birch Forest at Kiruna LCA. The Torneälven and Kalixälven rivers are both of national interest for outdoor recreation, natural environments of national interest and Natura 2000 areas. The LCA also possesses further protected areas, including Natura 2000 sites, mainly in the northern part of the Coniferous Forest at Kiruna LCA.

The LCA includes reindeer grazing land and constitutes winter pastures for the Talmas and Gabna Sami villages.

A starting point for planning concerning the Coniferous Forest at Kiruna LCA is that the landscape exhibits a robust quality through the physical aspects of human influence and through the growing forest that embeds settlements and other types of development.

Malmfälten/ Orefields

The Orefields LCA refers to the area of the ore-rich Kiruna-Gällivare route, which extends beyond the municipal border to Malmberget and Gällivare. The LCA is also demarcated in accordance with the Swedish National Atlas division of the country () into cultural geography regions; but the LCA also takes into account the boundary between the coniferous forest and mountain birch forest to the south of Kiruna.

This LCA is largely the same type of landscape as the Coniferous Forest at Kiruna LCA, but including visible elements of mining and related socio-economic infrastructure. The buildings generally possess a character that reflects the region's rapid industrial development during the 20th century. The central part of the LCA includes a Natura 2000 site.

In addition to the mining industry, reindeer husbandry is important, and the area comprises mainly spring and autumn pastures for the Gabna and Laeva Sami villages.

Summary of the Landscape of the Viscaria Mine Site

The Viscaria underground mine operated between 1982 and 1997, initially by LKAB, then from 1986 by Finnish mining company Outokumpu. They operated the mine through their subsidiary company Viscaria AB. Historically, the mine produced 12.5Mt of ore averaging 2.3% copper. The mine closed in 1996/7, since when all the surface buildings have been demolished. Figure A1.4 indicates the key landscape features of the site. The flooded open pits can be found in the centre and west of the site, while the closed, revegetated TMF is found in the south-east and the old, largely unvegetated waste rock dumps dominate the north of the site (Figure A1.5). The Viscaria site's man-made topography of waste rock dumps and a TMF is relatively low-lying and indistinct compared to those of the neighbouring Kiirunavaara and Luossavaara.

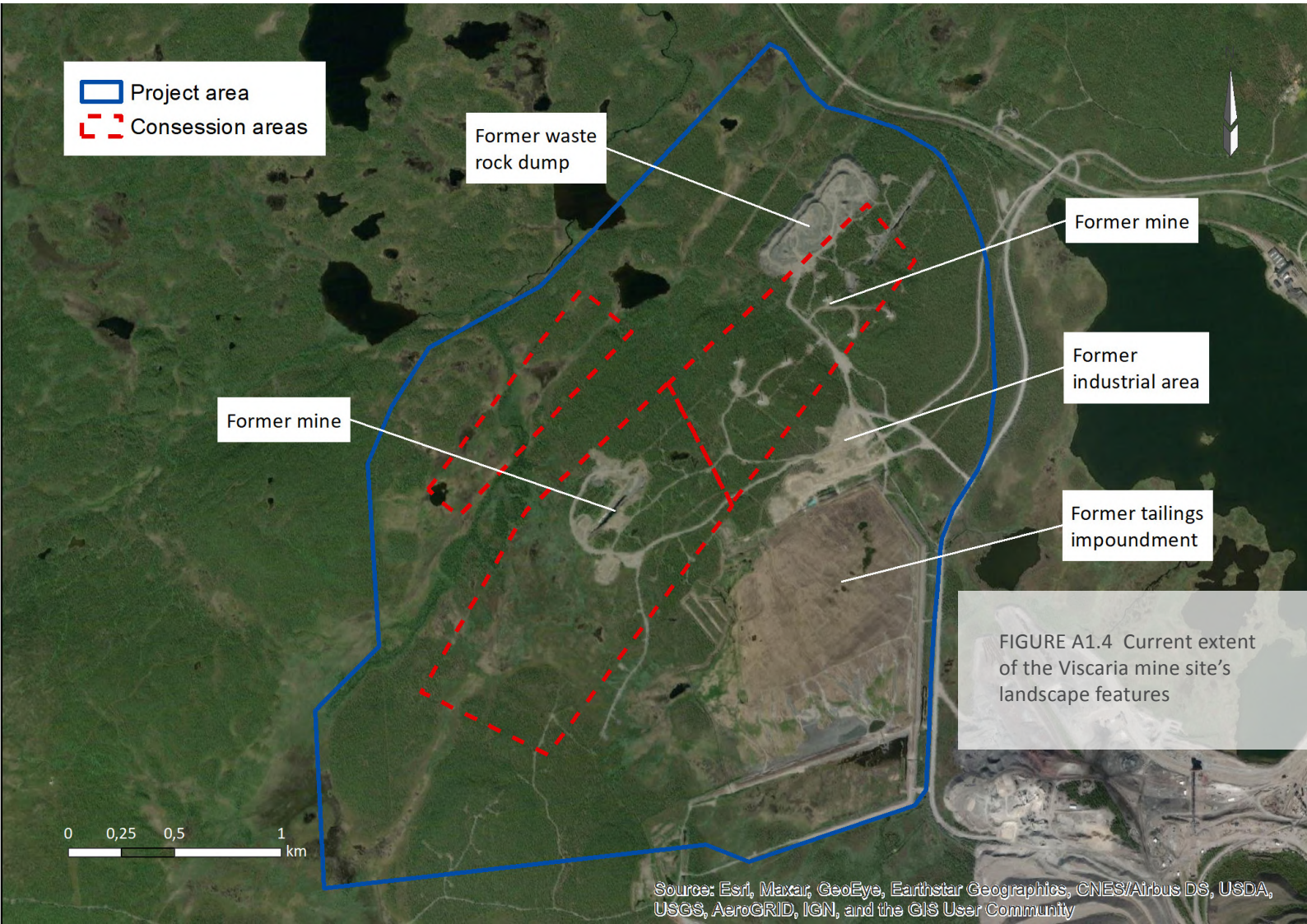

FIGURE A1.4 Current extent of the Viscaria mine site's landscape features

There remain some ongoing environmental management obligations that are addressed by the supervisory authority and Viscaria AB. Recent activities have included mineral exploration drilling by Copperstone-Viscaria AB, leaving a network of drilling access tracks and drill pads as a new feature of the old mine's landscape.

The Peuravaara ridge, upon which sit six wind turbines, is within the Viscaria site's perimeter (Figure A1.6). Both the ridge and the wind turbines are clearly visible from Kiruna town towards the west. The project area is also crossed by 130 kV powerlines (Figure A1.7).

There are no formally protected areas in the project area, although its northwestern perimeter abuts the Rautas Mountain Forest Nature Reserve Natura 2000 site. However, from a landscape character perspective, elements of a landscape can nevertheless have "value" as perceived by landscape users, whether or not the area is formally protected for species or habitat reasons. Previous natural value inventories carried out in the vicinity of the Viscaria site showed that high natural values may occur in or close to the project area (see text below). Further studies are under way to improve understanding of the local natural values as part of the Copperstone-Viscaria EIA.

FIGURE A1.5 The old waste rock dump in the northern part of the site viewed from the E10 in winter.

FIGURE A1.6 Wind turbines on the Peuravaara ridge and the wetland areas to the west and southwest of the site (Luossavaara mountain is in the distance to the right of the wind turbines)2021.

FIGURE A1.7 The high voltage powerlines crossing the north of the site.

The site is well-vegetated, which results from the ecological restoration work that happened during mine closure and the natural colonisation and vegetation development that has occurred since then (Figure A1.8). The vegetation is dominated by heath and mountain birch (Betula pubescens) forest on the hills Peuravaara and Nikhagobba (Figures A1.9 and A1.10). Juniper (Juniperus communis) and aspen (Populus tremula) also occur. The vegetation is of low species richness with different shrubs and wavy hair grass (Avenella flexuosa). Protected species that have been observed in the mountain birch forest include, for example, the clubmosses Lycopodium annotinum, L. complatanum and L. clavatum. In the western parts of the project site, there are more nutrient-rich forest areas with high herb vegetation and species such as melancholy thistle (Cirsium heterophyllum), globeflower (Trollius europaeus) and wood crane´s bill (Geranium sylvaticum), as well as the protected fragrant orchid (Gymnadenia conopsea) and frog orchid (Coeloglossum viride).

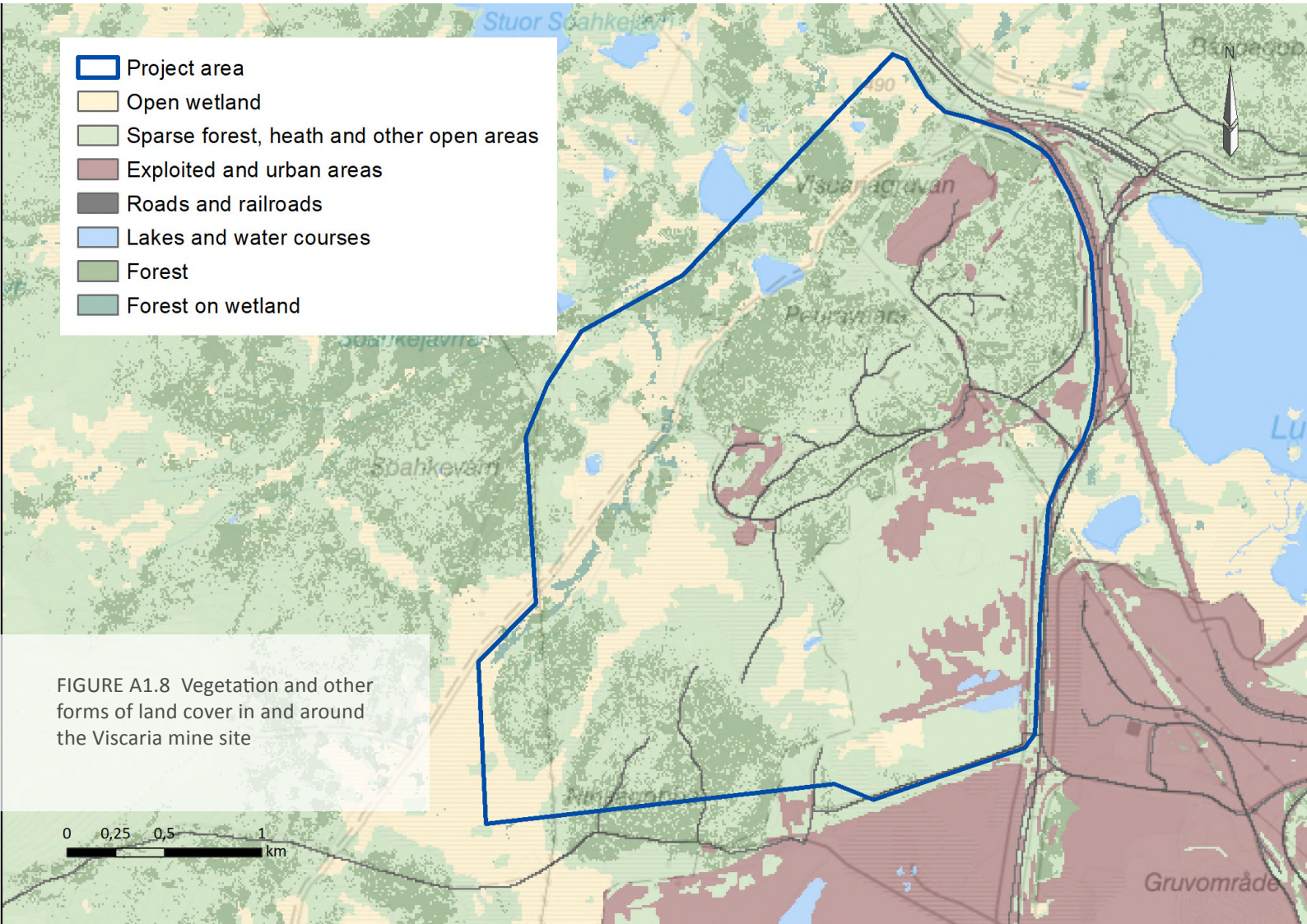

FIGURE A1.8 Vegetation and other forms of land cover in and around the Viscaria mine site

FIGURE A1.9 The open canopy of the mountain birch forest in the middle of the site, close to the wind turbines.

FIGURE A1.10 The more closed canopy of the mountain birch forest in the southern part of the site.

To the west of the Peuravaara ridge there is an extensive wetland area, that includes smaller lakes that are partly connected by streams (Figure A1.6). The streams are spring flows to the northward flowing Pahtajoki river. There is a small lake located in the southwest of the site (Figure A1.11).

Across the project site there are also mosaic-like wetlands with different types of bog and marsh, streams surrounded by willow (Salix spp.) - particularly sallow (S. caprea) – and bog lakes. The northern part of the large wetland Kirunavuoma stretches into the southern part of the project site. Within this wetland, the protected species marsh saxifrage (Saxifraga hirculus) and the moss Meesia longiseta occur. Adjacent to the old tailings deposit is another wetland dominated by shrubs and willows.

The Viscaria site lies within an area that has been inhabited and used by humans for centuries. The main land-uses were (and still are) reindeer husbandry and, more recently, mining. This is reflected in the tangible cultural heritage remains found on the site. Three of these are connected to mining activities while three more are associated with Sami culture: two remains of "Bläcka", resin expansion, and one "Härd", a kind of open fireplace. One of the cultural heritage remains, the "Härd", dates from before 1850 and therefore classified as a "Fornlämning" (ancient remains).

FIGURE A1.11 The small lake in the southwestern part of the site

Viscaria Landscape Character Baseline Study – 10km Study Area

Beyond the Kiruna Municipality regional landscape character assessment summarised above, to the study team's collective knowledge there has been no meaningful landscape character assessment of Kiruna city or the surrounding area local to the Viscaria project site. In this section, therefore, we describe our baseline landscape character assessment of the Viscaria study area, which consists of three different levels of assessment, as follows (Figure A1.12):

- Relevant aspects of the Kiruna Municipality regional landscape character assessment,
- An assessment of the local landscape character areas (LLCAs) present within the study area, and
- The landscape values attributed to each LLCA.
- Each of these is assessed in turn after, first, an overview of the study area considered as a whole.

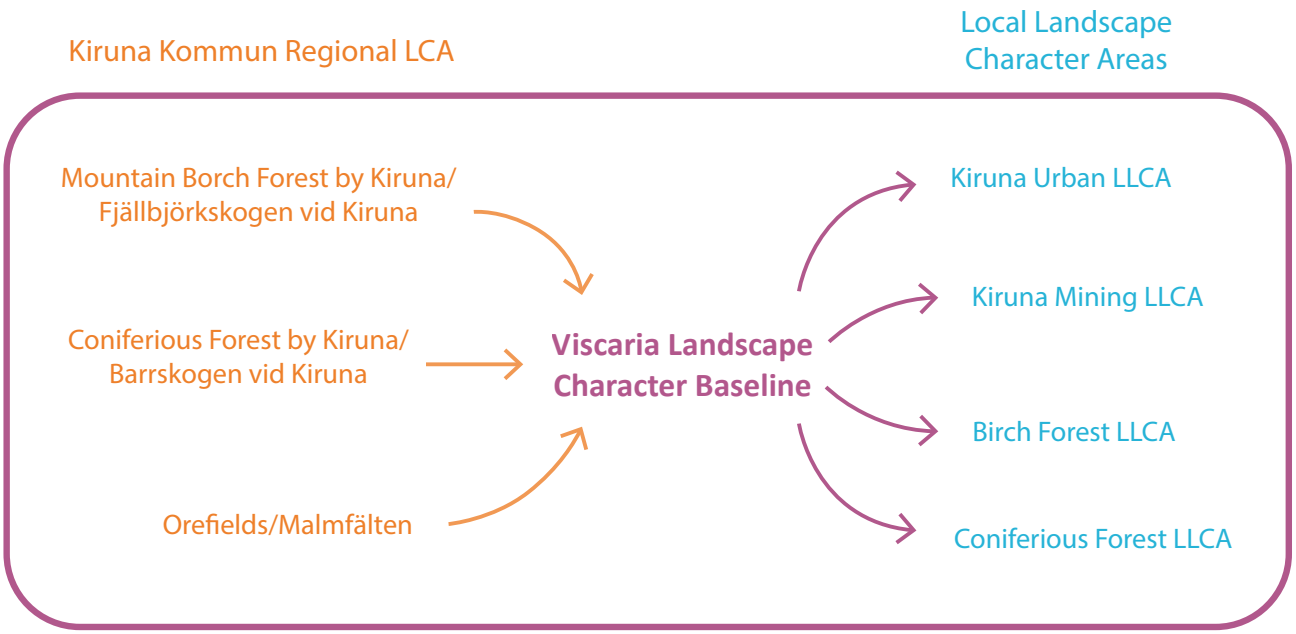

FIGURE A1.12 The levels of landscape character assessment involved in the Viscaria LCA.

Overview of the 10km study area

Summary description

The 10 km study area overlays various different landscape features designations, land-uses, habitats and cultural associations (Figure A1.13). It also incorporates three of the regional landscape character areas that were determined in the Kiruna Municipality study, namely:

- The Mountain Birch Forest by Kiruna/ Fjällbjörkskogen vid Kiruna regional landscape character area,
- The Coniferous Forest by Kiruna/ Barrskogen vid Kiruna regional landscape character area, and
- The Orefields/ Malmfälten regional landscape character area.

Compared to the many thousands of square kilometres of most of the rest of northern Sweden, at the scale of the Viscaria study area, these regional landscape character areas interact to produce a complex, dynamic and integrated natural, socio-economic and cultural landscape concentrated into a small area.

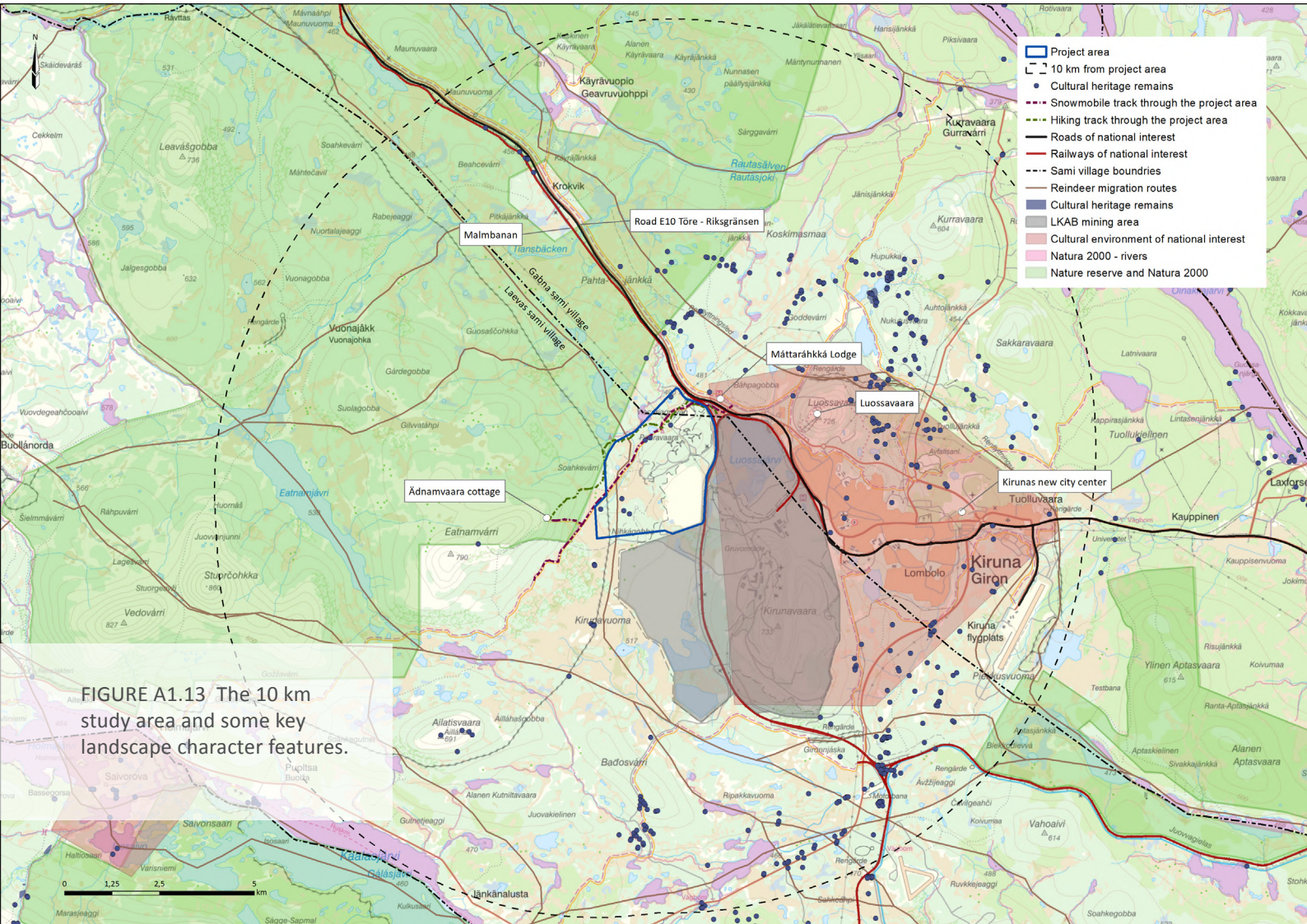

FIGURE A1.13 The 10 km study area and some key landscape character features.

The key environmental and cultural designations affecting the study area are:

- The Torne and Kalix river systems – National Rivers and Natura 2000,
- The Rautas Mountain Forest - Nature Reserve and Natura 2000, and
- A cultural environment of national interest (Kiruna – Kiirunavaara).

Four kilometres southwest of the Viscaria site are two designated national interests for outdoor recreation: Torneträsk-Paitasjärvi and Torneträsk–Kebnekaise. The sites partially overlap. The sites are designated due to their overall value to outdoor recreation with activities such as hiking and camping. The nearest national interests for unbroken mountains, Kebnekaise-Sjaunja, begin approximately 15 km to the west of the project area.

Key characteristics

The region surrounding the 10 km study area is very sparsely populated. To the north is Kurravaara in the Torne River valley. Beyond Kurravaara the land is undeveloped and uninhabited, consisting of birch forest and barren areas as far north as the Finnish and Norwegian borders. Eastwards beyond the study area, the land is dominated by boreal forest, which extends thousands of kilometres into Finland and Russia. To the south flows the Kalix river system. Both the Torne and Kalix rivers are highly protected.

The study area consists of a complicated mosaic of post-glacial, low-lying and upland areas, forest, wetlands and mountain heath (alpine tundra), which, over large areas, has been heavily modified by urban and industrial development. The modern industrial, urban landscape and society overlay – and are surrounded by – the traditional, indigenous, transhumance livelihood of the Sami reindeer herding communities.

Key characteristics of the study area are the mining industry, which dominates the local society, economy and environment, and Kiruna town – the only urban area of the 10 km study area and – by far – the largest population centre in Kiruna municipality. The town and its mining industry are highly developed aspects of the landscape and offer a stark contrast to the

surrounding natural landscape and its famed wilderness qualities. One does not need to travel far beyond the town to feel alone in wild nature. The contrast and dividing line between the land cover and landforms of the broader natural landscape and the intensely disturbed landforms and land cover of Kiruna town and the adjacent mining areas is very marked (Figure A1.14).

Landforms and drainage

The topography of much of the study area is characterized by vast lands of low, rounded hills and broad flat valleys, occupied by wetlands, lakes and rivers. Elevations range between 300 and 600 masl. Between 10 and 20 km west of the town are the prominent, rounded hills of Ädnamvaara (790 masl), Stuorčohkka (860 masl) and Vedovárri (827 masl). Beyond lie the distant high mountain peaks, starting about 45 km to the west, which are easily visible from the town. Kiruna town's two main hills are Kiirunavaara (733 masl) and Luossavaara (724 masl), which dominate views from the town. Both have been intensively mined.

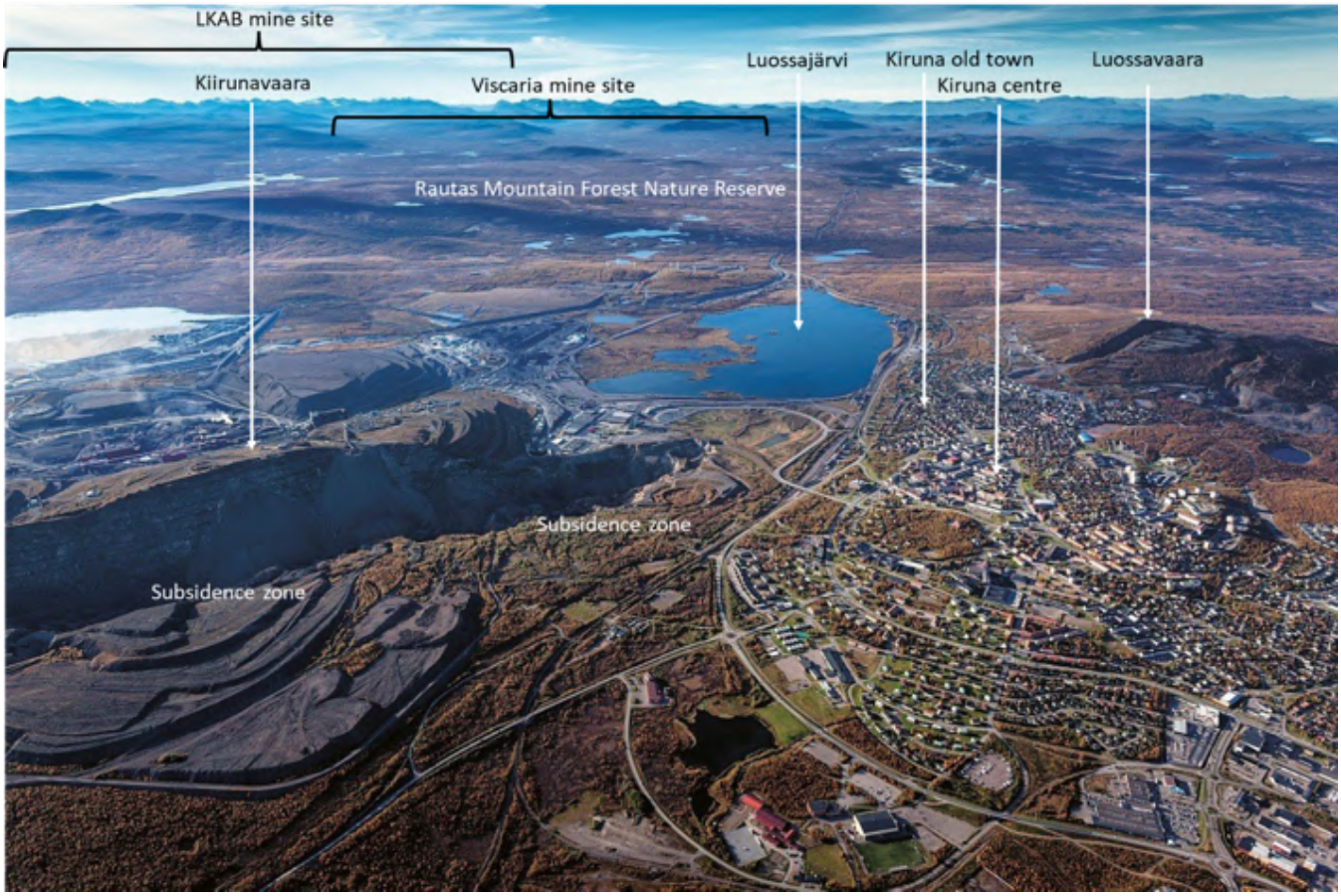

FIGURE A1.14 Aerial view of the northwest part of the study areas (photo from LKAB.com).

To the east is a low-lying landscape of lakes and the broad, flat Torne River valley. The Torne and Kalix rivers are rare western European examples of large, wild, unregulated river systems and are highly protected (see above).

Within the study area, at the foot of Luossavaara, Lake Luossajärvi has been partially drained by LKAB to reduce its surface area and volume in preparation for the advancing subsidence caused by the company's underground mining activities. To enable this the outflow of the lake was changed and now flows through a canal built between the project area on the southern side and the E10 road and railway on the northern side. The outflow channel flows into the Pahtajoki river to the north of Viscaria mine site (Figure 2.2 in the main text), which then flows into the Rautas river and then the river Torne.

Land cover and biodiversity

The main natural land cover type for the study area is mountain birch forest, with some mountain heath on hills above the treeline and some coniferous forest in the eastern parts of the study area (Figures A1.15 to A1.19). The harsh climate characterizes the natural environments and vegetation. The mining areas are generally poorly vegetated, with extensive areas either lacking vegetation, or covered by highly degraded vegetation. The Viscaria mine site is, to some extent, re-vegetated, resulting from a combination of ecological restoration work and natural re-colonisation of the land post-mining.

The mountain birch forests occur on low mountains up to approximately 625 masl. On nutrient-poor, dry soils, heather birch forest grows with a field layer dominated by shrubs. In richer and more moist soils, meadow birch forest or swamp forest habitat with high herbs occur. Within and in the immediate vicinity of the mine site, heather birch forest is more common than meadow birch forest and swamp forest.

Coniferous forest occurs at altitudes below approximately 500 masl. In the landscape around Kiruna town, coniferous forest occurs especially to the east and northeast of Kiruna. Spruce dominates, but pine also occurs on drier, sandy soils. The ground layer is dominated by shrub species.

Mountain heath generally lacks trees due to the high degree of exposure. Near Kiruna it consists mainly of low mountain heath dominated by shrubs and including herbs, lycophytes, terrestrial lichens and sparse, low-growing willows and junipers.

In low-lying areas, the land cover generally comprises large wetlands, consisting of various wetland habitats such as wet intermediate to rich marshes and different kinds of bogs, streams and bog lakes. The wetlands near the past and current mining areas are, to varying degrees, affected by the industry's activities and infrastructure. Some wetlands have been drained.

FIGURE A1.16 Birch forest near Kiruna.

FIGURE A1.16 Birch forest near Kiruna.

FIGURE A1.17 Birch forest with wetland near Kiruna.

FIGURE A1.18 An area of mixed birch and coniferous forest near Kiruna.

FIGURE A1.19 Mountain heath vegetation above the treeline on Kiirunavaara.

Rautas Mountain Forest Natura 2000 site and Nature Reserves

The Rautas Mountain Forest Natura 2000 site (SE0820243) consists of continuous old-growth forest and is part of a network of such reserves protecting Norrbotten's unique montane forests. It is a natural landscape of mountain birch forest and wetlands and pristine coniferous forests and covers almost half of the study area (Figure A1.20).

The Natura 2000 site is divided into two areas totalling 81,650 ha. The area west and northwest of Kiruna town extends close to the planned area of activity – the boundary of the site borders the Viscaria site. It extends in a 15 to 20-km-wide belt from Torneträsk in the north to the Kalix River in the south. The second area stretches from Kiruna airport to the west to about 3 km west of Svappavaara. A small part of the second area overlaps with the study area.

Rautas Mountain Forest has been designated as a Natura 2000 site due to the presence of the several habitat types included in the EU Species and Habitats Directive, including:

- Alpine heath (4060),
- Aapa mires* (7310),
- Palsa mires* (7320),
- Western taiga* (9010), and
- Mountain birch forest (9040).

* Priority habitat types

The Rautas site also contains several protected species, such as otter (Lutra lutra), lynx (Lynx lynx) and marsh saxifrage (Saxifraga hirculus).

Both parts of the Natura 2000 sites are also nationally designated nature reserves. The western part is the Rautas Mountain Forest Nature Reserve and the eastern part is the Aptasvaare Mountain Forest Nature Reserve.

Torne and Kalix National Rivers and Natura 2000 site

The Torne and Kalix river system is one of the largest river systems in Europe that has not been exploited for hydroelectric purposes and is a fine example of a wild and untamed river system. The Torne river flows along the north-eastern edge of the study area and the Kalix river flows along the southern edge (Figure A1.20). They join downstream of Kiruna.

The rivers are two of Sweden's four designated national rivers and are also Natura 2000 sites (SE0820430) due to the presence of specific habitat types included in the EU Species and Habitats Directive. The rivers are designated under special provisions in the Environmental Code (Chapter 4). The areas along the Torne and Kalix river systems also constitute a national interest for nature conservation and outdoor recreation under chapter 3 of the Environmental Code.

The rivers have well developed marginal and aquatic vegetation and are important migration routes for many migratory birds. The islets in the river are important bird breeding areas. The rivers are also very important breeding areas for salmon and trout. The Torne and Kalix river systems are designated as Natura 2000 sites due to the presence of the following habitat types included in the EU Species and Habitats Directive:

- Alpine streams with herbaceous beach vegetation,
- Natural, larger watercourses of the Fennoscandian type,
- Watercourses with floating vegetation or aquatic mosses,
- Oligo-mesotrophic lakes (comprise the largest proportion of the total lake area), and
- Dystrophic lakes and small waters.

Key protected species that inform the Natura 2000 designation include: otter (Lutra lutra), green snaketail (Ophiogomphus cecilia), salmon (Salmo salar), the European bullhead (Cottus gobio), freshwater pearl mussel (Margaritifera margaritifera) and the grass species Trisetum subalpestre.

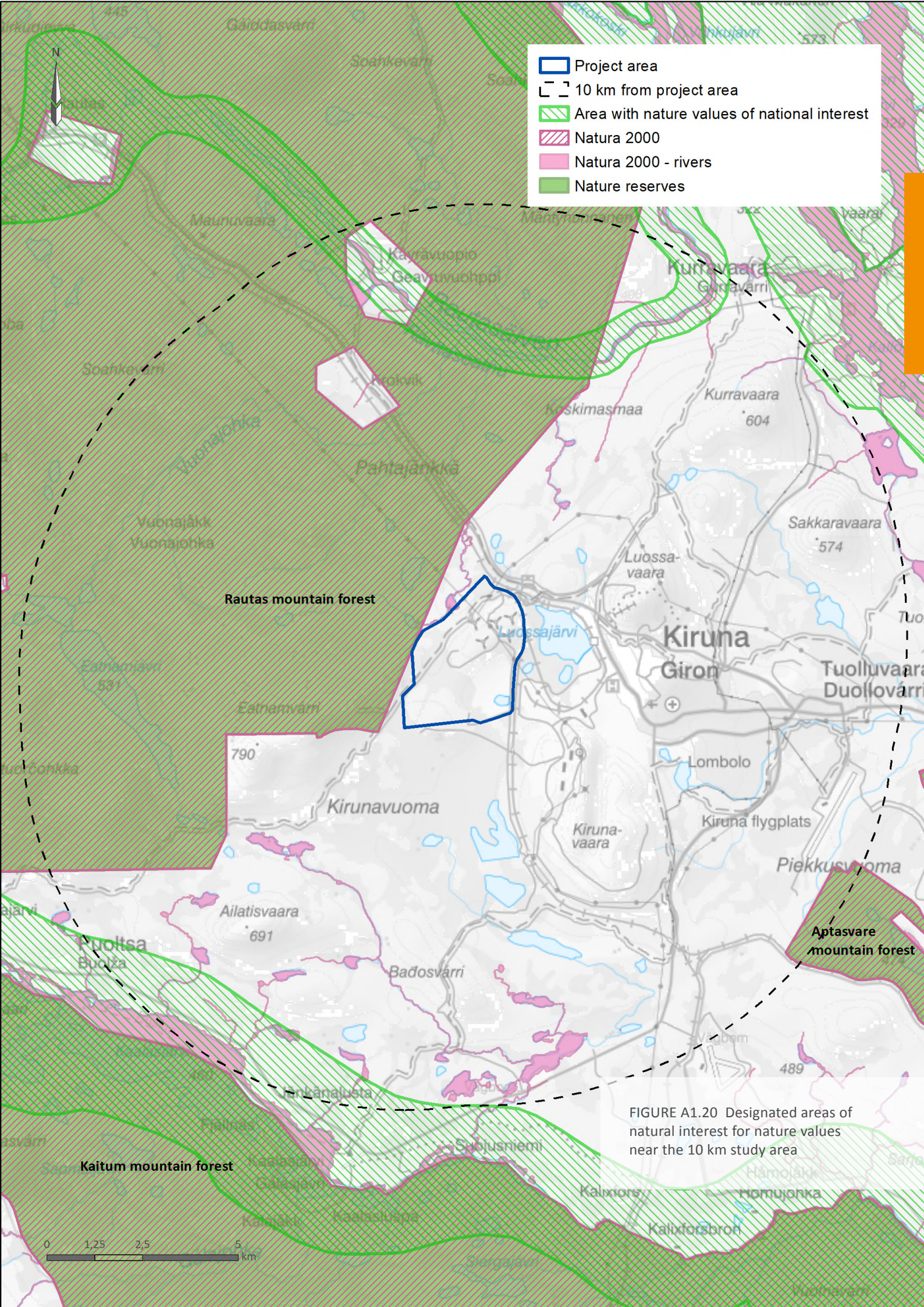

FIGURE A1.20 Designated areas of natural interest for nature values near the 10 km study area

Land-use

The land use of the study area is complex and multi-layered, belying the simplicity of the natural landscape that underpins it. It combines the traditional Sami reindeer herding livelihoods with modern mining and urban development and tourism. Although the mining and urban landscapes are relatively small compared to the more natural and traditional Sami lands, their influence has effected landscape changes beyond their immediate footprint.

Sami reindeer herding

Overlaying the natural landscape character is a Sami cultural landscape that is characterized by a long history of reindeer husbandry and Sami history. A large proportion of the study area is used for Sami reindeer transhumance by the Laevas and Gabna Sami villages – a practice that has endured in the region for centuries. Reindeer husbandry in the study area has been significantly affected by the historical and existing mining activities in the area, as the mining activities cause loss of pastures, restrict access to other areas and create disturbance. Today, the areas around Viscaria are mainly used during the winter, from November to April. Reindeer migration routes of national interest run north, south and west of the mining area (Figure A1.21). One particular migration route used by the Laevas Sami village crosses the Viscaria site. South of the mining area there are national interest areas in the form of rest grazing and passage.9 A reindeer fence runs northwest-southeast to distinguish winter and spring/ autumn pastures. The interaction of the project with reindeer husbandry is being assessed in a specific study for the EIA. To some degree the species richness of many typical habitats depends on the tradition of reindeer husbandry .

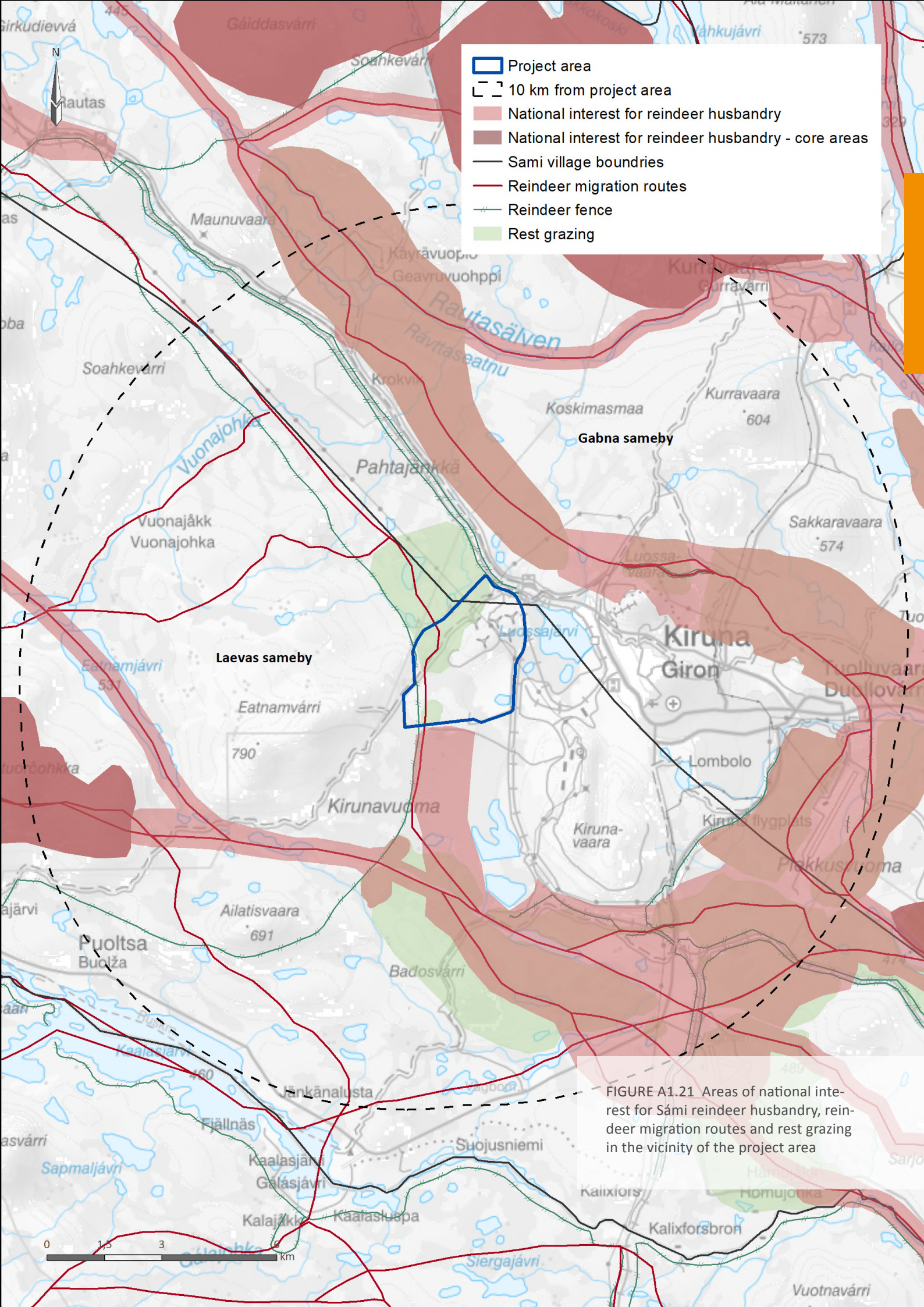

FIGURE A1.21 Areas of national interest for Sámi reindeer husbandry, reindeer migration routes and rest grazing in the vicinity of the project area

Mining

Mining of the Kiirunavaara and Luossavaara hills for iron ore began when the area became connected by railway to the sea at Narvik (Norway) and Luleå on the Baltic Sea at the start of the 20th century. For decades ore was extracted by open pit mining of the eastern flank of Kiirunavaara and, to a smaller extent, on Luossavaara. The open pits have left impressive, deep and elongated, north-south fissures in the surface, with the waste rock they produced deposited in waste rock dumps, with their distinctive unnatural landforms on the surface to the north and east at Kiirunavaara and to the east at Luossavaara (Figure A1.22). Viscaria copper mine is located immediately to the northwest of Kiirunavaara and LKAB's iron mining operations (Figure A1.23).

In both cases, surface mining has now ended, but mining at Kiirunavaara has moved underground, creating what is now the world's largest underground iron mine. The ore body dips steeply to the east and, as this is mined, subsidence at the surface has created a uniquely unstable landscape creeping insidiously, but predictably, towards Kiruna town. The ongoing development of the mine has produced hundreds of millions of tonnes of waste rock, which are now generally deposited in waste rock dumps to the west and south of Kiirunavaara. A tailings management facility also stores many millions of tonnes of mineral processing wastes to the west. Both tailings and waste have encroached onto Sami reindeer herding lands and have been a source of ongoing tension between LKAB and the Sami reindeer herding communities.

Urban development

Kiruna town is the largest in the Kiruna municipality. Since the early 20th century, the modern development of the area's landscape has taken place as the mining industry and the town of Kiruna developed interdependently (Figure A1.22). The town is dominated economically, environmentally, socially and culturally by LKAB's mine (Figure A1.24). It is centred on the Haukavaara hill and lies to the east of the Viscaria project site and LKAB's Kiirunavaara mining operations. The town is the main administrative, educational and medical centre for the interior of the region and acts as a focal point for numerous tourism activities. It houses workers for the mining industry and provides many of the necessary support services.

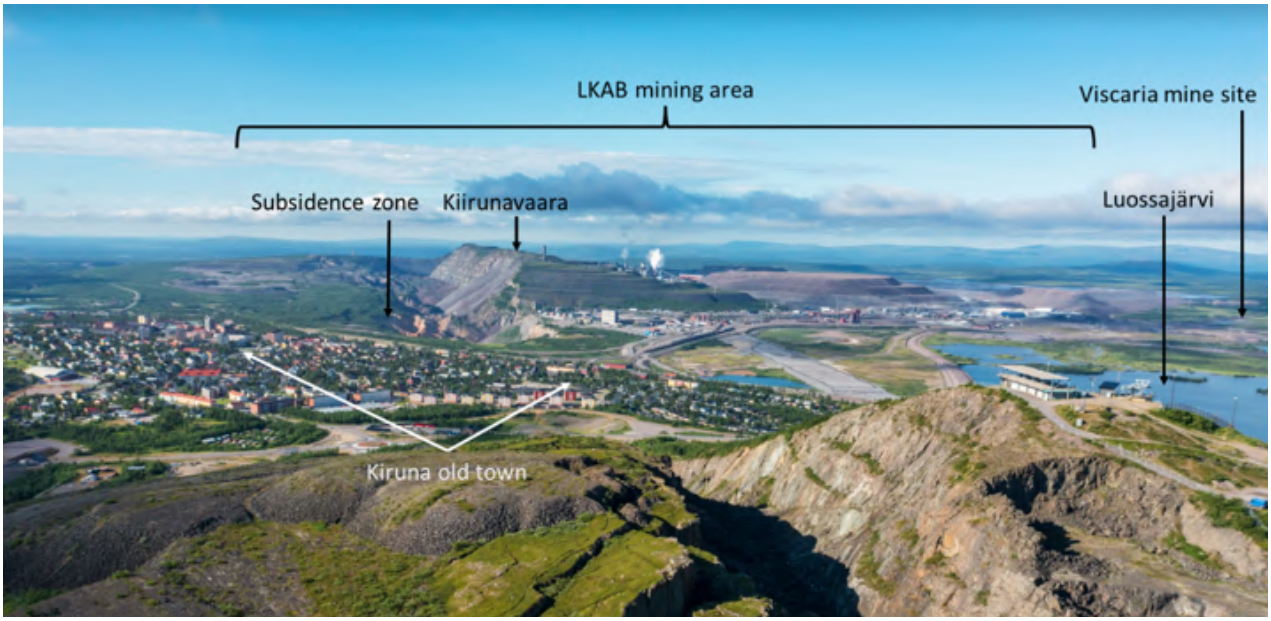

FIGURE A1.22 View to the southwest from above Luossavaara (photo by Linnea Lundkvist)

FIGURE A1.23 View to the west from above Luossavaara (photo by Linnea Lundkvist)

The town is now a highly dynamic area of deconstruction, relocation and construction, with rapid changes in various aspects of the townscape occurring from one year to the next. Over a century since Kiruna was founded, a large part of its older, western side is now being moved to extend the town to the east and away from the encroaching subsidence zone caused by LKAB's underground mining operation. The relocation itself is causing land disturbance and will cause changes in land cover and land-use over a period of decades. The relocation programme has been planned for many years and has become renowned for its forward-thinking and spectacle and has helped to raise the international profile of this remote Arctic town.

FIGURE A1.24 View of Kiirunavaara and LKAB's mine from the centre of Kiruna.

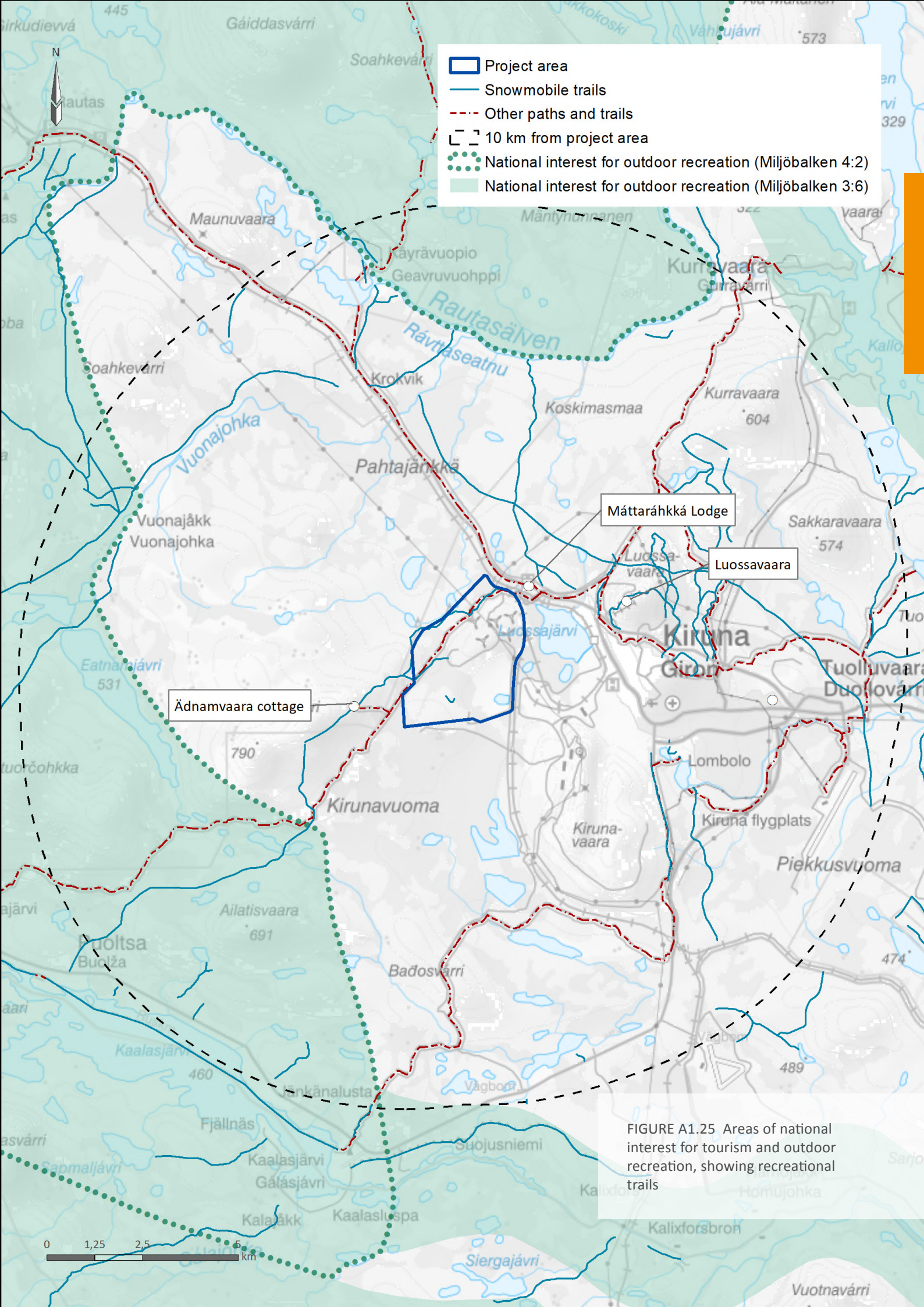

FIGURE A1.25 Areas of national interest for tourism and outdoor recreation, showing recreational trails

Tourism and wilderness recreation

In recent decades, the town has also become a major European centre for Arctic tourism and wilderness recreation, with large areas in and surrounding the 10 km study area designated as areas of national interest for tourism and outdoor recreation (Figure A1.25). Much of the tourism and outdoor recreation offer relies on access to open, pristine, Arctic wilderness landscapes in both winter and summer. Year-round activities such as hunting and fishing are important recreational and cultural activities for the local people. Moose hunting is conducted by people from Laevas Sami village and private landowners. Small game hunting is conducted primarily by local residents.

Winter tourism includes remote stays in Arctic lodges, downhill and cross-country skiing, snowmobile/ dog-sled expeditions and access to dark skies for viewing of the aurora borealis. The internationally famous Ice Hotel, constructed annually on the banks of the Torne River at Jukkasjärvi just beyond the study area, is a major winter tourism destination. It markets winter activities that rely on a pristine Arctic wilderness experience, including dark skies tourism.

In summer, the long days and 24-hour sun attract tourists and local people alike into the surrounding landscapes for hiking and camping, mountain-biking and stays in remote lodges.

Close to the northern entrance of the Viscaria mine site is the Máttaráhkká Northern Lights Lodge, which is accessible from the E10. It includes accommodation for national and international tourists and markets snowmobile and dog-sled tours into the 'wilderness' and views of the Aurora Borealis (Figure A1.26). The waste rock dumps of the old Viscaria mine are located only 700m to the west. Also, to the west of Kiirunavaara, is the popular Ädnamvaara Cottage, which sits above the tree line and is accessible by Ädnamvaara Trail in summer and winter (Figures A1.27 and A1.28) The cottage is a popular destination for Kiruna and visitors.

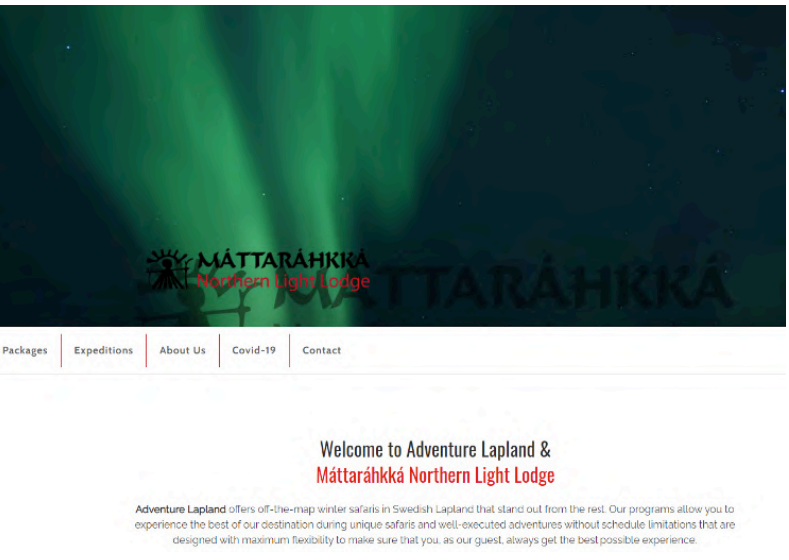

FIGURE A1.26 Website of Máttaráhkká Northern Lights Lodge

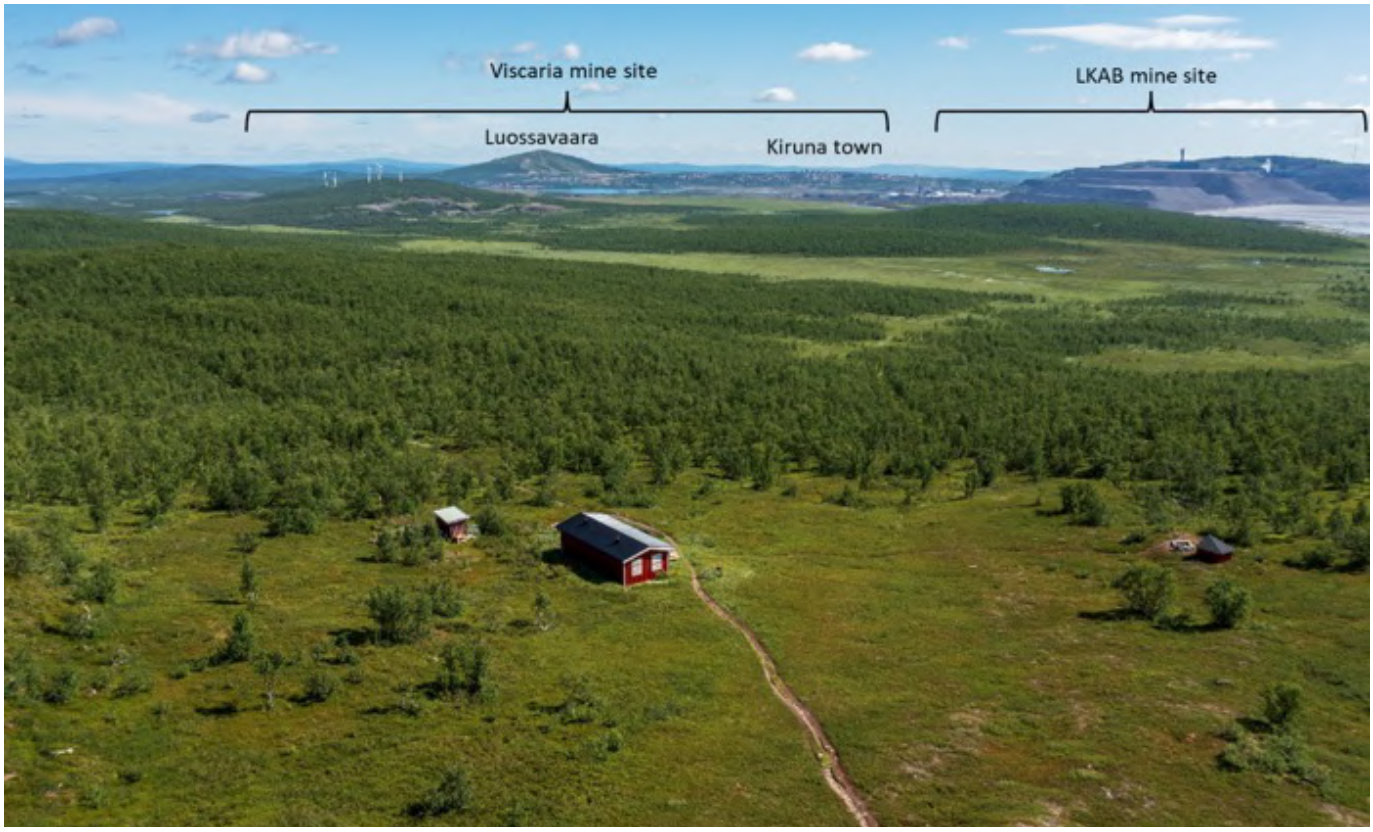

FIGURE A1.27 Summer view to the northwest over Ädnamvaara Cottage towards LKAB, and the Viscaria mine site (note the wind turbines) (photo by Linnea Lundkvist)

FIGURE A1.28 Winter view Ädnamvaara Cottage to the northwest from towards LKAB's operations (photo by Anders Lundkvist)

Public access and transport infrastructure

Kiruna town is well-served by modern transport infrastructure. Kiruna Airport is located to the southeast of the city with a several daily flights to Stockholm. The town is on the E10 road, which connects Luleå on the Gulf of Bothnia, to Norway, via Riksgränsen to Narvik (180 km), and to the south to Gällivare. Other roads connect to Kurravaara and the mountain recreation and tourism centre of Nikkaluokta close to Kebnekaise (Sweden's highest mountain) and passing along the Kalix river valley.

The railway connects the town with Luleå, Gällivare and Narvik. It is primarily a mineral railway, transporting ores from the mines of the interior to the coast, but it also carries passengers to other parts of the country, including Stockholm. The line to Narvik also serves recreational trips to the mountains near Abisko, Björkliden and Riksgränsen.

The steady encroachment of LKAB's deformation zone has meant the re-routing of key transport infrastructure in recent years. The railway was recently moved from the western edge of the town to the west and south of Kiirunavaara, and a new passenger railway station has been built. Similarly, the E10 was re-routed from the western and southern edges of the town to run along the northern side.

The hills of Ädnamvaara and Luossavaara are publicly accessible by trails and, in the case of the latter, by road and ski-lift. Kiirunavaara is the third culturally significant hill in the study area, however, it is contained within the LKAB mining concession and is not publicly accessible.

The wilderness area beyond the urban and mining areas is easily accessible year-round via established and well-used snowmobile trails, ski trails and hiking trails. The entrance to the former Viscaria mine is the starting point for various trails into the surrounding countryside and some of these run through the Viscaria mine site itself, leading to Ädnamvaara Cottage and other places (Figure A1.25).

Settlement pattern and building distribution

Kiruna town is the main population centre, dominating the study area and the surrounding – sparsely-populated – municipality. This is discussed in more detail in the urban landscape type of the next section. The twin cities Gällivare and Malmberget are some 120 km south of Kiruna.

The other settlements in the study area are much smaller villages or hamlets and are located in the more sheltered valleys. There are also isolated cabins dotted throughout the wilder landscapes. These all tend to be a part of the landscape type in which they exist, rather than dominating and defining it. Around 15 km east of Kiruna is a group of villages on the Torne River, most notably Jukkasjärvi – the location for the Ice Hotel.

The nearest settlement to Viscaria is the Máttaráhkká Lodge, which is located at a distance of about 500 m from the planned activity area. The nearest residential development is located in Karhuniemi at a distance of about 1.5 km northeast of the planned area of activity.

Historic features and cultural heritage

The town of Kiruna and its immediate surroundings, including Kiirunavaara and the LKAB mining area, is of national interest for its cultural environment under section 6, chapter 3 of the Environmental Code. The reason being that the area constitutes an "urban environment and industrial landscape showing a unique community building at the beginning of the 20th century, where the ideals of urban construction of the time were realised on virgin land. Kiruna was founded on the country's largest industrial venture at the time, as well as the continued development into a city in a formal sense and also a centre for Norrland's hinterland."

Kiruna was originally planned and constructed as a model industrial town and, as such, has become historically important in Sweden. The design of the streets and neighbourhoods accommodated the local topography. The original buildings were

FIGURE A1.29 View to the north-east from Kiirunavaara towards Luossavaara and the old town in March 2007. The Company Area is located in the far left of the built-up area. Much of the flatter land between them and Kiirunavaara is now part of the deformation zone

FIGURE A1.30 One of the old (Bläckhornen) buildings of the Company Area.

FIGURE A1.31 The old fire station in Kiruna.

constructed mainly of wood, although these were replaced with modern concrete buildings in the mid-20th century, completely changing the character of the city centre. The company area, together with the city plan area and the so-called SJ area, is one of the oldest districts in Kiruna, emerging during the early 20th century (Figure A1.29). Here, LKAB created extensive housing developments for its workers, including the so-called Bläckhornen, which are characteristic of the old part of Kiruna (Figure A1.30). Housing for managers, company offices and company hotels were also built, and the area was developed into LKAB's administrative and representative core. A large number of buildings from this time are preserved within the Company Area, but will be relocated.

Some older, characteristic buildings from the early 20th century were preserved, including the fire station from 1909 (Figure A1.31) and the hospital from 1900. On the outskirts of the centre is Kiruna's church, constructed from timber (Figure A1.32). The church was placed at the highest point of the city plan. It dates from the early 20th century and its design reflects that of a traditional Sami hut. The building was voted Sweden's most beautiful building in 1950. The church and its bell tower are being moved as part of the relocation programme. It is a technically complex and also emotionally challenging operation for the people of Kiruna.

As the deformation zone approaches the culturally important city centre, many parts of it, including the business district, the main railway area, and parts of the districts of Östermalm and Norrmalm, are or will be relocated. Adjacent to the town centre, in the eastern part of the company area, is the Gruvstadsparken. The park is located between the town and LKAB's current mining area, and as the deformation zone moves towards the town, the park is designed to progress across the town too, as adjacent buildings are demolished or relocated, the decommissioned areas are becoming part of the new park (Figure A1.33) The park offers imposing views of LKAB's mine and Kiirunavaara to the east. In the park, in addition to vegetation dominated by mountain birch, there are playgrounds and barbecue areas, a small public farm, a skate park and an outdoor gym.

FIGURE A1.32 Kiruna's historic wooden church.

FIGURE A1.33 The site of the old town hall, which has been demolished and is now a public park in the buffer zone between the deformation zone and the town.

A new town centre is growing to the east, including a new town hall, Kristallen, cultural buildings, residential housing and more. The new district has a denser character and taller buildings than other parts of Kiruna. At present, the area is characterised by construction work.

Sami culture

Sami culture has progressed in the area for thousands of years. The area in and around the study area has traditionally been used by the Sami for hunting, fishing and reindeer herding. In the immediate vicinity of the project area there are a number of cultural heritage artifacts and remains. Within 10 km from the project area, there are more than 350 cultural heritage remains, shown in Figure A1.34. The majority of these are remains of mining activities or nature object with different kinds of traditional uses or names.

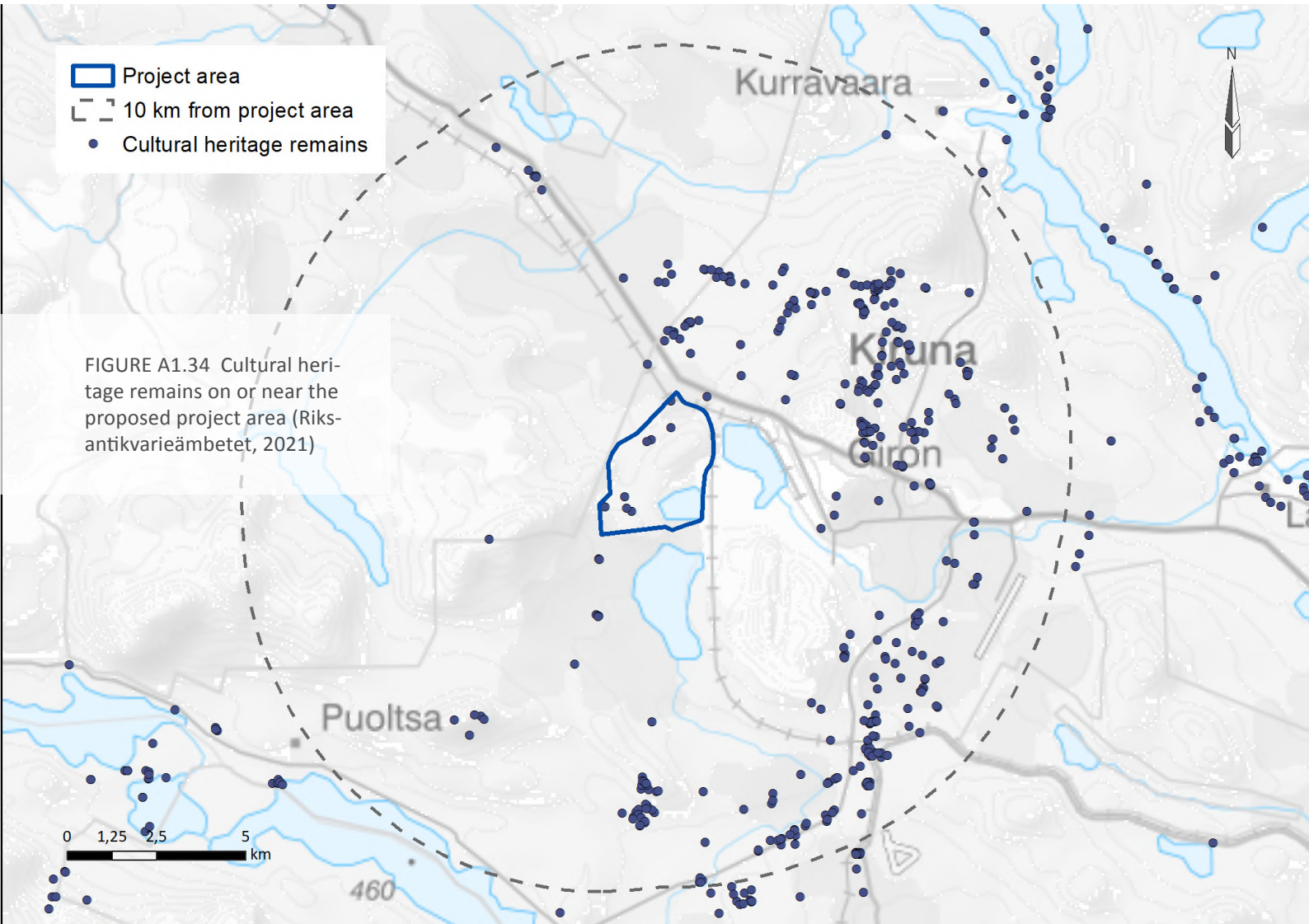

FIGURE A1.34 Cultural heritage remains on or near the proposed project area (Riksantikvarieämbetet, 2021)

Distinctive features

The setting of Kiruna town to the east of Kiirunavaara and south of Luossavaara are widely recognised. The town is located on a slight slope facing northeast-southwest with the main views towards the southwest over LKAB's mine site, which dominates the views.

The hills of Kiirunavaara, Luossavaara and Ädnamvaara dominate the local topography and can be seen from afar. A distinctive topography also results from the effects of over a century of mining activity superimposed on the first two of these natural landforms. The waste rock dumps consisting of millions of tonnes of dark grey rock sculpted into angular, geometric landforms create a distinct profile largely devoid of vegetation. These, coupled with LKAB's highly visible gaseous plumes and diffuse, fugitive dust emissions, which discolour a blue sky back-drop, give a distinctive character to the local area. The visibility of the industrial area gives a certain character to the town and reinforces external perceptions of Kiruna as a mining town. Such views are underpinned by the industrial sounds and mining vibrations, which are frequently noticed.

The remote Arctic setting and easy access to pristine wilderness on the doorstep of the town and views thereof, and intense – almost alien – industry, combine with the above to create the area's local distinctiveness and sense of place and forms the foundation of local peoples cultural identity. In the distance, high mountain ranges to the west, including Kebnekaise, the tallest mountain in Sweden, creates a distinct, wild backdrop to the study area (Figure A1.35).

FIGURE A1.35 The high mountains to the west of the study area, including Sweden's highest peak, Kebnekaise, viewed from the slopes of Luossavaara

Aesthetic, perceptual and sense of place

There is a general acceptance of the importance of the mining industry to the local area socially and economically; however, with respect to the relocation, Kiruna residents have been described as reacting to the "forced move with a mix of stoicism, enthusiasm, and melancholy" and as having a "dysfunctional emotional relationship with the town". The progressive planning model for the original town seems to be mirrored by the precise procedural methodology and engineered nature of the relocation, which will continue for most of the rest of this century. There is an acceptance that mining formed the town and is now responsible for its destruction and re-birth.

Many perceive Kiruna town as an outpost of civilisation – a frontier community and a gateway to pristine wildlands. The views from the town's high land to distant mountains to the north and west engender a visceral pull, yet also a foreboding of the wild. The town and its immediate surroundings, however, appear intensely industrial, alien and recent.

Vibrations from underground blasting activities regularly remind surface dwellers that this is an industrial town, the encroaching subsidence an inevitable consequence. Rumbles and dust plumes from rock falls in the deformation zone are regularly observed, confirming ongoing ground movements.

Rapidly, on leaving the town and entering the undeveloped part of the study area and beyond, the perception quickly changes to expansive openness and increasing remoteness, though if looking in the right direction, the industrial and urban landscapes offer a reassuring connection to civilisation. In the more open parts of the birch forest and from the hills above the treeline, views to the mountains or back towards Kiruna town' urban and mining landscape feel further away than they are. But the wildlands are close; the coniferous and birch forest landscape character areas impart a sense of wilderness, even as the mining and urban landscapes are within view. Diminishing numbers of people and the enveloping nature of the forest insulates against the unnatural views and sounds of the urban and industrial areas, instead offering a softer, vegetated perspective and natural sounds such as bird song, running water in spring and summer and the wind through the trees, and an all-consuming tranquillity. The scent of conifers in the coniferous forest and the earthy scent of the mountain birch forest stimulate these perceptions further.

The study area changes markedly and rapidly between the seasons, which evoke differing aesthetics and experiences, though the visceral feeling of 'wilderness' remains. In winter, the insulating snow reduces noise considerably – even in the urban and industrial landscapes. It also hides visual distinctions between different land-uses under a white blanket and, to a degree, enhances the visual appeal of the city and the mining landscapes.

The largely unspoilt and continuous post-glacial landscape creates a profound sense of deep time extending to ice ages past. It is easy and profound to imagine ice sheets and vast glaciers filling the current landscape's voids and carving out its features, especially as snow covers the landscape. A further – more recent – element of deep time is expressed through the millennia of continuous occupation of this land by the Sami.

Visual characteristics

The landscape surrounding Kiruna is very open and views can extend for great distances. From the three high points of the study area, Loussavaara, Kiirunavaara and Ädnamvaara, the views are panoramic and all extend to the mountain ranges to the west and north, across a sea of forest and wetland. Luossavaara and Kiirunavaara are set within the mining/ urban landscapes and their panoramic views showcase the landscape setting of the study area and the various landscape character areas in question.

At night and especially in winter, there are no distant views; but the dark skies provide a good opportunity to view the aurora borealis, offering an ethereal – almost spiritual – experience. Closer to the urban and mining areas, light pollution dims this view and the darkness is punctuated by points of artificial light, particularly as one views LKAB's mining area across from the town.

FIGURE A1.36 Combination of early and mid-20th century buildings in central Kiruna.

FIGURE A1.37 Characteristic buildings from the 1960s in central Kiruna.

FIGURE A1.38 The new town centre buildings under construction in the new part of the town in the east.

FIGURE A1.39 New residential buildings under construction close to Luossavaara

From the summit of Luossavaara, the 360o view encompasses the entire study area and beyond. The summit could be classed as a characteristic viewpoint for the study area. In particular, in the near to middle distance, viewer's attention is drawn to the southwest to the focal point of Kiirunavaara and its linear open pit and geometric, grey waste rock dumps, to the town to the south and south-east over the town and to the west across the partially drained Luossajärvi to the wind turbines on the Viscaria site. To the north and east, rolling hills and continuous forest disappear into the distance. Long-distance views to the northwest, west and southwest are dominated by the Skanderna (Scandinavian mountains), which are also visible from the (old) city centre. Kebnekaise, 75 km from the town centre, can be seen on a clear day.

From the old town centre of Kiruna situated on Haukivaara, the main middle-distance viewpoints extend across the deformation zone towards Kiirunaavara's mining landscapes and LKAB's buildings.

From above the treeline on Ädnamvaara, there are characteristic views to the east of the area's mining landscapes and Luossavaara. In other directions, the views are of continuous natural landforms and land cover and high mountains in the west.

Luossajärvi is adjacent to the northwest of Kiruna and is a part of LKAB's licence area. Larger water bodies, such as Luossajärvi, give a certain character to an area, and offer wide views to the distance. The urban area relates a story of architectural progression from the characteristic old wooden buildings of the Company Area to the re-built new city centre of the mid-20th century to the modern 21st century buildings of the new town in the east (and some other areas) (Figures A1.36 to A1.39).

Relationship to adjacent landscape character areas

The study area is not a specific landscape character area in itself, but consists of four local landscape character areas, which have been defined for the purposes of this LVIA and are described more systematically below. The demarcations between local landscape character areas are well-defined, with marked boundaries and sudden transitions between them. The more natural local landscape character areas merge gradually into the broader landscape character areas beyond the study area, as the effects of the industrial and urban landscapes diminish with increasing distance from the developed land.

Landscape condition

The parts of the study area directly affected by mining activities exhibit dramatically modified and highly degraded natural landforms and drainage patterns and new, engineered landforms, with extensive areas of minimal vegetation cover. Between Kiirunavaara and the town, a growing area of subsidence is causing catastrophic changes in landform and land use and has led to the draining of part of Luossajärvi lake (Figures A1.14, A1.22 and A1.40).

FIGURE A1.40 The deformation zone approaching Kiruna, viewed from the top of Kiirunavaara towards the northeast

The subsidence-induced town relocation activities have led to rapid transformation of the natural landscape into urban settings, with the attendant degradation of natural features, particularly to the east of the town. As linear developments, the previously described re-routing of the railway and E10 road have produced a more fragmented landscape in the areas where they have been constructed.

Generally, as one moves from the urban/ industrial settings into more natural land cover, the degrading effects of development become less noticeable in quite a short distance, including reductions in the extent and frequency of gaps in tree cover caused by developments of buildings and infrastructure and more natural landforms.

Local landscape character areas

The characteristics of the three regional LCAs aided the description of four bespoke local LCAs, which share some similarities in character to the regional LCAs, but possess other characteristics directly related to their proximity with Kiruna city and its mining area.

To assist development of the Viscaria landscape character baseline and the subsequent impact analysis, the study area was divided into four local landscape character areas (LLCAs), namely:

- **Kiruna Mining LLCA,**
- **Kiruna Urban LLCA,**
- **Mountain Birch Forest/ Fjällbjörkskogen LLCA,** and
- **Coniferous Forest/ Barrskogen LLCA.**

Note that the Torne-Kalix river system is not in included as a separate LLCA, because the main river channels are outside the study area and its minor water bodies and waterways permeate and are integral to the existing forest LLCAs. The related values are captured, however, in the LLCA descriptions. The local landscape character areas are analysed further in the main text.

Note that the Torne-Kalix river system is not in included as a separate LLCA, because the main river channels are outside the study area and its minor water bodies and waterways permeate and are integral to the existing forest LLCAs. The related values are captured, however, in the LLCA descriptions.

APPENDIX 1B: CLIMATE CHANGE IN NORTHERN SWEDEN

The Arctic regions are the most rapidly warming parts of the world due to climate change. The average annual temperature for Norrbotten County is expected to increase by between 3.5 and 6.5 degrees by the end of this century, with increases in average annual precipitation of 20-40 percent. Most of the precipitation increase is likely to occur in the mountains. Both the intensity of rainfall events and maximum daily rainfall are predicted to increase – the latter by approximately 15-25 percent.

By 2069 climate models indicate that the summer will last about a month longer by mid-century in most of Northern Europe. In northern Lapland and the coasts of the Arctic Ocean, summer lengthening may be even more than 30 days. Concurrently, the projections show that winter will shorten by 30-60 days. Winters are projected to start 15-30 days later and end 15-30 days earlier. Changes are largest near the coasts of the Arctic Ocean and the Baltic Sea, and relatively modest in the northern inland areas. The landscape-scale implications of this, manifested in changes to the physico-chemical environment and the ecological environment are summarised as:

- glacial retreat, exposing more bare rock mountain sides, unvegetated moraines and (temporary) glacial lakes.
- a decrease in thickness and a retreat northwards of the permafrost, with concomitant effects on infrastructure and soil biogeochemical cycles, which will affect the overlying ecology, surface waters and land-use systems.
- a northwards move of agricultural zones, including their establishment in areas where agriculture does not currently occur. With the increased drainage of peatlands to enable agriculture, there is a risk of land subsidence and effects on local drainage. The opening up of new agricultural areas (and other land-use change) in the north will synergistically interact with the ecological changes underway caused directly by climate change.

- increased tree growth rates resulting from a warmer climate, longer growing seasons and higher atmospheric CO2 concentrations. This will result in more productive forests and forestry, with more amenable conditions for new tree species to occur, or to be planted. The tree line has already been observed shifting higher up mountainsides. There is potential for this to occur by several hundred metres. Forests will also expand northwards at the expense of the tundra. Forests could be negatively affected by – and increasing damage from – tree pests and diseases, storms and wetter land. The increased severity of extreme weather events (wind, drought, freezing conditions) could also be damaging.
- an increased risk of avalanches and landslides in some areas, while in other areas, the risk is decreasing as the snow melt season becomes longer and the spring flood and high flows decrease in magnitude.
- Away from the coastal zone of Norrbotten, freshwater and wetland biodiversity will be affected by increased water temperatures, the earlier melting of ice, increased run-off and therefore higher sedimentation and increased concentrations of nitrogen, phosphates, nutrient salts and humus. This will cause discoloured water, eutrophication and blooms of algae and cyanobacteria leading to poorer water quality overall. Poorer water quality will affect aquatic life, including fish populations. Higher summer temperatures will change lacustrine thermal stratification, exacerbating the above problems. Increased harmful algal blooms will lead to increase lake beach closures. Non-native species will also spread more as water temperatures increase.
- a change in the phenologies of many species, including the timing of leaf burst and flowering in plants, the arrival of migratory birds (and other animals), insect life cycles, etc. The consequential effects on the ecological interactions between different species can be destabilising for some species and habitats.

- The treeline is already moving northward and to higher elevations, with forests replacing tundra and tundra vegetation moving into the polar deserts. During the 20th century, the tree line rose 100-150m on Swedish mountains and is predicted to climb several hundred metres higher during this century. Downy birch forests will shrink as the snow cover thins and becomes less permanent. Tree species such as pine and spruce will become more dominant on mountain slopes. Ultimately, 40-60% of the current area of mountain heath (alpine tundra) vegetation may be lost.
- The tundra will be invaded by the northern boreal forest due to longer and warmer growing seasons, while the southern ecotone of the boreal forest is likely to retreat due to increasing drought, pest populations, disease and fire. The changes to the southern ecotone of the boreal forest are likely to be more rapid than for the northern ecotone, leading to an overall negative effect on boreal forest area and quality, until a new equilibrium becomes established. Overall, a general increase in deciduous vegetation at the expense of evergreen vegetation is predicted at all latitudes.
- The climate zones that determine the ranges of the current (ecological) biomes are predicted to move northwards at 50-80km per decade. This will affect the present of local plant and animal species, as some die out locally, while other species move in. Species that depend on cold, deep, inland lakes and the mid to high altitude zones on mountains, or permafrost bogs may also disappear. These movements could affect migratory bird species as breeding and feeding grounds change.

APPENDIX 2: LVIA METHODOLOGY

This appendix provides the detailed methodology as used in this LVIA to determine the significance of landscape and visual effects. It considers the methodologies for each separately.

Assessment of Landscape Effects

The methodology for the landscape impact assessment is summarised in Figure 4.4 in the main text, with the details of each step described below.

Establishing landscape sensitivity

The sensitivity of a landscape receptor is determined from a consideration of its landscape value and its susceptibility to change.

Assessing landscape value

The value of the landscapes in question should be established as part of the baseline description. Landscape value is defined in GLVIA as, "the relative value that is attached to different landscapes by society. A landscape may be valued by different stakeholders for a whole variety of reasons." It is a subjectively determined, relative value that should reflect the reality that a given landscape may be valued differently by different stakeholders and reach beyond any formal designations. It is necessary to determine landscape value to inform judgements about the significance of project effects. Landscape values are determined qualitatively by considering a range of factors such as, for example, the following criteria (or similar) (Table A2.1):

- Designations: international (e.g., World Heritage Site, Natura 200 Site), national (e.g. national park, nature reserve, conservation area, protected monuments or buildings), or local (local nature reserves, parks, heritage areas;
- Character and sense of place;
- Value attributes, such as topography, perceptual qualities, cultural and historical features and associations, biodiversity, protected areas and special qualities;

- Community values;
- Recreational values;
- Intrinsic value;
- Other aspects, e.g. local landscape character or distinctiveness assessments, ecosystem services and green infrastructure, etc.

Table A2.1. Criteria for determining landscape value

Value	Description
High	Highly valued for one or more attributes. National or international designations, e.g. national park, World Heritage Site, Natura 2000 site. Landscape/ features worthy of protection. Strong sense of place; unique cultural associations. Long-established traditional/ indigenous land-uses that remain important in local population. Absence of detracting features. Extensive areas of natural vegetation/ significant townscapes. Unspoilt aspects used/ marketed for recreation/ tourism. A very high-quality landscape/ feature; unspoilt; attractive; exceptional.
Medium	Positive landscape character. Local/ regional designations, e.g. local nature reserves, cultural designations. Positive landscape character. Local/ regional designations, e.g. local nature reserves, cultural designations. Traditional/ indigenous land-uses are less important in local population. Unusual locally. A number of distinguishing features worthy of protection; some degradation; occasional detracting features. Some vulnerability to change; features that are locally common. Strong perceptual/ aesthetic elements; reasonably attractive landscape/ feature. Ordinary to good quality landscape/ feature; reasonably attractive.
Low	Undesignated, with little recognised value, though sometimes some local value. Traditional/ indigenous land-uses are very minor activities amongst the local population. Areas which are relatively commonplace with few notable landscape features that contribute to local distinctiveness or are worth protecting; degradation and detracting features are common. Ordinary landscape/ feature; quality is fairly commonplace.
Negligible	Receptor maybe a detracting feature – damaged or eroded. Undesignated landscape/ feature that does not contribute positively to the landscape. No traditional/ indigenous land-uses. No landscape features worthy of protection; widespread degradation with many detracting features. Low quality landscape/ feature; limited variety or distinctiveness; very common.

Assessing landscape susceptibility to change

Landscape susceptibility is defined as, "the ability of a defined landscape or visual receptor to accommodate the specific proposed development without undue negative consequences." Although this definition is generic, the criteria for determining landscape susceptibility are unique and are based on the landscapes and proposed development of the individual assessment – in this case the Viscaria project. Criteria and indicators for determining the susceptibility of landscape receptors to the Viscaria project development are presented in Table A2.2. Note that such criteria and indicators are always dependent upon – and tailored from – the landscapes of the study area and the development scenario being considered.

Table A2.2. Criteria for determining the susceptibility of landscape receptors to change

Susceptibility	Description
High	Landscape: Receptor is highly susceptible to the development because the landscape's key characteristics have no or very limited ability to accommodate it. Expansive, open natural landscape. Intact with little major development. Landcover of continuous natural vegetation and naturally connected water courses, water bodies and wetlands. Extensive, intact ecosystem and habitats, with continuous ecological gradients and transition zones. Well-connected habitats. Intact ecological processes and functions. Little obvious/ infrequent modern development with occasional low-profile buildings. Sparsely populated, with isolated disperse settlements and extensive unpopulated areas. Cultural: Indigenous peoples inhabit the land and carry-out traditional reindeer herding activities. Hunting and fishing are a common recreational pursuit for local people. Land-uses, which include indigenous peoples' traditional land-uses, have little/ a small impact on the landscape's natural values. Landscape is publicly accessible via trail system and a single major road. Able to roam freely. Aesthetic, perceptual and experiential: Perceived as being in pristine, natural condition. Remote, peaceful and tranquil Arctic wilderness dominated by natural features, systems and processes. Engenders spiritual feelings. Exceptional scenic quality, dark skies, with a strong sense of place. Feels timeless. Visual: Open/ exposed landscapes with exceptional, far-reaching views from scenic routes and high points (less so in forest). Distinctive, distant mountain ranges. Few unnatural features are visible. Intervisibility between sites. Skylines dominated by uninterrupted, undeveloped topographic profiles. Sparsely populated with low-key accessibility. Unnatural movement in landscape is generally difficult to see. Surrounding landscapes may be of high, medium or low sensitivity. Landscape important to the settings/ approaches/ gateways to designated landscapes. Contributes to wider landscape with distinctive or complex backdrops. Strong associations with the landscape and adjacent landscape character areas. Dark skies. Value: Landscape is protected by international and national designations for both biodiversity and cultural heritage reasons. Marketed domestically and internationally as an Arctic wilderness tourism destination. Landscape is highly valued by the traditional (Sámi) landowners, local community and visitors. Visual values include iconic views and views related to designated landscape related features.

Susceptibility	Description
Medium	Landscape: Receptor is of moderate susceptibility to the development because the landscape's key characteristics have some ability to accommodate it. Extended areas of open landscape and natural landforms dominate, although some, similar development is present. Landcover of continuous natural vegetation and ecological connectivity becoming fragmented with noticeable ecological discontinuity. Sporadic settlements and infrastructure development. Cultural: Some scope for traditional land-uses and wilderness-based recreational activities, though access is increasingly restricted due to private land ownership. Some areas increasingly developed for non-wilderness recreation, e.g. downhill skiing. Increasing population size – may be dispersed or centralised. Aesthetic, perceptual and experiential: Moderate land conditions, with some areas of degraded and some areas of intact landscape. There are some rare/ distinctive elements that form a notable contribution to the character of the area, but some unnatural landforms and features. Lacks perception of remoteness and wilderness, but tranquillity and closeness to nature may be possible under certain circumstances. Sense of place is possible. Scenic quality varies depending on perspective. Increasing light pollution. Visual: Far-reaching views possible from certain viewpoints, but often marred by development and degraded land. Skylines vary between natural and unnatural according to perspective. Mixture of landscape colour and texture from monochrome and rough to muted organic colours and soft texture. Some areas with relatively high accessibility and obvious movement, alongside other areas where movement may be hidden (amongst trees). Surrounding landscapes may be of high, medium or low sensitivity. Often a gradation between landscapes of high susceptibility and low susceptibility. Moderate associations with the landscape and adjacent landscape character areas. Good to poor intervisibility between sites. Value: Designated areas at a regional or local level and considered a distinctive component of the region's/ locality's character experienced by a large proportion of its population. Has some value to Arctic tourism, but arguably as a gateway to the 'wilderness'. Visual values include regionally/ locally valued views and views valued by the local community.
Low	Landscape: receptor is of low susceptibility to the development because the landscape's key characteristics have a large ability to accommodate it. Fragmented landscape with human-scale elements. Discontinuous land cover with disrupted ecological gradients and habitat discontinuities. Unnatural, industrial landforms with a geometric topography of straight lines, sharp angles, and flat-topped, benched hills. Open pits and subsidence cover large areas. Discontinuous landcover. Areas of urban/ industrial development and modern social and economic infrastructure. Modern settlements. Cultural: High-intensity, modern industrial and urban activities over large areas. Different land-uses over relatively small areas. Heavily developed urban and industrial setting. Few traditional and/or land-based activities possible. May be heavily populated. Restricted access due to private landholdings Aesthetic, perceptual and experiential: Perceived as being degraded with relatively few natural features. Widespread denuded, unstable areas. Natural landforms degraded with mineral workings, ski slopes, artificial lighting, urban and industrial development. Degraded ecological processes and functions. Low scenic quality, with a weak sense of place. Constantly changing urban and industrial landscape. Light pollution and movement. Feels alien, threatening, unattractive, noisy, unsettled. Visual: Landscape confined/ contained/ enclosed with restricted inward or outward views. Highly visible with views of non-natural skylines, angular, geometric landforms, vertical features and built development. Monochromic industrial landscape. Busy with lots of movement. Surrounding landscapes may be of high, medium or low sensitivity. Contributes little to wider landscape. Large-scale, simple backdrops. Weak association with adjacent landscape character areas. Good to poor intervisibility between sites. Value: Few, if any, natural or cultural heritage values worth protecting. Some areas of local relevance, including public open spaces. Of little marketing value to visitors. Some views may be valued by a small proportion of the local community.

Determining landscape sensitivity

Landscape sensitivity is defined as "a measure of the resilience, or robustness, of a landscape to withstand specific change arising from development types or land management practices, without undue negative effects on the landscape and visual baseline and their value." It is determined from combining the landscape value and landscape susceptibility. The resulting criteria for judging sensitivity are presented in Table A2.3.

Table A2.3. Criteria for determining the sensitivity of landscape receptors

Sensitivity	Description
High	Highly valued landscape. Very susceptible to change to even small changes. Unable to accommodate a development without significant character change or adverse effects. Thresholds for significant change are low.
Medium	Medium valued landscape. Susceptible to change. Some potential to accommodate a development in some defined situations without significant character change or adverse effects. Thresholds for significant change are intermediate.
Low	Low valued landscape. Resilient landscape of low susceptibility to change. It can accommodate a development in many situations without significant character change or adverse effects. Thresholds for significant change are high.
Negligible	Very low to negligible landscape value. Landscape is robust or degraded and is not susceptible to change. It can accommodate a development without significant character change or adverse effects. Thresholds for significant change are very high.

Magnitude of landscape change

The magnitude of each project effect on the landscape character receptor needs to be assessed before the overall significance can be determined. As explained in GLVIA3 and illustrated in Figure A2.1, a project effect's magnitude is a combination of its size or scale, geographical extent and duration and reversibility.

Size or scale

Judgements are needed about the size or scale of change in the landscape that is likely to be experienced as a result of each project effect. GLVIA3 states that such 'judgements' should, for example, consider:

- The extent of the existing landscape elements that would be lost, the proportion of the total extent that this represents and the contribution of that element to the character of the landscape, which may be quantified;
- The degree to which aesthetic and perceptual aspects of the landscape are altered either for example, removal of existing components of the landscape or by addition of new ones; and
- Whether the effect changes the key characteristics of the landscape, which are critical to its distinctive character.

These are considered in relation to the Viscaria project in Table A2.4.

Table A2.4. Magnitude of landscape change: judging size or scale

Size/ scale	Description
Large	Substantial change of landscape elements representing a considerable proportion within the landscape, resulting in a large change to the landscape character. Large scale changes to the aesthetic or perceptual aspects of the landscape, such as removal of existing landscape components or addition of new ones.' Substantial changes to key characteristics of the landscape, which are critical to its distinctive character.
Medium	A moderate degree of landscape elements would be changed, representing a moderate proportion of this represented in the landscape, resulting in an overall moderate or medium change to the landscape character. The aesthetic and perceptual aspects of the landscape, such as the removal of existing landscape components or the addition of new ones, are moderately affected. The effect/ impact alters key landscape characteristics, which are critical to its distinctive character, to a moderate degree.
Small	A small, but noticeable, change of landscape elements representing only a limited proportion within the landscape, resulting in a small negative change to the landscape character. Small scale, limited alterations to the aesthetic or perceptual aspects of the landscape and landscape character, such as removal of existing landscape components or addition of new ones. The effect/ impact alters key landscape characteristics, which are critical to its distinctive character, to a small – but still noticeable – degree.
Negligible	A barely perceptible loss/ change of landscape elements representing only a very limited proportion within the landscape, resulting in a negligible negative change to the landscape character. There is a barely discernible change to aesthetic and perceptual aspects of the landscape and landscape character and those changes occur across a very limited geographical area and/ or proportion of the landscape receptor. The effect/ impact alters a barely discernible number of key landscape characteristics, which are critical to its distinctive character.
None	No changes to the landscape character, elements, features or setting of the area.

Geographical extent

It is important to also consider the geographical area over which the landscape effects will be experienced. The geographical extent of the project effects depends on the nature of the project development and the scale of the effects upon the landscape/ landscape character. The levels described in Table A2.5 have been used in the analysis in this report.

Table A2.5. Magnitude of landscape change: judging geographical extent

Extent of impact	Description
Large	Effects are extensive, influencing most or all of the landscape receptors and several landscape types or character areas.
Medium	Effects are more moderate, extending to the scale of the landscape type or character area within which the development lies.
Small	Effects are of limited geographical extent, such as the area of the site's immediate setting, and affecting only a very limited number of the landscape receptors being assessed.
Negligible	Effects are very limited in extent, such as the site level within the footprint of the project site.
None	The project does not affect any of the landscape receptors being assessed.

Duration and reversibility

Duration and reversibility are separate, but linked considerations. Duration can be measured simply in relation to the project in question (Table A2.6).

Table A2.6. Magnitude of landscape and visual change: judging duration

Duration of Impact	Description
Very long term	>25 years
Long term	10-25 years
Medium term	5-10 years
Short term	0-5 years

Reversibility is a judgement of whether or not a development will be removed and, if removed, whether the landscape can be fully restored. Table A2.7 explains this, based on examples provided in GLVIA3.

Table A2.7. Magnitude of landscape change: judging reversibility

Degree or reversibility	Description
Permanent	Irreversible change to the landscape. It is not possible to restore the land to its original state, e.g. a housing development.
Partially reversible	Change to the landscape after which the landscape can be restored to something similar to that which was removed, e.g. mineral workings.
Reversible	Change to the landscape after which the landscape can be fully restored to (almost) its original state, e.g. wind turbine installations.

Overall magnitude of landscape change

The overall magnitude of landscape change combines the factors described in detail above, namely: size and scale, geographical extent, duration and reversibility, to produce a specific magnitude of change category. For the purpose of the Viscaria project, these categories are described in Table A2.8.

Table A2.8. Overall magnitude of landscape change

Magnitude of change	Description
Large	Substantial change of landscape elements representing a considerable proportion within the landscape, resulting in a large change to the landscape character.Large scale changes to the aesthetic or perceptual aspects of the landscape, such as removal of existing landscape components or addition of new ones. Substantial changes to key characteristics of the landscape, which are critical to its distinctive character. Project effects are geographically extensive, influencing most or all of the landscape receptors and several landscape types or character areas. Project effects are of long or very long duration, with permanent landscape change.

Magnitude of change	Description
Medium	A moderate degree of landscape elements would be changed, representing a moderate proportion of this represented in the landscape, resulting in an overall moderate or medium change to the landscape character. The aesthetic and perceptual aspects of the landscape, such as the removal of existing landscape components or the addition of new ones, are moderately affected. The effect/ impact alters key landscape characteristics, which are critical to its distinctive character, to a moderate degree. Project effects are of a moderate geographic extent, extending to the scale of the landscape type or character area within which the development lies. Project effects are of medium to long duration, with permanent, partially reversible or reversible landscape change.
Small	A small, but noticeable, change of landscape elements representing only a limited proportion within the landscape, resulting in a small change to the landscape character. Small scale, limited alterations to the aesthetic or perceptual aspects of the landscape and landscape character, such as removal of existing landscape components or addition of new ones. The effect/ impact alters key landscape characteristics, which are critical to its distinctive character, to a small – but still noticeable – degree. Project effects are of limited geographical extent, such as the area of the site's immediate setting, and affecting only a very limited number of the landscape receptors being assessed. Project effects are of short to medium duration with reversible to partially reversible landscape change.
Negligible	A barely perceptible change of landscape elements representing only a very limited proportion within the landscape, resulting in a negligible change to the landscape character. There is a barely discernible change to aesthetic and perceptual aspects of the landscape and landscape character and those changes occur across a very limited geographical area and/ or proportion of the landscape receptor. The effect/ impact alters a barely discernible number of key landscape characteristics, which are critical to its distinctive character. Project effects are very limited in geographic extent, such as the site level within the footprint of the project site.Project effects are of short duration and are reversible.
None	No change to the landscape receptor.

Assessment of Visual Effects

The assessment of visual effects is defined by GLVIA3 as:

> *"…the effects of change and development on the views available to people and their visual amenity. The concern here is with assessing how the surroundings of individuals or groups of people may be specifically affected by changes in the context and character of views as a result of the change or loss of existing element so the landscape and/or the introduction of new elements".*

GVLIA3 defines visual receptors as:

> *"…people within the area who would be affected by the changes in views and visual amenity … They may include people living in the area, people who work there people passing through on road, rail or other forms of transport, people visiting promoted landscapes or attractions, and people engaged in recreation of different types."*

Visual receptors are people, not viewpoints. People respond differently to views and changes in views depending on the context (location, time of day, season, and degree of exposure to views) and also their purpose for being in a particular place (recreation, residence or employment, or passing through on transport routes).

As people pass through the landscape, certain activities or locations may be specifically associated with the experience and enjoyment of the landscape, such as the use of paths and trails, tourist and scenic routes and associated (and promoted) viewpoints.

The methodology for the visual impact assessment is summarised in Figure 4.5 in the main text. Inevitably, such assessments are based on subjective and professional judgement.

Establishing the sensitivity of visual receptors

Each visual receptor (that is the person or people likely to be affected at a specific viewpoint) should be assessed in terms of both the value attached to particular views and their susceptibility to change in views and visual amenity.

Assessing the value attached to views

Values attached to views are based on judgements informed by the following:

- Recognition of the value attached to particular views, for example, in relation to heritage assets, or through statutory/ planning designations.
- Indicators of the value attached to views by visitors, as promoted in visitor-related information on websites, tourist maps, related parking areas, interpretive material and provision of facilities to aid their enjoyment and references to them in literature or art.

The values used in this project are described in Table A2.9.

Table A2.9. Criteria for determining the value attached to views

Value	Description
High	Recognised high quality view. Popular and well-frequented. Promoted as a beauty spot/ visitor destination. The view is an important part of the experience. Views/ visual amenity may be recognised in planning designations, such as conservation areas and cultural heritage assets. View with strong cultural associations, recognised in art, literature, other media, or even spiritual connections. A view which relates to the experience of other features, such as heritage assets, in which landscape or visual factors are an important consideration. A view which is likely to be an important part of, or the primary, reason for the receptor being present at the location.
Medium	A view, which may be valued locally or regionally, but is not widely recognised for its quality or has low visitor numbersIt may have local cultural associations. The view may have local planning designations.An attractive view, but it is unlikely to be the receptor's primary reason for being there.
Low	An ordinary, but not necessarily unattractive view, with no recognised quality. Unlikely to be visited specifically for the view and is usually incidental to the receptor's reason for being there.
Negligible	A poor quality or degraded view, which is unvalued or discordant and is unlikely to be the receptor's reason for being there. Minimal cultural associations. Not particularly popular as a viewpoint. A view which detracts from the receptors experience of being there.

Assessing the susceptibility of visual receptors to change

The susceptibility of visual receptors (people) to changes in views and visual amenity is a function of:

- the occupation or activity of people experiencing the view at particular locations; and
- the extent to which their attention or interest may therefore be focussed on the view and the visual amenity they experience at particular locations.

The related criteria determined for this project are described in Table A2.10. Note that the criteria determined in the table form a gradation in susceptibility to change and not definite divisions. Individual projects should consider the nature of the groups or people who will be affected and the extent to which their attention is likely to be focussed on views and visual amenity. Related judgements on these criteria must relate back to the baseline evidence.

Table A2.10. Criteria for determining the susceptibility of visual receptors to change

Susceptibility	Description
High	Residents at home.Traditional/ indigenous groups/ landowners, who live and work in their original natural landscapes. Residents or visitors engaged in outdoor recreation, including the use of public rights of way, whose attention or interest is likely to be focussed on the landscape and on particular views. Visitors to heritage assets, or to other attractions where views of the surroundings contribute significantly to the experience. Communities where views contribute to the landscape setting enjoyed by residents. Travellers on identified scenic routes, which people take to experience or enjoy the view.
Medium	Travellers on transport routes (road, rail, etc.), who may anticipate some enjoyment of the landscape as part of the journey, but where the primary focus is not the landscape. Users of public rights of way where the view is of moderate interest. Schools and other institutional buildings and their outdoor areas, play areas.
Low	People engaged in outdoor sport or recreation which does not involved or depend upon appreciation of views of the landscape. People at their workplace, whose attention may be focussed on their work or activity, not on their surroundings; and where the setting is not important to the quality of working life. Travellers, where views along the route are fleeting and incidental to the journey. Determining the sensitivity of visual receptors

Determining the sensitivity of visual receptors

The sensitivity of the visual receptors is a subjective determination based on the relationship between the value of the views and the susceptibility of the visual receptors to the proposed change. Categories of sensitivity are described in Table A2.11.

Table A2.11. Criteria for determining the sensitivity of visual receptors

Visual Sensitivity	Description
High	Activity resulting in a specific interest or appreciation of the view, such as residents, indigenous peoples, or people engaged in outdoor recreation whose focus of attention is the landscape. And/or a high value view, e.g. a designated landscape or conservation area, unspoilt countryside.
Medium	Activity resulting in general interest or appreciation of the view, such as residents, or people engaged in outdoor recreation that does not focus on an appreciation of the landscape. And/or a medium value of view, e.g. suburban residential areas, undesignated landscape, some degraded natural features.
Low	Activity in which interest or appreciation of the view is secondary to the activity, such as people at work, or travellers passing through the area.A nd/or a low value of views, e.g. featureless agricultural land, poor quality urban fringe, the edge of mined lands.
Negligible	Activity in which interest of appreciation of the view is inconsequential, such as people at work with limited views, or travellers along routes with embankments, etc. restricting views, industrial areas, derelict land.

Magnitude of visual change

The magnitude of the visual effects identified needs to be determined in terms of its size or scale, the geographical extent of the area affected and its duration and reversibility. These are expanded upon in turn below.

Size or scale

The size/ scale of the change in the view needs to consider:

- the scale of the change in the view regarding the loss or addition of features in the view and changes in its composition, including the proportion of the view occupied by the proposed development;
- the degree of contrast or integration of any new features or changes in the landscape with the existing or remaining landscape elements and characteristics in terms of form, scale and mass, line, height, colour and texture; and
- the nature of the proposed development regarding the relative amount of time over which it will be experienced and whether views will be full, partial or glimpses.

These factors are categorised in Table A2.12.

Table A2.12. Magnitude of visual change: judging size or scale

Size/ scale	Description
Large	Extensive change to the composition of the existing view, such as widespread loss of characteristic features or a widespread addition of new features within the view and the visual amenity. A high degree of exposure to the view (e.g., full, close, direct or open views).
Medium	Clearly noticeable, partial or moderate change to the composition of the existing view resulting from the loss of features or the addition of new ones. A moderate degree of exposure to the view (e.g., partial/ intermittent).
Small	Subtle change in the view, caused by the loss of features of the addition of new ones, such that this would partially alter the composition of the view and its visual amenity.Partial views only.
Negligible	Barely perceptible change to the view, caused by the loss of features or the addition of new ones, such that there is hardly any change to the composition of the view and the visual amenity.V ery brief exposure/ glimpsed views only.
None	No change to the view.

Geographical extent

The geographical extent of the visual change will vary at different viewpoints and is likely to reflect:

- the angle of view in relation to the main activity of the receptor;
- the distance of the viewpoint from the proposed development; an
- the extent of the area over which the changes would be visible.

These are considered in Table A2.13.

Table A2.13. Magnitude of visual change: judging geographical extent

Extent of impact	Description
Large	Wide angle of view in relation to the main activity of the receptor. The viewpoint is close to the development. Changes would be visible across a large area.
Medium	Moderate angle of view in relation to the main activity of the receptor. The viewpoint is a moderate distance from the development.Changes would be visible across a moderate area.
Small	Narrow angle of view in relation to the main activity of the receptor. The viewpoint is far from the development. Changes would be visible across a small area.
Negligible	Very narrow/ barely perceptible angle of view in relation to the main activity of the receptor. The viewpoint is distant from the development. Any changes would be visible across a barely perceptible area.
None	No changes to the existing view.

Duration and reversibility

As for landscape effects, these are separate, but linked considerations. The same duration descriptions apply as for landscape effects, see Table A2.6. The criteria for judging the reversibility of visual change are similar to those for landscape effects, and are described in Table A2.14.

Table A2.14. Magnitude of visual change: judging reversibility

Degree or reversibility	Description
Permanent	Irreversible change to the view or visual amenity. It is not possible to restore the view to its original state, e.g. a housing development.
Partially reversible	Change to the view or visual amenity after which it can be restored to something similar to that which was removed, e.g. mineral workings.
Reversible	Change to the view or visual amenity after which it can be fully restored to (almost) its original state, e.g. wind turbine installations.

Overall magnitude of visual change

The magnitude of visual change is determined from considering the factors described above. These are summarised in Table A2.15.

Table A2.15. Overall magnitude of visual change

Magnitude of change	Description
Large	Complete or very large change in the view, caused by the loss of important features or the addition of significant new ones. Receptor has a high degree of exposure to the view (e.g., full, close, direct or open views). Wide angle of view in relation to the main activity of the receptor. The viewpoint is close to the development. Changes would be visible across a large area. Long term to very long term and irreversible changes to views.
Medium	Clearly noticeable, partial or moderate change to the composition of the existing view resulting from the loss of features or the addition of new ones. Receptor has a moderate degree of exposure to the view (e.g., partial/ intermittent). Moderate angle of view in relation to the main activity of the receptor. The viewpoint is a moderate distance from the development. Changes would be visible across a moderate area. Project effects are of medium to long duration, with permanent, partially reversible or reversible change to views.

Magnitude of change	Description
Small	Subtle change in the view, caused by the loss of features of the addition of new ones, such that this would partially alter the composition of the view and is visual amenity. Partial views only. Narrow angle of view in relation to the main activity of the receptor. Viewpoint is far from the development. Changes would be visible across a small area. Project effects on views are of short to medium duration with reversible to partially reversible landscape change.
Negligible	Barely perceptible change to the view, caused by the loss of features or the addition of new ones, such that there is hardly any change to the composition of the view and the visual amenity. Very brief exposure/ glimpsed views only. Very narrow/ barely perceptible angle of view in relation to the main activity of the receptor. The viewpoint is distant from the development. Any changes would be visible across a barely perceptible area. Project effects on views are of short duration and are reversible.
None	No change to views.

Significance of landscape and visual effects

The significance of the effects of the development on a particular landscape or visual receptor is determined by considering a combination of the sensitivity of that receptor with the magnitude of the effect in question. Table A2.16 presents a matrix to guide the determination of the significance of effects, which is informed by the baseline assessment and professional judgement.

A robust and sequential methodology to assessing the significance effects, based on summary tables and professional judgement, demonstrates a clear process for determining the development's landscape and visual effects upon the agreed receptors and the significance of these effects.

For the purposes of this report, moderate, moderate/major and major effects are considered as likely significant effects, with minor and negligible considered as not significant. The categories, so defined, are described in Table A2.17.

Table A2.16. Determining the significance of landscape and visual effects (only the coloured table cells are considered to be significant)

Sensitivity of Receptor	Magnitude of Effect				
	Large	Medium	Small	Negligible	None
High	Major	Major/ Moderate	Moderate	Minor/ Negligible	None
Medium	Major/ Moderate	Moderate	Moderate/ Minor	Negligible	None
Low	Moderate	Moderate/ Minor	Minor	Negligible	None
Negligible	Minor/ Negligible	Negligible	Negligible	Negligible	None

Type of Effect

The magnitude of a project effect also needs to be assessed as being either a beneficial or adverse change as follows:

- **Beneficial effects** are those where the development, or part of it, contributes to the landscape or visual resources, or introduces new, positive attributes. This includes the removal of undesirable/ intrusive features, or their replacement with more appropriate elements.
- **Neutral effects** are those in which the project neither contributes to nor detracts from the landscape or visual resource, or where the effects are hardly noticeable. An alteration to the existing situation is not necessarily automatically adverse.
- **Adverse effects** are those that detract from or weaken the landscape character and visual resource by introducing elements that contrast detrimentally with the existing landscape or visual resource, or by removing key positive character elements.

Perceptual effects

Landscape characteristics, such as wildness, sounds, tranquillity, remoteness, human activities and the presence and movement of wildlife are perceptual. Information will be available from other studies in the EIA to inform understanding of the degree of potential change on the perceptual qualities, but assessment of the perceptual aspects of a landscape will remain largely subjective.

Table A2.17. Definitions of the categories of landscape and visual effects

Level of Effect	Description of Landscape Effect	Description of Visual Effect
Major	Where the development substantially changes an extensive area of highly sensitive landscape, which fundamentally affects the key characteristics and overall impression of its character.	The development becomes a prominent feature resulting in an obvious change to an existing, highly sensitive and well composed view.
Moderate	Where the development causes small or noticeable change to highly sensitive landscape, or more intensive change to a landscape of medium or low sensitivity, which affects some key characteristics and the overall impression of its character.	The development introduces some enhancing or detracting features to an existing highly sensitive and well composed view, or would be prominent within a less well composed and less sensitive view, resulting in a noticeable improvement or deterioration of the view.
Minor	Where the development causes small change to a landscape of low sensitivity, which affects relatively few characteristics without altering the overall impression of its character.	The development forms a perceptible, but neither enhancing or detracting feature within a view of high or medium sensitivity, or would be a prominent feature within a view of low sensitivity, causing either a small improvement or deterioration of the existing view.
Negligible	No discernible change (either improvement or detrimental) to the existing landscape character.	No discernible change (either improvement or detrimental) to the existing view.
None	No effect of the development on the landscape receptor.	No effect of the development on the view.

APPENDIX 3: ANALYSIS OF LANDSCAPE EFFECTS

The detailed analyses of the project's predicted landscape effects are presented in the tables below. These are summarised in the main text, where only the significant effects are presented.

Analysis of Project Landscape Effects during Construction

Table A3.1. Analysis of the magnitude and significance of individual landscape effects during the **construction** phase on the **Kiruna Mining LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Mining LLCA Landscape Change: Construction				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Medium	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Presence of people	Small	Small	Long term, reversible	Small	Minor/ Adverse
Noise	Large	Medium	Short term, reversible	Medium	Moderate/ Minor/ Adverse
Vibration	Small	Small	Short term, reversible	Small	Minor/ Adverse
Lights	Large	Large	Long term, reversible	Large	Moderate/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Minor
Odours	Negligible	None	Short term, reversible	Negligible	Negligible
Vegetation removal	Large	Small	Long term, reversible	Large	Moderate/ Adverse
Soil clearance	Large	Small	Long term, reversible	Large	Moderate/ Adverse
Unnatural landforms	Small	Small	Very long term, permanent	Small	Minor/ Adverse
Vertical structures	Medium	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Linear structures	Medium	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Emissions plumes	None	None	Short term, reversible	None	None
Dust	Small	Medium	Short term, reversible	Medium	Moderate/ Minor/ Adverse
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.2. Analysis of the magnitude and significance of individual landscape effects during the **construction** phase on the **Kiruna Urban LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Urban LLCA Landscape Change: Construction				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Small	Small	Long term, reversible	Small	Minor/ Adverse
Presence of people	Small	Negligible	Long term, reversible	Negligible	Negligible
Noise	Small	Medium	Short term, reversible	Small	Minor/ Adverse
Vibration	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Lights	Medium	Large	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Minor/ Adverse
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Small	Small	Long term, reversible	Small	Minor/ Adverse
Soil clearance	Small	Small	Long term, reversible	Small	Minor/ Adverse
Unnatural landforms	Small	Negligible	Very long term, permanent	Negligible	Negligible
Vertical structures	Small	Small	Long term, reversible	Small	Minor/ Beneficial
Linear structures	Small	Negligible	Long term, reversible	Small	Minor/ Adverse
Emissions plumes	None	None	Short term, reversible	None	None
Dust	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Discolouration of water courses/ bodies	Negligible	Small	Short term, reversible	Small	Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.3. Analysis of the magnitude and significance of individual landscape effects during the **construction** phase on the **Mountain Birch Forest/ Fjällbjörkskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Mountain Birch Forest/ Fjällbjörkskogen LLCA Landscape Change: Construction				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Presence of people	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Noise	Large	Medium	Short term, reversible	Large	Major/ Moderate/ Adverse
Vibration	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Lights	Medium	Large	Long term, reversible	Large	Major/ Moderate/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Odours	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vegetation removal	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Soil clearance	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Unnatural landforms	Small	Negligible	Very long term, permanent	Small	Moderate/ Minor/ Adverse
Vertical structures	Medium	Small	Long term, reversible	Small	Moderate/ Minor/ Beneficial
Linear structures	Medium	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Emissions plumes	None	None	Short term, reversible	None	None
Dust	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.4. Analysis of the magnitude and significance of individual landscape effects during the **construction** phase on the **Coniferous Forest/ Barrskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Coniferous Forest/ Barrskogen LLCA Landscape Change: Construction				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Presence of people	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Noise	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vibration	None	Negligible	Short term, reversible	None	None
Lights	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Soil clearance	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Unnatural landforms	Negligible	Negligible	Very long term, permanent	Negligible	Negligible
Vertical structures	Small	Negligible	Long term, reversible	Small	Moderate/ Minor/ Beneficial
Linear structures	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Emissions plumes	None	None	Long term, reversible	None	None
Dust	None	None	Short term, reversible	None	None
Discolouration of water courses/ bodies	Negligible	Negligible	Short term, reversible	Negligible	Negligible

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Analysis of Individual Project Landscape Effects during Operations (Year 5)

Table A3.5. Analysis of the magnitude and significance of individual landscape effects during **operations (year 5)** on the **Kiruna Mining LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Mining LLCA Landscape Change: Operations (Year 5)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Medium	Small	Long term, reversible	Medium	Moderate/ Minor/ Neutral
Presence of people	Small	Small	Long term, reversible	Small	Minor/ Adverse
Noise	Large	Medium	Short term, reversible	Medium	Moderate/ Minor/ Adverse
Vibration	Large	Medium	Short term, reversible	Medium	Moderate/ Minor/ Adverse
Lights	Medium	Large	Long term, reversible	Large	Moderate/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Minor/ Adverse
Odours	Small	Small	Short term, reversible	Small	Negligible
Vegetation removal	Large	Small	Long term, reversible	Large	Moderate/ Adverse
Soil clearance	Large	Small	Long term, reversible	Large	Moderate/ Adverse
Unnatural landforms	Large	Large	Very long term, permanent	Large	Moderate/ Adverse
Vertical structures	Medium	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Linear structures	Medium	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Emissions plumes	Large	Large	Long term, reversible	Large	Moderate/ Adverse
Dust	Small	Medium	Short term, reversible	Medium	Moderate/ Minor/ Adverse
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.6. Analysis of the magnitude and significance of individual landscape effects during **operations (year 5)** on the **Kiruna Urban LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Urban LLCA Landscape Change: Operations (Year 5)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Small	Small	Long term, reversible	Small	Minor/ Adverse
Presence of people	Small	Negligible	Long term, reversible	Negligible	Negligible
Noise	Small	Medium	Short term, reversible	Small	Minor/ Adverse
Vibration	Small	Medium	Short term, reversible	Small	Minor/ Adverse
Lights	Medium	Large	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Minor/ Adverse
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Small	Small	Long term, reversible	Small	Minor/ Adverse
Soil clearance	Small	Small	Long term, reversible	Small	Minor/ Adverse
Unnatural landforms	Large	Large	Very long term, permanent	Large	Moderate/ Adverse
Vertical structures	Small	Small	Long term, reversible	Small	Minor/ Adverse
Linear structures	Small	Negligible	Long term, reversible	Small	Minor/ Adverse
Emissions plumes	Medium	Large	Long term, reversible	Large	Moderate/ Adverse
Dust	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.7. Analysis of the magnitude and significance of individual landscape effects during **operations (year 5)** on the **Mountain Birch Forest/ Fjällbjörkskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Mountain Birch Forest/ Fjällbjörkskogen LLCA Landscape Change: Operations (Year 5)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Presence of people	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Noise	Large	Large	Long term, reversible	Large	Major/ Moderate/ Adverse
Vibration	Medium	Large	Short term, reversible	Medium	Moderate/ Adverse
Lights	Medium	Large	Long term, reversible	Large	Major/ Moderate/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Odours	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Vegetation removal	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Soil clearance	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Unnatural landforms	Large	Large	Very long term, permanent	Large	Major/ Moderate/ Adverse
Vertical structures	Medium	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Linear structures	Medium	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Emissions plumes	Medium	Large	Long term, reversible	Large	Major/ Moderate/ Adverse
Dust	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.8. Analysis of the magnitude and significance of individual landscape effects during **operations (year 5)** on the **Coniferous Forest/ Barrskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Coniferous Forest/ Barrskogen LLCA Landscape Change: Operations (Year 5)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Presence of people	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Noise	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vibration	None	Negligible	Short term, reversible	None	None
Lights	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Soil clearance	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Unnatural landforms	Small	Small	Very long term, permanent	Small	Moderate/ Minor/ Adverse
Vertical structures	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Linear structures	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Emissions plumes	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Dust	None	None	Short term, reversible	None	None
Discolouration of water courses/ bodies	Negligible	Negligible	Short term, reversible	Negligible	Negligible

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Analysis of Individual Project Landscape Effects during Closure

Table A3.9. Analysis of the magnitude and significance of individual landscape effects during **closure** on the **Kiruna Mining LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Mining LLCA Landscape Change: Closure				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Small	Small	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Presence of people	Small	Small	Long term, reversible	Small	Minor/ Neutral
Noise	Small	Small	Short term, reversible	Small	Minor/ Adverse
Vibration	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Lights	Medium	Large	Long term, reversible	Large	Moderate/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Minor/ Adverse
Odours	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vegetation removal	Large	Small	Long term, reversible	Large	Moderate/ Adverse
Soil clearance	Medium	Small	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Unnatural landforms	Medium	Large	Very long term, permanent	Large	Moderate/ Adverse
Vertical structures	Small	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Linear structures	Medium	Medium	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Emissions plumes	None	None	Long term, reversible	None	None
Dust	Small	Medium	Short term, reversible	Medium	Moderate/ Minor/ Adverse
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.10. Analysis of the magnitude and significance of individual landscape effects during **closure** on the **Kiruna Urban LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Urban LLCA Landscape Change: Closure				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Small	Small	Long term, reversible	Small	Minor/ Adverse
Presence of people	Small	Negligible	Long term, reversible	Negligible	Negligible
Noise	Small	Small	Short term, reversible	Small	Minor/ Adverse
Vibration	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Lights	Medium	Large	Long term, reversible	Medium	Moderate/ Minor/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Minor/ Adverse
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Small	Small	Long term, reversible	Small	Minor/ Adverse
Soil clearance	Small	Small	Long term, reversible	Small	Minor/ Adverse
Unnatural landforms	Medium	Large	Very long term, permanent	Large	Moderate/ Adverse
Vertical structures	Small	Small	Long term, reversible	Small	Minor/ Adverse
Linear structures	Small	Negligible	Long term, reversible	Small	Minor/ Adverse
Emissions plumes	None	None	Long term, reversible	None	None
Dust	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.11. Analysis of the magnitude and significance of individual landscape effects during **closure** on the **Mountain Birch Forest/ Fjällbjörkskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Mountain Birch Forest/ Fjällbjörkskogen LLCA Landscape Change: Closure				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Presence of people	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Noise	Small	Medium	Long term, reversible	Medium	Moderate/ Adverse
Vibration	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Lights	Medium	Large	Long term, reversible	Large	Major/ Moderate/ Adverse
Reflections	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Odours	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vegetation removal	Medium	Small	Long term, reversible	Medium	Moderate/ Adverse
Soil clearance	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Unnatural landforms	Large	Large	Very long term, permanent	Large	Major/ Moderate/ Adverse
Vertical structures	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Linear structures	Medium	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Emissions plumes	None	None	Long term, reversible	None	None
Dust	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse
Discolouration of water courses/ bodies	Small	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.12. Analysis of the magnitude and significance of individual landscape effects during **closure** on the **Coniferous Forest/ Barrskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Coniferous Forest/ Barrskogen LLCA Landscape Change: Closure				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Presence of people	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Noise	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vibration	None	None	Short term, reversible	None	None
Lights	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Soil clearance	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Unnatural landforms	Small	Small	Very long term, permanent	Small	Moderate/ Minor/ Adverse
Vertical structures	Small	Negligible	Long term, reversible	Small	Negligible
Linear structures	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Emissions plumes	None	None	Long term, reversible	None	None
Dust	None	None	Short term, reversible	None	None
Discolouration of water courses/ bodies	Negligible	Negligible	Short term, reversible	Negligible	Negligible

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Analysis of Individual Project Landscape Effects during Post-Closure (Year 10)

Table A3.13. Analysis of the magnitude and significance of individual landscape effects during **post-closure (year 10)** on the **Kiruna Mining LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Mining LLCA Landscape Change: Post-Closure (Year 10)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Small	Small	Long term, reversible	Small	Minor/ Adverse
Presence of people	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Noise	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Vibration	None	None	Short term, reversible	None	None
Lights	Small	Small	Long term, reversible	Small	Minor/ Adverse
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Small	Small	Long term, reversible	Small	Minor/ Adverse
Soil clearance	None	None	Long term, reversible	None	None
Unnatural landforms	Medium	Medium	Very long term, permanent	Medium	Moderate/ Minor/ Adverse
Vertical structures	Medium	Small	Long term, reversible	Medium	Moderate/ Minor/ Beneficial
Linear structures	Small	Small	Long term, reversible	Small	Minor/ Adverse
Emissions plumes	None	None	Long term, reversible	None	None
Dust	None	None	Short term, reversible	None	None
Discolouration of water courses/ bodies	Negligible	Negligible	Short term, reversible	Negligible	Negligible

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.14. Analysis of the magnitude and significance of individual landscape effects during **post-closure (year 10)** on the **Kiruna Urban LLCA** (sensitivity: low)

Effect	Magnitude of Kiruna Urban LLCA Landscape Change: Post-Closure (Year 10)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Presence of people	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Noise	None	None	Short term, reversible	None	None
Vibration	None	None	Short term, reversible	None	None
Lights	Small	Small	Long term, reversible	Small	Minor/ Adverse
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Small	Small	Long term, reversible	Small	Minor/ Adverse
Soil clearance	None	None	Long term, reversible	None	None
Unnatural landforms	Small	Small	Very long term, permanent	Small	Minor/ Adverse
Vertical structures	Small	Negligible	Long term, reversible	Small	Minor/ Beneficial
Linear structures	Small	Negligible	Long term, reversible	Small	Minor/ Adverse
Emissions plumes	None	None	Long term, reversible	None	None
Dust	None	None	Short term, reversible	None	None
Discolouration of water courses/ bodies	Negligible	Negligible	Short term, reversible	Negligible	Negligible

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.15. Analysis of the magnitude and significance of individual landscape effects during **post-closure (year 10)** on the **Mountain Birch Forest/ Fjällbjörkskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Mountain Birch Forest/ Fjällbjörkskogen LLCA Landscape Change: Post-Closure (Year 10)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Presence of people	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Noise	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Vibration	None	None	Short term, reversible	None	None
Lights	Small	Negligible	Long term, reversible	Small	Moderate/ Minor/ Adverse
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Soil clearance	None	None	Long term, reversible	None	None
Unnatural landforms	Small	Small	Very long term, permanent	Small	Moderate/ Minor/ Adverse
Vertical structures	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Beneficial
Linear structures	Small	Small	Long term, reversible	Small	Moderate/ Minor/ Adverse
Emissions plumes	None	None	Short term, reversible	None	None
Dust	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Discolouration of water courses/ bodies	Negligible	Small	Short term, reversible	Small	Moderate/ Minor/ Adverse

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

Table A3.16. Analysis of the magnitude and significance of individual landscape effects during **post-closure (year 10)** on the **Coniferous Forest/ Barrskogen LLCA** (sensitivity: medium)

Effect	Magnitude of Coniferous Forest/ Barrskogene LLCA Landscape Change: Post-Closure (Year 10)				Significance*
	Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
Movement of machinery	None	None	Long term, reversible	None	None
Presence of people	None	None	Long term, reversible	None	None
Noise	None	None	Short term, reversible	None	None
Vibration	None	None	Short term, reversible	None	None
Lights	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Reflections	Negligible	Negligible	Short term, reversible	Negligible	Negligible
Odours	None	None	Short term, reversible	None	None
Vegetation removal	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Soil clearance	None	None	Long term, reversible	None	None
Unnatural landforms	Negligible	Negligible	Very long term, permanent	Negligible	Negligible
Vertical structures	Small	Negligible	Long term, reversible	Small	Moderate/ Minor/ Beneficial
Linear structures	Negligible	Negligible	Long term, reversible	Negligible	Negligible
Emissions plumes	None	None	Long term, reversible	None	None
Dust	None	None	Short term, reversible	None	None
Discolouration of water courses/ bodies	Negligible	Negligible	Short term, reversible	Negligible	Negligible

*, 'significance' is deduced from combining the sensitivity of the landscape receptor with the magnitude of the effect (see Appendix 2)

APPENDIX 4: ANALYSIS OF VISUAL EFFECTS

The detailed analyses of the project's predicted visual effects are presented in the tables below. These are summarised in the main text, where only the significant effects are presented.

Analysis of Project Visual Effects during Construction

Table A4.1. Analysis of the magnitude and significance of visual effects on visual receptors during the **construction** phase

ID	Viewpoint Name (Sensitivity)	Magnitude of Visual Change: Construction				Significance
		Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
1	**Ädnamvaara cottage** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Large	Permanent	Large	Major/ Adverse
3	**Ädnamvaara Trail car-park** (Low sensitivity)	Medium	Large	Permanent	Large	Moderate/ Beneficial
4	**E10 north of Kiruna** (Medium sensitivity)	Medium	Small to Large	Permanent	Medium	Moderate/ Beneficial
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Medium	Permanent	Medium	Moderate/ Beneficial
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
7	**Loussavaara carpark** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
8	**Loussavaara summit** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
9	**Dübengatan** (Medium sensitivity)	Small	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Large	Permanent/ partially reversible	Medium	Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Large	Large	Permanent/ partially reversible	Large	Moderate/ Adverse
12	**Porfyrvägen** (Medium sensitivity)	Medium	Large	Permanent/ partially reversible	Medium	Moderate/ Adverse
13	**Rallarvägen carpark** (Medium sensitivity)	Medium	Large	Permanent/ partially reversible	Medium	Moderate/ Adverse
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
15	**Gruvstadsparken** (Low sensitivity)	Small	Medium	Permanent/ partially reversible	Small	Minor/ Neutral
16	**Högalidskolan** (Low sensitivity)	Small	Small	Permanent/ partially reversible	Small	Minor/ Adverse
17	**Triangelskolan** (Negligible sensitivity)	Negligible	Small	Permanent/ partially reversible	Negligible	Negligible

Analysis of Project Visual Effects during Operations (Year 5)

Table A4.2. Analysis of the magnitude and significance of visual effects on visual receptors during **operations (year 5)** phase. Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been lightly greyed out.

ID	Viewpoint Name (Sensitivity)	Magnitude of Visual Change: Operations (Year 5)				Significance
		Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
1	**Ädnamvaara cottage** (High sensitivity)	Large	Large	Permanent & partially reversible	Large	Major/ Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Large	Permanent	Large	Major/ Adverse
3	**Ädnamvaara Trail car-park** (Low sensitivity)	Large	Large	Permanent	Large	Moderate/ Adverse
4	**E10 north of Kiruna** (Medium sensitivity)	Medium	Small to Large	Permanent	Large	Major/ Moderate/ Adverse
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
7	**Loussavaara carpark** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
8	**Loussavaara summit** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
9	**Dübengatan** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Large	Permanent/ partially reversible	Large	Major/ Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Large	Large	Permanent/ partially reversible	Large	Moderate/ Adverse
12	**Porfyrvägen** (Medium sensitivity)	Medium	Large	Permanent/ partially reversible	Medium	Moderate/ Adverse
13	**Rallarvägen carpark** (Medium sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Moderate/ Adverse
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
15	**Gruvstadsparken** (Low sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Minor/ Adverse
16	**Högalidskolan** (Low sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Minor/ Adverse

17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Small	Permanent/ partially reversible	Negligible	Negligible
	Triangelskolan (Predicted: low sensitivity)	Medium	Small	Permanent/ partially reversible	Medium	Moderate/ Minor/ Adverse

Analysis of Project Visual Effects during Closure

Table A4.3. Analysis of the magnitude and significance of visual effects on visual receptors during **closure**. Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been lightly greyed out.

ID	Viewpoint Name (Sensitivity)	Magnitude of Visual Change: Closure				Significance*
		Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
1	**Ädnamvaara cottage** (High sensitivity)	Large	Large	Permanent & partially reversible	Large	Major/ Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Large	Large	Permanent	Large	Major/ Adverse
3	**Ädnamvaara Trail car-park** (Low sensitivity)	Large	Large	Permanent	Large	Moderate/ Adverse
4	**E10 north of Kiruna** (Medium sensitivity)	Medium	Small to Large	Permanent	Large	Major/ Moderate/ Adverse
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
7	**Loussavaara car-park** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
8	**Loussavaara summit** (High sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Adverse
9	**Dübengatan** (Medium sensitivity)	Small	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Large	Permanent/ partially reversible	Large	Major/ Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Medium	Large	Permanent/ partially reversible	Large	Moderate/ Adverse
12	**Porfyrvägen** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
13	**Rallarvägen car-park** (Medium sensitivity)	Large	Large	Permanent/ partially reversible	Large	Major/ Moderate/ Adverse

14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Medium	Permanent/ partially reversible	Medium	Moderate/ Adverse
15	**Gruvstadsparken** (Low sensitivity)	Small	Medium	Permanent/ partially reversible	Medium	Moderate/ Minor/ Adverse
16	**Högalidskolan** (Low sensitivity)	Small	Medium	Permanent/ partially reversible	Medium	Moderate/ Minor/ Adverse
17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Small	Permanent/ partially reversible	Negligible	Negligible
	Triangelskolan (Predicted: low sensitivity)	Medium	Small	Permanent/ partially reversible	Medium	Moderate/ Minor/ Adverse

Analysis of Project Visual Effects during Post-Closure (Year 10)

Table A3.4. Analysis of the magnitude and significance of visual effects on visual receptors **post-closure (year 10)**. Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been lightly greyed out.

ID	Viewpoint Name (Sensitivity)	Magnitude of Visual Change: Closure				Significance*
		Size/Scale	Geographical Extent	Duration & Reversibility	Overall Magnitude	
1	**Ädnamvaara cottage** (High sensitivity)	Medium	Medium	Permanent	Medium	Major/ Moderate/ Adverse
2	**Ädnamvaara Trail** (High sensitivity)	Medium	Medium	Permanent	Medium	Major/ Moderate/ Adverse
3	**Ädnamvaara Trail carpark** (Low sensitivity)	Small	Medium	Permanent	Medium	Moderate/ Minor/ Neutral
4	**E10 north of Kiruna** (Medium sensitivity)	Small	Small to medium	Permanent	Small	Moderate/ Minor/ Neutral
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Medium	Permanent	Medium	Moderate/ Neutral
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Medium	Medium	Permanent	Medium	Major/ Moderate/ Adverse
7	**Loussavaara car-park** (High sensitivity)	Small	Medium	Permanent	Medium	Major/ Moderate/ Adverse
8	**Loussavaara summit** (High sensitivity)	Small	Medium	Permanent	Medium	Major/ Moderate/ Adverse

9	**Dübengatan** (Medium sensitivity)	Small	Medium	Permanent	Small	Moderate/ Neutral
10	**Nordkalottvägen** (Medium sensitivity)	Small	Large	Permanent	Medium	Moderate/ Adverse
11	**Kiruna railway station** (Low sensitivity)	Small	Medium	Permanent	Medium	Moderate/ Minor/ Neutral
12	**Porfyrvägen** (Medium sensitivity)	Small	Small	Permanent	Small	Moderate/ Minor/ Neutral
13	**Rallarvägen car-park** (Medium sensitivity)	Medium	Large	Permanent	Medium	Moderate/ Adverse
14	**Scandic Ferrum hotel** (Medium sensitivity)	Small	Medium	Permanent	Medium	Moderate/ Neutral
15	**Gruvstadsparken** (Low sensitivity)	Small	Medium	Permanent	Small	Minor/ Neutral
16	**Högalidskolan** (Low sensitivity)	Small	Medium	Permanent	Small	Minor/ Neutral
17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Small	Permanent	Negligible	Negligible
	Triangelskolan (Predicted: low sensitivity)	Small	Small	Permanent	Small	Minor/ Neutral

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COPPERSTONE

Viscaria

LIGHTING IMPACT

assessment

Supplementary report to the
main LVIA report

APPENDIX B2:2

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Photos and illustrations by Future terrains and Ecogain if nothing else mentions.

CONTENTS

NON-TECHNICAL SUMMARY

A preliminary lighting impact assessment was carried out as a supplement to the main landscape and visual impact assessment report. It was preliminary because it was based on only a very high level lighting plan of the site. The assessment was conducted by UK-based Future Terrains and Sweden-based Ecogains. The preliminary assessment introduces the basics of what constitutes light pollution and its key effects and recommends some key best practice guidance on mitigating light pollution.

The Viscaria site is an ecological, socio-economic, visual and cultural transition zone, or figurative corridor, between the urban – industrial complex of Kiruna and the surrounding Arctic wilderness, inhabited by traditional Sami reindeer herding communities. This visual and physical accessibility of the wilderness is a key element of the cultural identity of Kiruna's people. A key element of this cultural identity are the easy access – physically and figuratively – to the dark Arctic skies and views of the aurora borealis. This resource is also marketed widely to a growing number of visitors as part of their Arctic wilderness experience.

The Viscaria site currently presents a dark space adjacent to the widely illuminated LKAB site and enables viewers from the city to access dark skies to the west. Also, to the north of Kiruna along the E10, Viscaria offers a dark space or corridor between LKAB and the brightly lit Luossavaara ski slopes.

The foreseeable lighting effects related to the development of the Viscaria copper mine are:

- **Light spill** – outside the boundaries of the site, or area that is being lit within the site, thus increasing illumination of an area and thus its visibility from a distance.
- **Glarecaused** – by direct views of various light sources.
- **Direct upward light** – from light sources, including façade lighting.

- **Moving and flashing lights** – from machinery and vehicles, which will draw attention of the viewer. It is also known to have a detrimental effect on reindeer behaviour. Flashing lights on vehicles moving increases visibility to human and animal receptors.
- **Emissions plumes** – smoke, gases and water vapour emitted from point sources, such as flues, chimney stacks and, if underground workings are present, ventilation shafts. In the cold Arctic air, their elevation and their movement exacerbate their visibility from a distance and can affect views. The visibility of plumes increases in cold weather. Plumes reflect artificial light, which also illuminates the plumes and their movement at a high level increases night-time visibility to receptors. Plumes will be produced primarily during the operational phase.
- **Sky glow** – a combination of direct upward light and reflected light scattered in the atmosphere that illuminates the night sky above an area. It is also partly caused by atmospheric conditions, such as humidity, presence of aerosols, atmospheric pollution, etc. Mining activities are likely to increase sky glow by both increasing the light at source, but also increasing particles in the atmosphere above the site, which will increase the scattering of the light and therefore increase the sky glow. Reflected is exacerbated by snow cover.
- **Lighting in patterns or straight lines** – such forms are unnatural and increase visibility to the viewer. Typically these occur along roads and railways, but LKAB has such lighting on the side of Kiirunavaara and along its railway.
- **Light colour/ wavelength** – the colour or wavelengths of artificial light vary with the type of lighting used. The resulting ecological effects on insects, bats and other animals can be complicated and also vary with the type of lighting. It is recommended that a detail assessment of this issue is carried out in relation to the prospective lighting options for the project, given the ecological sensitivities of – particularly the western side of – the Viscaria site.

A range of mitigations that could address these effects in a variety of ways was also suggested. The impact assessment was carried out to determine the significance of residual effects after the postulated mitigations had been applied.

The landscape and visual receptors considered were the same as those described in the landscape and visual impact assessment. The landscape receptors were:

- The Kiruna Mining LLCA,
- The Kiruna Urban LLCA,
- The Mountain Birch Forest/ Fjällbjörkskogen LLCA, and
- The Coniferous Forest/ Barrskogen LLCA.

And the visual receptors were:

- Ädnamvaara Cottage,
- Ädnamvaara Trail,
- Ädnamvaara Trail car-park,
- E10 north of Kiruna,
- Máttaráhkká Northern Lights Lodge,
- Maria Taavenikkus Gata,
- Loussavaara car-park,
- Loussavaara summit,
- Dübengatan,
- Nordkalottvägen,
- Kiruna railway station,
- Porfyrvägen,
- Rallarvägen car-park,
- Scandic Ferrum hotel,
- Gruvstadsparken,
- Högalidskolan, and
- Triangelskolan.

For some visual receptors, the effects of project lighting in relation to the proposed 2035 LKAB deformation zone line was also considered.

The assessment methodology aligns with that of the main landscape and visual impact assessment. In particular it looked at four key stages in the life of mine:

- The height of construction,
- The fifth year of operations when site disturbance will be at its maximum and rehabilltation and restoration will not yet have begun in earnest,
- The height of mine closure, and
- Ten years after mine closure.

It was found that mobile lighting and movement will predominate in the construction and closure phases, with the operational phase having the most significant adverse effects overall. The landscape receptor that will be most affected will be the Mountain Birch Forest/ Fjällbjörkskogen LLCA, because artificial lighting will diminish the perception of its 'wilderness' values of remoteness and tranquillity. Visually, significant lighting effects will adversely impact Kiruna residents with good views to the west and those closest to the site and with elevation and for which Viscaria currently offers a dark sky juxtaposition to the visually predominant LKAB. The most significantly affected visual receptors will be: Ädnamvaara Cottage, Ädnamvaara Trail, E10 north of Kiruna, Máttaráhkká Northern Lights Lodge, Maria Taavenikkus Gata, Loussavaara car-park, Loussavaara summit, Dübengatan and Porfyrvägen. Scandic Ferrum hotel will also be significantly affected in the first few years, but will succumb to the deformation zone before the main period of operations.

The proximity of existing bright light sources, particularly LKAB and, on winter nights, the floodlit Luossavaara ski slopes, will cause substantial cumulative effects when combined with light emanating from the Viscaria project. These cumulative effects will include:

- Impinging on easy visual access to dark skies for Kiruna residents and visitors,
- Increasing glare across a wider horizon as Viscaria's lights extend the glare already produced by LKAB making the city and LKAB feel closer, or conversely, making Ädnamvaara feel less remote or wild.

- LKAB's emissions plumes are already highly visible on cold nights and reflect light that emanates – primarily – from LKAB's activities. Similar plumes from Viscaria's operations will combine with LKAB's and will dominate views from Kiruna.
- Increased light pollution emanating from the Viscaria site will interact with existing light emissions to increase the general sky glow over the area with concomitant effects on surrounding wilderness landscape character.
- Viscaria's proposed road lighting will interact visually with LKAB's existing linear lighting to produce a broader, more noticeable effect.
- As Viscaria develops, its lights will fill the dark void between the well-lit city and LKAB and Luossavaara's ski slopes, impacting the night-time visual experience as one leaves or approaches Kiruna.
- The ecological effects of artificial light and its wavelengths may be important in the Viscaria context, but to what extent is not currently known. This should be examined in more detail.

As previously stated, this study was carried out to a preliminary level; therefore, it is recommended that a more detailed lighting assessment is carried out by a lighting specialist, once a more detailed lighting plan is available. Also, several references to best practice are highlighted in this report. It is recommended that this – and similar – guidance is used by Copperstone to prepare a lighting management system for the Viscaria project that sets a best practice benchmark for mining projects in Sweden.

1. INTRODUCTION

The Swedish copper exploration and mining company, Copperstone Viscaria AB (Copperstone Viscaria), is preparing an application to the Land and Environment Court in Umeå for an environmental permit to open the former Viscaria copper mine (Viscaria, or the project), at Kiruna, Sweden. Future Terrains and Ecogain were engaged by Copperstone Viscaria to carry out a landscape and visual impact assessment (LVIA) and, subsequently, a preliminary lighting impact assessment of the project in support of the permit application.

This lighting impact assessment is a supplementary report to the main LVIA report completed. It is considered as a preliminary report because a more detailed, quantitative study is recommended when more technical detail on the project's lighting design is available.

The permitting authority did not provide specific guidance as to what was required for an LVIA in the context of the Viscaria project, other than an LVIA was required as part of the EIA process; therefore, the scope of the lighting impact assessment was determined by Copperstone-Viscaria and Future Terrains and Ecogain, based on the project's early stage lighting layout plans (Figure 1.1). These plans are low in detail and essentially describe the planned locations of some on-site lighting installations.

Please note that parts of the main LVIA report are directly relevant to this preliminary lighting impact assessment. This report will refer to the LVIA report where necessary, but for the sake of brevity will not seek to repeat that information in this report.

1.1 Limitations

This study is a preliminary qualitative assessment to help inform initial design mitigations against light pollution emanating from proposed artificial lighting at the Viscaria site. Once more technical detail is known about the project's lighting design proposals, an environmental lighting specialist should be engaged to carry out a comprehensive, quantitative dark skies and lighting impact assessment for the project.

During the winter field visit, it was difficult to take good quality, meaningful photographs of lighting conditions in the Arctic winter from every viewpoint. A couple of representative viewpoint photographs are included in the report, which illustrate certain key aspects of the discussion. Nighttime lighting effects from the Ädnamvaara side of the site were not assessed on the ground.

1.2 Report structure

This report consists of the following sections:

1. **Introduction** – the rationale and scope of this preliminary lighting impact assessment report, including limitations, report structure and a brief project description.
2. **Light pollution and its effects** – a summary of what lighting pollution is and what effects it can have and an introduction to some key best practice guidance on this topic.
3. **Methodology**
4. **Baseline** – a summary of the site's context from a lighting perspective, including existing artificial lighting.
5. **Predicted lighting effects and mitigations** – discussion of the expected lighting effects and some mitigation options available.
6. **Assessment of effects** – receptor sensitivity and potential lighting effects at four key stages in the life of mine.
7. **Cumulative effects**
8. **Conclusions**

1.3 Project description

The main aspects of the project description for the lighting impact assessment are the same as for the main LVIA report. Additional high-level information specific to the project's lighting design is provided in the site map (Figure 1.1). This shows the following lighting features:

- **Lighting masts** (**belysningsmaster**) to provide outdoor spatial lighting across work areas, particularly in the open pits and at the eastern edge of the site;
- **Road lighting** (**vägbelysning**) linearly spaced at 40 m centres, to provide lighting for the safety or road-users, mainly along the main access road from the E10 to the centre of the site, and
- **Façade lighting** (**fasadbelysning**) to illuminate the outside of buildings in the centre of the site.

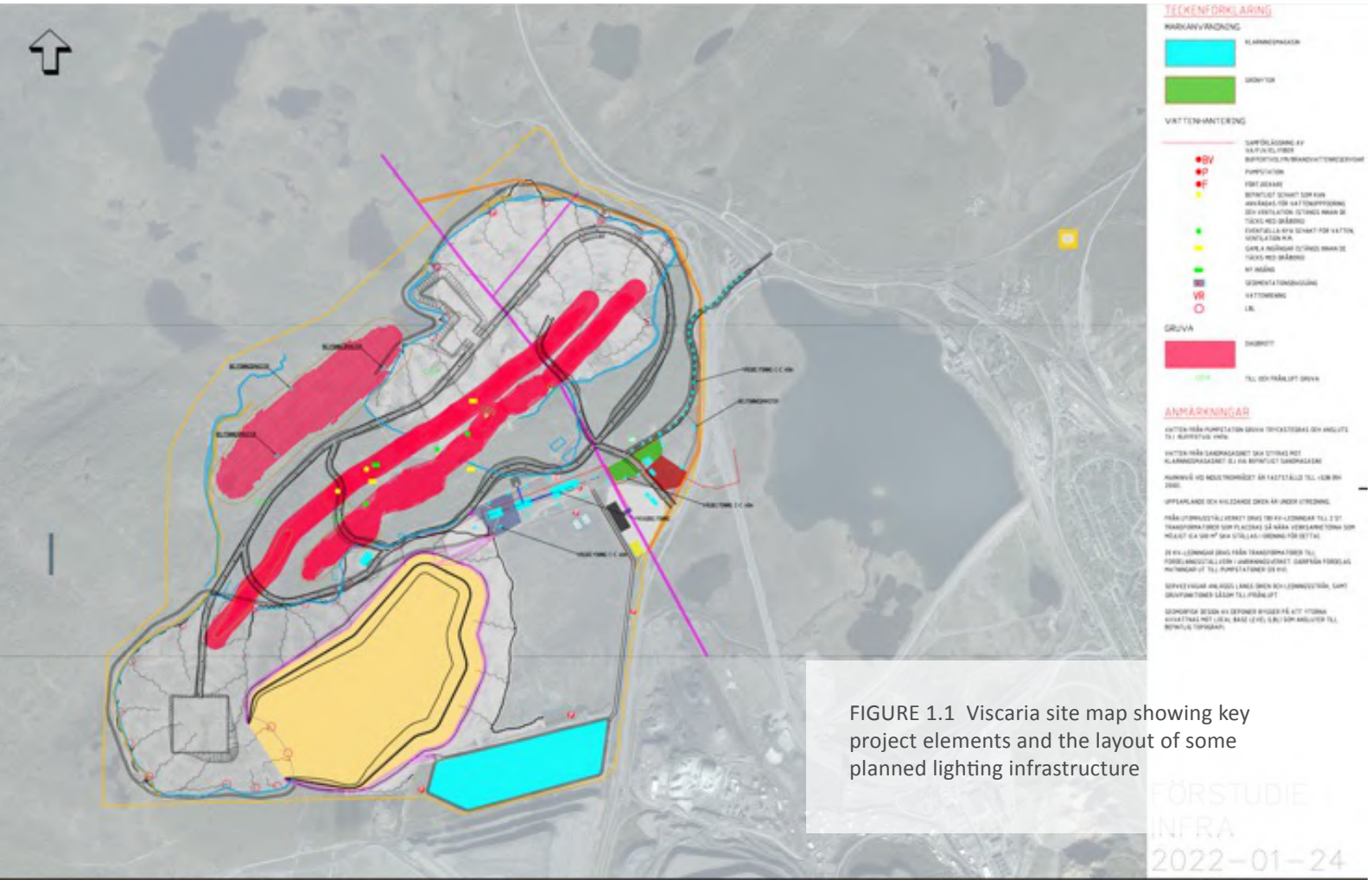

FIGURE 1.1 Viscaria site map showing key project elements and the layout of some planned lighting infrastructure

Other types of lighting that will be on-site include:

- The illumination of **signs,**
- Lighting from **moving vehicles and machinery**, and
- Lighting emanating from the **inside of buildings through windows.**

From a light pollution perspective, Copperstone will be locating the project's main buildings and permanent site access infrastructure at the centre and to the east side of the site, which faces Kiruna.

The project's main activity phases considered in this assessment with respect to lighting, include:

1. Construction

It is assumed construction activities will operate on a 24-hour basis. The movement of machinery and of vehicles around the site will be a major feature of the construction phase. Site lighting during dark periods will be dominated by that emanating from moving vehicles and machinery, including headlamps, orange flashing lights and red aviation warning lights on tall machinery, such as cranes. Lighting masts will be used illuminate work spaces. It is assumed that the main access route on to the site from the E10 will also be constructed and operating during this period, which will require road lighting. Most construction lighting effects will be temporary in nature and will cease when the construction phase ends.

2. Operations (year 5)

All the lighting types listed above will apply, but will be dominated by fixed lighting. Mobile lighting will occur and will be highly noticeable. Buildings will be lit from the inside, which will produce glare to the outside. Façade lighting and the lighting of signs will be in place. Key working areas will be lit by lighting masts. Operational lighting effects will be long term – at least for the life of mine – and will eventually cease as mine closure proceeds.

3. Closure and ecological restoration

Site lighting will diminish as mining and process activities end and buildings are removed and the need for fixed lighting is reduced/ eliminated. Closure activities will involve fewer people on-site, but mobile lighting will be more obvious as site features and landforms are reclaimed, regraded and restored. The artificial lighting to illuminate closure activities will be temporary and short term and will end as the closure phase ends.

4. Post-closure monitoring and aftercare

On-site lighting will be limited to mobile lighting during infrequent site visits to carry out site inspections and aftercare. This degree of lighting effect will continue as long as the monitoring and aftercare phase continues.

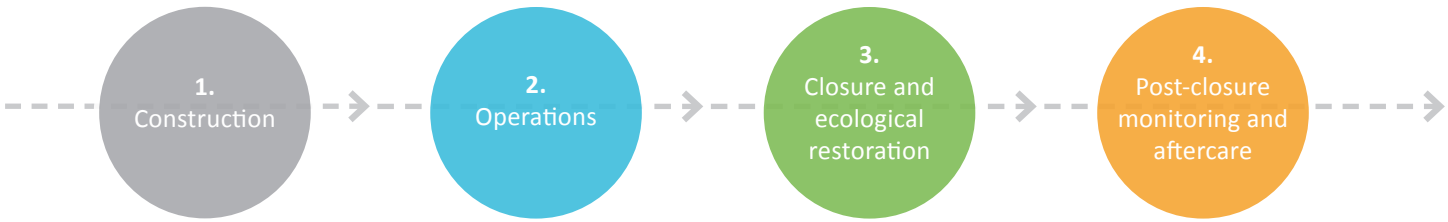

FIGURE 1.2 The projects main activity phases.

2. LIGHT POLLUTION AND ITS EFFECTS

Unwanted obtrusive artificial light, or light pollution, can lead to: physiological harm by keeping people awake at night, the erosion of cultural heritage, impeding views of the night skies, disrupting animal behaviour and affecting the performance of adjacent lighting installations. Light intrusion can also be a nuisance in law in some countries (such as the UK). Poor lighting design and unnecessary lighting also wastes money and energy.

2.1 Types of light pollution

The following types of light pollution have been described by the institution of Lighting Professionals:

- **Sky glow** – the brightening of the night sky caused by the scattering of light in the atmosphere (also depends on atmospheric conditions);
- **Glare** – the uncomfortable brightness of a light source when viewed against a darker background;
- **Light spill** – light spreading beyond the boundary of the area being lit; and
- **Light intrusion or nuisance lighting** – all forms of lighting which may cause nuisance to others, or adversely affect plants and animals, as well as waste energy and money.

These are illustrated in Figure 2.1 and can be observed from the night-time views of LKAB in Figure 2.2. Such effects are exacerbated by poorly designed lighting systems that provide too much light in the wrong place. In northern Sweden, the night-time lighting effects are exacerbated by the high reflectance of artificial light by the snow cover, which persists for many months through the winter.

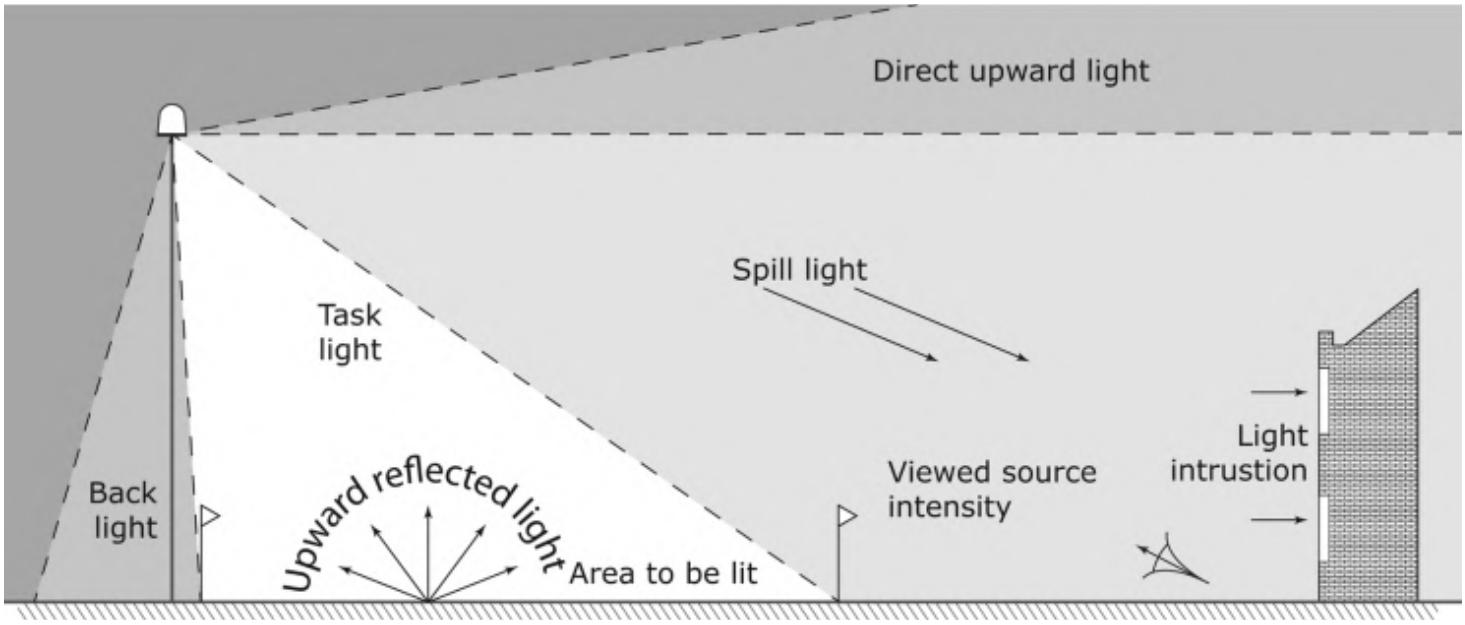

FIGURE 2.1 Types of light pollution. Sourced from Guidance Note GN01/21. The Reduction of Obtrusive Light. Institution of Lighting Professionals.

FIGURE 2.1 Night-time lighting effects of LKAB's operations viewed from Maria Taavenikkus Gata in the north of Kiruna. Various forms of light pollution are evident, including, sky glow, reflection from clouds and emissions plumes, glare, light spill, and nuisance lighting.

2.2 Effects of light pollution

The intrusion of spill light into areas that were previously dark will impact views of the area. The direct view of bright lights, or glare, can directly affect the health of those affected if it interrupts with sleep, for example, or annoyance, distraction or discomfort.

There is a road safety aspect to light pollution too. Glare caused by bright light sources can momentarily reduce road-users' (e.g. motorists, cyclists, pedestrians) ability to see. The apparent contrast of objects against their backgrounds will be lowered, rendering them less visible or even invisible, especially if the environment is intrinsically dark.

Over-bright or unsuitably coloured decorative lighting and signage will be considered as obtrusive to sightseers, rather than as enhancing the night-time experience.

Light emitted from above the horizontal, or reflected from surfaces below the light source, has the potential to cause sky glow, which can impact dark skies. Dark skies with their clear, unobstructed views of the night sky, including the aurora borealis in northern latitudes, are important culturally and for astronomy, but they are becoming increasingly uncommon for the populations of towns and cities due to the rapid expansion of artificial lighting worldwide and the poor design of lighting systems. There is growing awareness of the cultural value of dark skies internationally and the International Dark Sky Association (IDA) promotes a network of International Dark Sky Reserves around the world, including many in Europe[1]. The ILP guidance introduced above places limits on the percentage of direct upward light emitted from lighting installation.

Light pollution also negatively impacts animals. Light falling on bat roosts can delay some species of bats from emerging, thus shortening the amount of time available to them for feeding. This is particularly important at dusk, which is their main feeding time. Lighting also attracts some species of insect, which can disrupt bat feeding behaviour. It is not certain whether the Taiga bat (or Taigafladdermus, Myotis brandtii) occurs in the Kiruna area, but it is a possibility.

[1] See https://www.darksky.org/

As well as the amount of light, the colour and intensity of light pollution results in complex and unpredictable effects on animal vision and behaviour. Recent research has shown how the colour spectrum of artificial lighting impacts the visual ecology of many organisms, including nighttime pollinating insects and reproduction[2].

2.3 Legislation and planning context and good practice guidance

The legislation and planning context relating to the effects of artificial lighting of new developments in northern Sweden are as described in the main LVIA report. The authors are not aware of any specific Swedish legislation in relation to protecting dark skies and reducing light pollution.

The following good practice guidance has informed this assessment:

- The Reduction of Obtrusive Light. Guidance Note 01/21. Institution of Lighting Professionals (ILP).
- Vägbelysningshandboken. Trafikverket.
- Dark Sky Assessment Guide. Update 6-1-19. Utah Community Development Office and the Colorado Plateau Dark Sky Cooperative.

The Swedish standard, SS-EN 12464-2 Light and lighting - lighting of work places – Part 2: Outdoor, was not available for this assessment.

Further technical guidance available from the Commission Internationale de l'Eclairage (International Commission on Illumination) on reducing the negative effects of lighting are:

- CIE 150: 2017 Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations, and
- CIE 126: 1997 Guidelines for Minimizing Sky Glow.

Copperstone is advised to use the above guidance – and other similar guidance – in developing a lighting system for Viscaria that meets international best practice.

[2] Briolat, E.S., Gaston, K.J., Bennie, J., Rosenfeld, E.J. and Troscianko, J. (2021). Artificial nighttime lighting impacts visual ecology links between flowers, pollinators and predators. Nature Communications

In terms of assessing the effects of artificial lighting on residential receptors, the ILP guidance is considered best practice and reflects the European standard EN 12464-2. The guidance presents a system for classifying environmental zones with respect to limits to light pollution. These classifications are presented in Table 2.1. Based on these criteria, the Viscaria site arguably traverses two zones: zone E2 on the eastern side and zone E1 on the western side.

Table 2.1. Environmental zones (from ILP Guidance Note 01/21)

Zone	Surrounding	Lighting environment	Examples
E0	Protected	Dark (SQM 20.5+)	Astronomical Observable dark skies, UNESCO Starlight Reserves, IDA dark sky places
E1	Natural	Dark (SQM 20 to 20.5)	Relatively uninhabited rural areas, national parks, areas of outstanding natural beauty, IDA buffer zones, etc.
E2	Rural	Low district brightness (SQM ~15 to 20)	Sparsely inhabited rural areas, village or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Well inhabited rural and urban settlements, small town centres of suburban locations
E4	Urban	High district brightness	Town/ city centres with high levels of night-time activity

Notes:

1. Where an area to be lit lies close the boundary of two zones, the obtrusive light (i.e. light pollution) limitation values used should be those applicable to the most rigorous zone.

2. Rural zones under protected designations should use a higher standard of policy.

3. Zone E0 mush always be surrounded by an E1 Zone.

4. Zoning should be agreed with the local planning authority. Due to local requirements, a more stringent zone classification may be applied to protected special/ specific areas.

5. SQM (Sky Quality Meter) is referenced by the International Dark Skies Association (IDA). SQM is a instrument used to measure the luminance of the night sky. It is typically used by astronomers to quantify sky glow, using units of magnitudes per square arcsecond. The scale is between 16:00 (a bright night sky) and 22:00 (the least light pollution). The criteria for zone E0 was revised in mid-2019, with the new requirements not being made retrospective.

6. Astronomical Observable Dark Skies will offer clearer views of the Milky Way and of other objects such as the Andromeda Galaxy and the Orion Nebula.

7. Although values of SQM 20 to 20.5 may not offer clear views of astronomical dark sky objects such as the Milky Way, these skies will have their own relative intrinsic value in the UK [this is guidance of the UK, but similar would apply in Sweden].

The ILP guidance (and others related to EN 12464-2) provides technical recommendations on limiting light pollution by reducing sky glow according to optimal luminaire installation heights and angling; recommending maximum light value parameters for controlling light pollution by limiting the illumination of surrounding premises, limiting bright luminaires in the field of view, limiting the effects on transport systems, limiting sky glow and limiting the effects of over-lit building facades and signs. It is recommended that Copperstone uses this guidance, or other similar guidance, in developing a detailed mitigation strategy for mitigating light pollution, based on best practice.

There is also increasing research and guidance on addressing the ecological impacts of artificial lighting, for example:

- Bruce-White, C. and Shardlow, M. (2011). A review of the impact of artificial lighting on invertebrates. Buglife.
- Briolat, E.S., Gaston, K.J., Bennie, J., Rosenfeld, E.J. and Troscianko, J. (2021). Artificial nighttime lighting impacts visual ecology links between flowers, pollinators and predators. Nature Communications.
- ILP and the Bat Conservation Trust (2018). Bats and artificial lighting in the UK. Guidance Note 08/18.
- Voigt, C.C. et al, (2018). Guidelines for consideration of bats in lighting projects. EUROBAST Publication Series No. 8. UNEP/ EUROBATS [this reference also deals with the effects of lighting on insects to a degree]

3. METHODOLOGY

This is a qualitative assessment focussing on the values and properties of the landscape and visual receptors in the project area and the effects of the project's proposed lighting upon these. Potential mitigations are described and recommended and are included in the significance analyses. Only limited information on the project's lighting plans was available at the time of writing, so a worst case scenario has been assumed in this analysis. Cumulative lighting effects are also discussed.

The lighting effects are considered for the same life of mine activity phases as in the LVIA, namely:

- **Construction** – assuming peak construction activity;
- **Operations (Year 5)** – the period of the maximum extent of ore production and related landscape and visual effects;
- **Closure** – assuming the peak of mine closure activity, and
- **Post-Closure (Year 10)** – how the site will appear 10 years after mine closure.

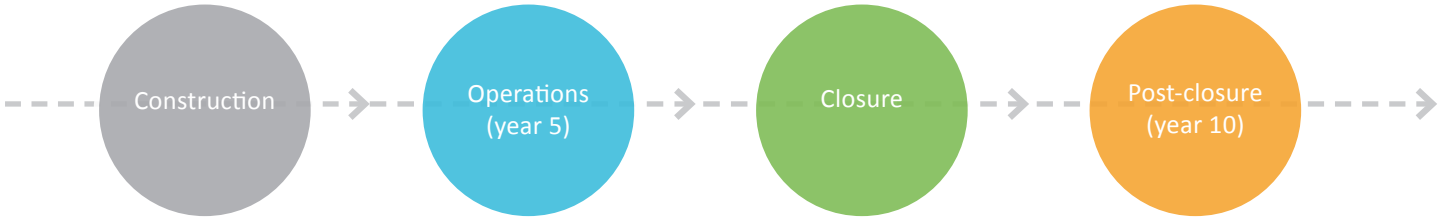

FIGURE 3.1 The lighting effects are considered for the same life of mine activity phases as in the LVIA, shown in the figure above.

This lighting assessment draws on the relevant findings from the LVIA report and includes them here, while adding new and more detailed assessments of lighting related effects, as appropriate.

The study area and viewpoints for this assessment are the same as those described in the companion LVIA report (Figures 3.2 and 3.3). Night-time photography of the site and its environs was taken in early December 2021 from the following representative viewpoints: Maria Taavenikkus Gata (new residential area), Luossavaara car-park and Máttaráhkká Northern Lights Lodge.

The assessment will need to be updated as the project's lighting design proposals become progressively refined and the predicated lighting effects become clearer. Regardless, it is recommended that a comprehensive lighting impact assessment is carried out by a lighting specialist in due course.

3.1 Significance criteria

The approach taken in the LVIA for determining the significance of project effects on receptors have been used here to determine the significance of lighting effects.

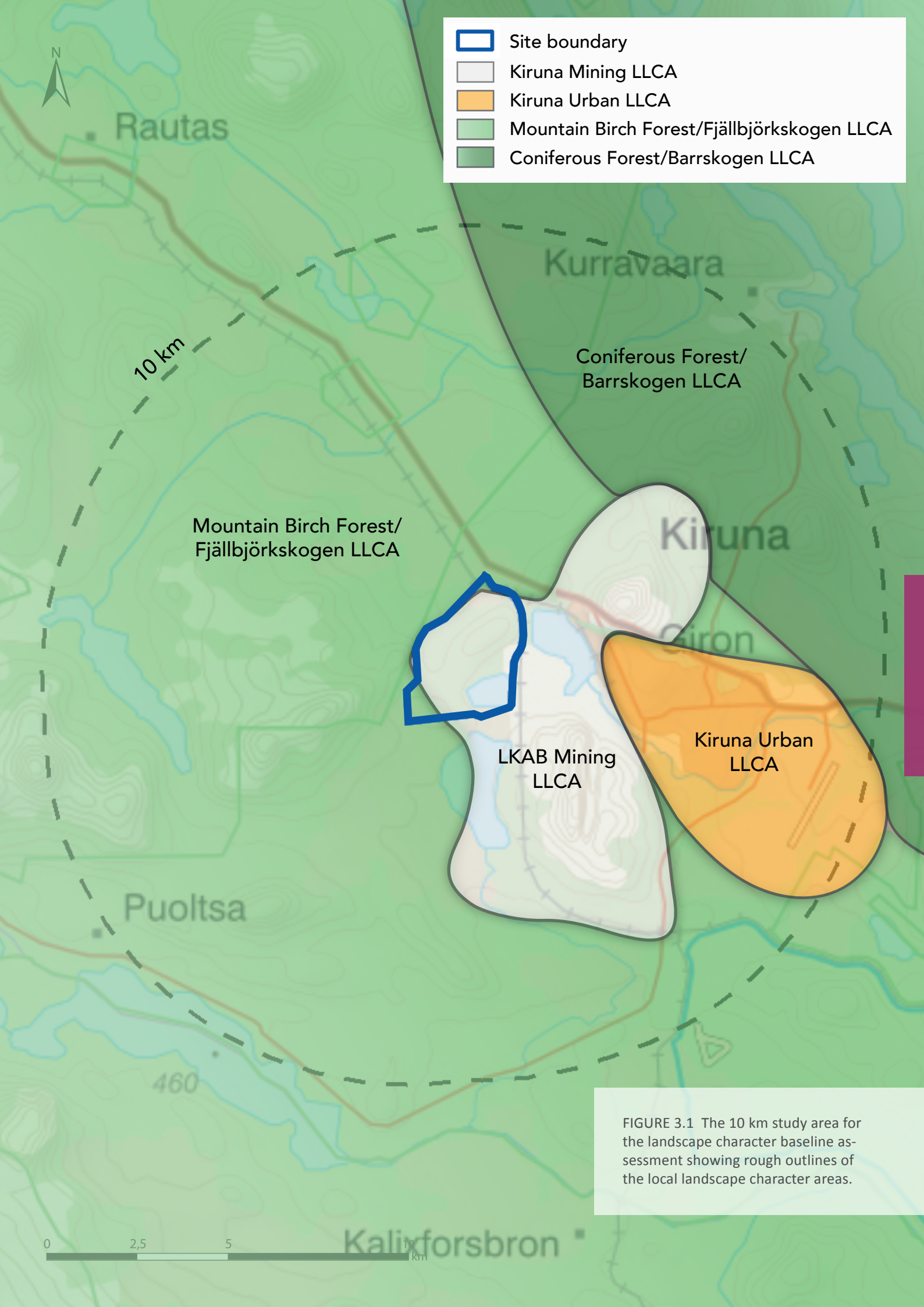

FIGURE 3.1 The 10 km study area for the landscape character baseline assessment showing rough outlines of the local landscape character areas.

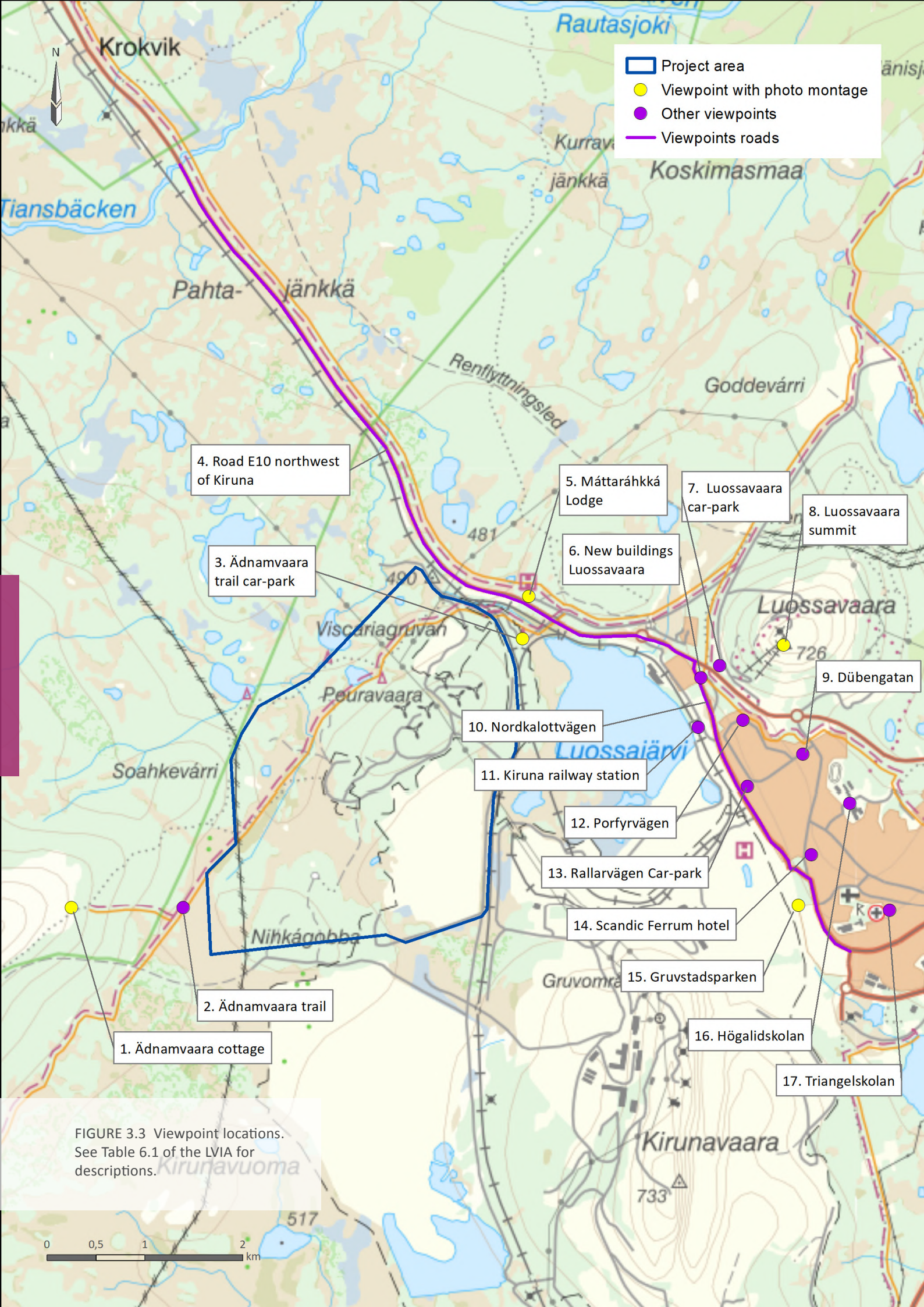

FIGURE 3.3 Viewpoint locations. See Table 6.1 of the LVIA for descriptions.

4. BASELINE

4.1 Site context

The landscape and visual baseline of the Viscaria site is described at length in the LVIA report. This section will focus purely on the site and its context from a dark skies and artificial lighting perspective.

The Kiruna mining and urban complex is located in a remote part of inland, northern Sweden, surrounded by hundreds of miles of Arctic wilderness. The Viscaria mine site is located on the edge of this complex, in the transition zone between urban and intense mining development and protected Arctic landscapes. The Artic winter night means several months of prolonged, daily darkness in the project area, where artificial lighting is an important element of safety and security; but the dark skies of north Sweden are also culturally and, in some places, socio-economically important. Dark skies are an essential component of the character of Arctic "wilderness" and offer easy, unrestricted views of the night sky and aurora borealis. As well as being culturally important to local people in terms of 'sense of place', such experiences are marketed to tourists as being authentic, yet easily accessible from Kiruna. Arctic wilderness tourism, including in winter, is a growing sector in the economy of Kiruna and its surroundings.

The LVIA's 10 km study area overlays various different landscape features, designations, land-uses, habitats and cultural associations. The project area is on the edge of extensive areas of wilderness and very close to a number of national natural protected areas, including two Natura 2000 sites, and overlaps with areas of national interested for nature conservation, outdoor life and recreation. Reindeer herding is also an important land-use by the Sami reindeer herding communities of the Laevas and Gabna villages.

The Kiruna Mining LLCA

The Kiruna Urban LLCA

The Mountain Birch Forest/ Fjällbjörkskogen LLCA

The Coniferous Forest/ Barrskogen LLCA

The LVIA's landscape character assessment determined four local landscape character areas (LLCAs) based on their natural characteristics, cultural/ social characteristics, aesthetics and perceptual characteristics, landscape condition and visual characteristics. They are:

- The Kiruna Mining LLCA,
- The Kiruna Urban LLCA,
- The Mountain Birch Forest/ Fjällbjörkskogen LLCA, and
- The Coniferous Forest/ Barrskogen LLCA.

Of these, it was found that dark skies are key landscape character elements for the Mountain Birch Forest/ Fjällbjörkskogen LLCA and Coniferous Forest/ Barrskogen LLCA and these two LLCAs were deemed to be highly valued.

The Ädnamvaara Trail passes the northern and western perimeter of the site. It is a popular access route into the Mountain Birch Forest/ Fjällbjörkskogen LLCA and beyond, even in winter. This side of the site is largely vegetated, apart from the old waste rock dumps. There is no artificial lighting here, apart from the red lights on top of the wind turbines.

The Viscaria site is visually prominent from many locations, but at night it is a dark space lit only weakly by the light spill from LKAB and red aircraft warning lights atop the wind turbines. The space it occupies is a valued 'gap' through which the Kiruna residents and visitors can access – physically or emotionally – the wilderness on their doorstep (Figures 4.1 to 4.3). In winter and at night, the dark skies and lack of lighting over Viscaria enhance this perceptual corridor to the wilderness and enables views of the night sky and aurora borealis.

4.2 Existing artificial lighting

Night-time views west from Kiruna are dominated by the lighting of LKAB's operations with obvious sky glow, glare, reflection and light spill (Figures 2.2, 4.1, 4.4 and 4.5). There is also the added effect of lighting reflecting from emissions plumes, which adds an element of distracting movement.

The town itself emits some light pollution, but most night-time views are from the city towards the west – predominantly LKAB and Viscaria. The north of Kiruna is generally not densely lit from urban lighting; the main lighting impact in winter derives from illumination of the ski-slopes on the flanks of Luossavaara. The combination of the bright, unmitigated lighting, reflection from the underlying snow, light spill, glare and the high elevation of the slopes has a major impact on light pollution during the winter evening hours (Figure 4.5). Together, LKAB and Kiruna create an obvious sky glow effect when viewed from the E10 to the north and south of the town.

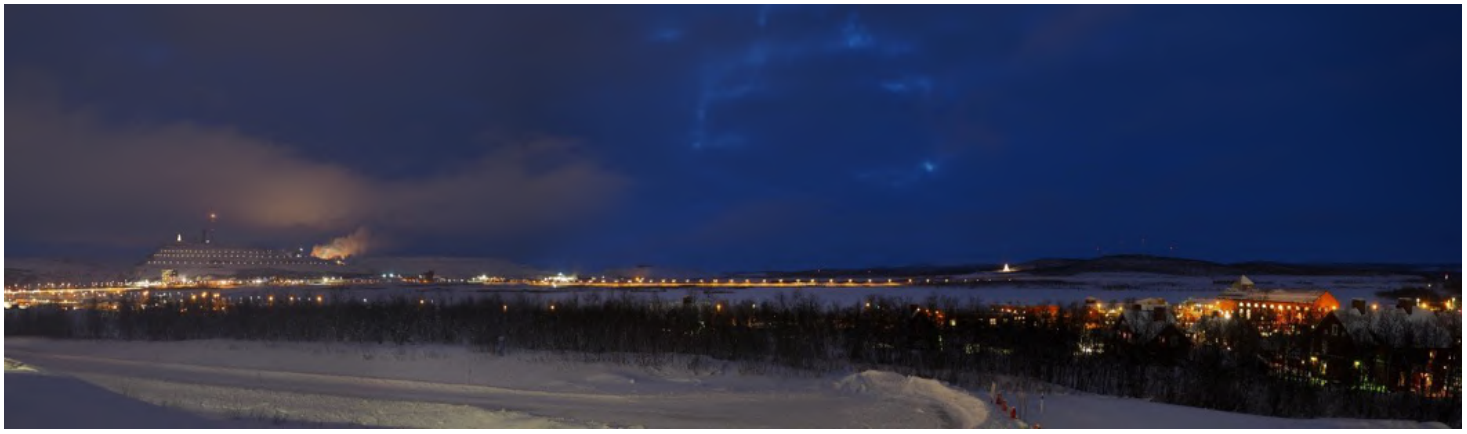

FIGURE 4.1 A panorama of the well-lit LKAB Kiruna mine site (left) to the dark Viscaria site (right – identifiable from the lone, lit-up Christmas tree) from Maria Taavenikus Gata.

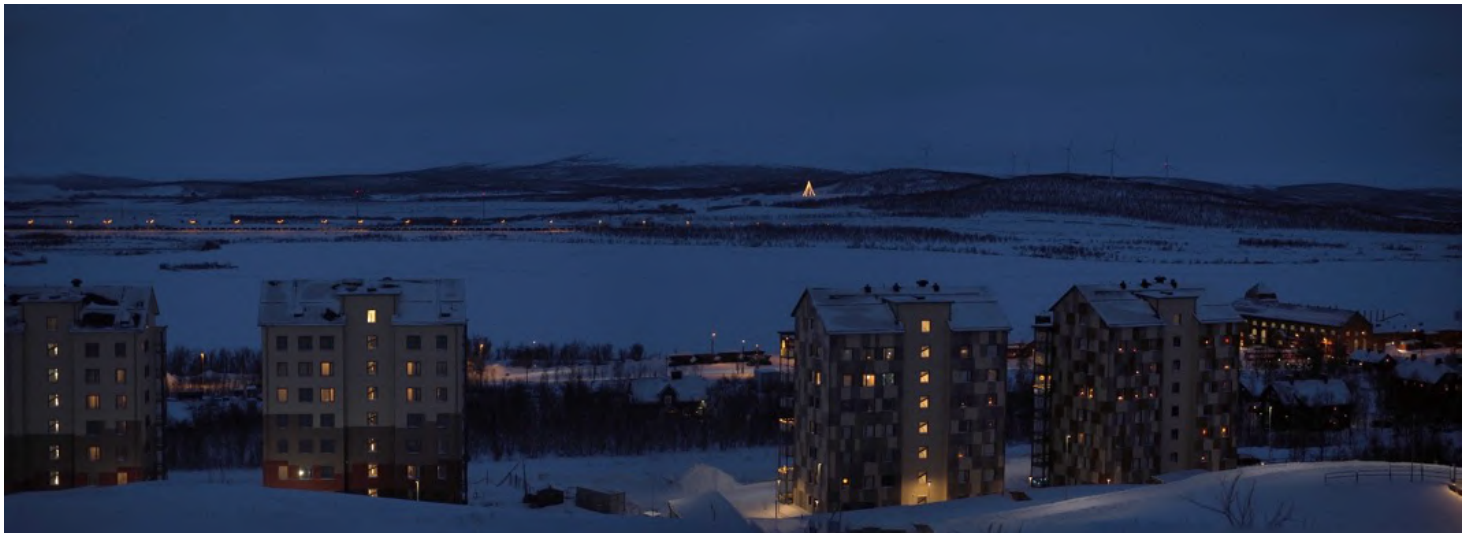

FIGURE 4.2 Night-time view towards Viscaria over Maria Taavenikus Gata from Luossavaara car-park.

FIGURE 4.3 View towards Viscaria site from Máttaráhkká Northern Light Lodge at dusk. Lights to the left are of the northern part of Kiruna. Note the darkness above Viscaria.

FIGURE 4.4 Panorama of Kiruna town and LKAB from Luossavaara car-park. Note the relative difference in lighting pollution between the two.

FIGURE 4.5 View east from Maria Taavenikus Gata towards the Luossavaara ski-slopes and illuminated bridge over the E10.

5. PREDICTED LIGHTING EFFECTS AND MITIGATIONS

5.1 Introduction

The prime reason for using artificial lighting in an industrial setting like the proposed Viscaria mine is for the safety of workers and visitors while working on-site, or travelling around and to and from it. No lighting, therefore, is not an option and artificial lighting, no matter how well designed, will cause some negative effects on the surrounding environment. However, there are many ways to mitigate the undesirable effects of artificial lighting to create an appropriately lit site that is safe while respecting human and other sensitive receptors in the surrounding areas.

The project description above briefly describes the current, high-level plan lighting plan for the project. Its predicted lighting effects and potential mitigations are discussed below.

5.2 Potential lighting effects

The foreseeable potentially significant lighting effects related to the development of a mining operation such as that planned at Viscaria are:

- **Light spill** – outside the boundaries of the site, or area that is being lit within the site, thus increasing illumination of an area and thus its visibility from a distance.
- **Glare** – caused by direct views of various light sources.
- Direct upward light – from light sources, including façade lighting
- **Moving and flashing lights** – from machinery and vehicles, which will draw attention of the viewer. It is also known to have a detrimental effect on reindeer behaviour. Flashing lights on vehicles moving increases visibility to human and animal receptors.
- **Emissions plumes** – smoke, gases and water vapour emitted from point sources, such as flues, chimney stacks and, if underground workings are present, ventilation shafts. In the cold Arctic air, their elevation and their movement exacerbate their visibility from a distance and can affect views. The visibility of

plumes increases in cold weather. Plumes reflect artificial light, which also illuminates the plumes and their movement at a high level increases night-time visibility to receptors. Plumes will be produced primarily during the operational phase.

- **Sky glow** – a combination of direct upward light and reflected light scattered in the atmosphere that illuminates the night sky above an area. It is also partly caused by atmospheric conditions, such as humidity, presence of aerosols, atmospheric pollution, etc. Mining activities are likely to increase sky glow by both increasing the light at source, but also increasing particles in the atmosphere above the site, which will increase the scattering of the light and therefore increase the sky glow. Reflected is exacerbated by snow cover.
- **Lighting in patterns or straight line**s – such forms are unnatural and increase visibility to the viewer. Typically these occur along roads and railways, but LKAB has such lighting on the side of Kiirunavaara (Figure 2.2) and along its railway (Figure 4.1).
- **Light colour/ wavelength** – the colour or wavelengths of artificial light vary with the type of lighting used. The resulting ecological effects on insects, bats and other animals can be complicated and also vary with the type of lighting[3]. It is recommended that a detail assessment of this issue is carried out in relation to the prospective lighting options for the project, given the ecological sensitivities of – particularly the western side of – the Viscaria site.

Each effect will not be considered alone by the viewer, but will form an ensemble of effects that interact to create an overall effect. Such effects will vary in severity according to the stage in the mine lifecycle, but also with the varying duration of time during day- and night-time and between winter and summer.

[3] Briolat, E.S., Gaston, K.J., Bennie, J., Rosenfeld, E.J. and Troscianko, J. (2021). Artificial night-time lighting impacts visual ecology links between flowers, pollinators and predators. Nature Communications; and Voigt, C.C. et al, (2018). Guidelines for consideration of bats in lighting projects. EUROBAST Publication Series No. 8. UNEP/ EUROBATS [this reference also deals with the effects of lighting on insects to a degree]

5.3 Effect mitigations

Many of the potential effects caused by artificial lighting result from interactions between two or more individual effects. It follows, therefore, that mitigations to address one effect can have more than one beneficial outcome. Many of the potential effects can be mitigated by developing an appropriate lighting strategy that takes a best practice approach to good lighting design and the selection of suitable lighting equipment. Key mitigations include:

- **Receptors.** Given the sensitivities around the site, consider the effects of light pollution on ecological, reindeer and cultural receptors, as well as human receptors.
- **Avoidance**. Avoid using artificial lighting unless it is absolutely necessary. If fixed lighting is necessary, if possible, avoid parts of the site that increase visibility of the artificial lighting from dark areas beyond the perimeter. Wasted light is wasted energy and a waste of money!
- **Oversizing**. Avoid oversizing lighting systems.
- **Locations**. Locate key infrastructure requiring permanent lighting towards the centre or east of the Viscaria site and behind the Peuravaara hill to reduce light pollution on the more sensitive western side, namely the Coniferous Forest LLCA (and Natura 2000 site).
- **Best practice guidance.** Follow the best practice guidance on the maximum values of light technical parameters for the control of light pollution.
- **Management system.** Consider an active lighting management system. Implement timed lighting and lighting curfews in which unnecessary lighting is switched-off and other lighting is dimmed when not needed and between certain hours of darkness.
- **Shielding.** Avoid glare by following the basic principle of shielding light sources as much as a possible (including vehicular lights). Also, choose lights sources/ luminaires, that minimise glare and then test these in the field environment and review before installation.

- **Lighting support structures.** Road lighting takes up a large visual space in the road space, but in daylight the lighting structures do not serve any purpose, so the design of the structures and their installation should aim to be as visually minimal as possible in daylight. At night, it is really only the points of light that such structures support that are visible.[4] This is particularly important in sensitive landscape areas.
- **Contrast.** In rural areas amidst dark surroundings, road lighting should be relatively dim to avoid dazzling and minimise contrasts between the illuminated road and the unlit surroundings.
- **Reflections.** Avoid/ minimise light scattering not just from the light source, but also from reflections off surrounding surfaces (e.g. from road surfaces, windows, water bodies or snow). This could include considering the colours and surface coverings of buildings and road surfaces.
- **Automatic light switches.** Automatic lighting switches in buildings and use blinds at night on windows.
- **Screening bunds.** Construct screening bunds along transport/ traffic/ haul routes, in sensitive areas (to be modelled) to hide glare from vehicle lights. Locations of screening bunds and mounds would also reduce noise and can be temporary in nature, for example, during construction and closure activities.
- **Vegetation screens.** Use existing vegetation, or plant trees and shrubs, to reduce light scatter and consider vegetation height in the selection of light post height.
- **Low-level illumination.** Where appropriate, consider using low or ground level illumination, for example along footpaths or in car-parks, with less glare and light scatter, than overhead lighting systems.
- **Luminaire selection.** Select luminaires that are energy efficient, minimise light scatter and produce a light wavelength that minimises disruption to wildlife and insect behaviour.

[4] *Vägbelysningshandboken*. Chapter 4. Trafikverket.

- **Lines and patterns.** Avoid designs that produce unnatural straight lines or geometric patterns of lights in natural areas or, if necessary, consider solutions to reduce the effect by screening (for example).
- **Colours/ wavelengths.** Choose light colours/ wavelengths that minimise effects on insects, bats, reindeer and other wildlife. This will require research and interaction with the EIA's biodiversity specialists.
- **Emissions plumes.** The effects of illuminated emissions plumes will be much reduced if the on-site lighting carries out relevant mitigations from those described above. However, plumes will also reflect and scatter light from other – non-project – sources, so may still be visible.

Some different options for mitigating light pollution are presented in ILP Guidance Note 01/21 and CIE 150:2017 and are presented in Figures 5.1 to 5.3. These diagrams are backed up by detailed technical explanations in the documents themselves and readers are referred to this guidance for more details and further mitigation examples.

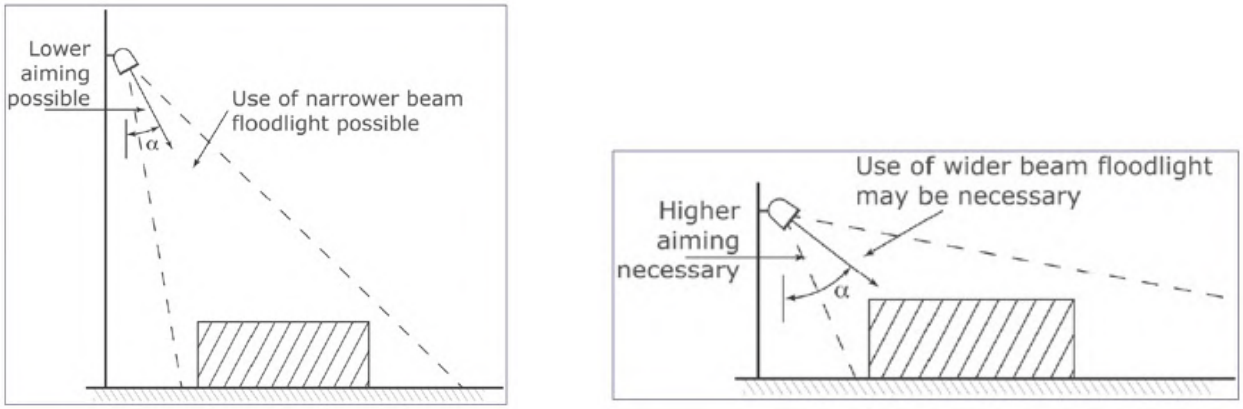

FIGURE 5.1 Left: ☺ Higher mounting height – less spill light and glare. Right: ☹ lower mounting height – more spill light and glare.

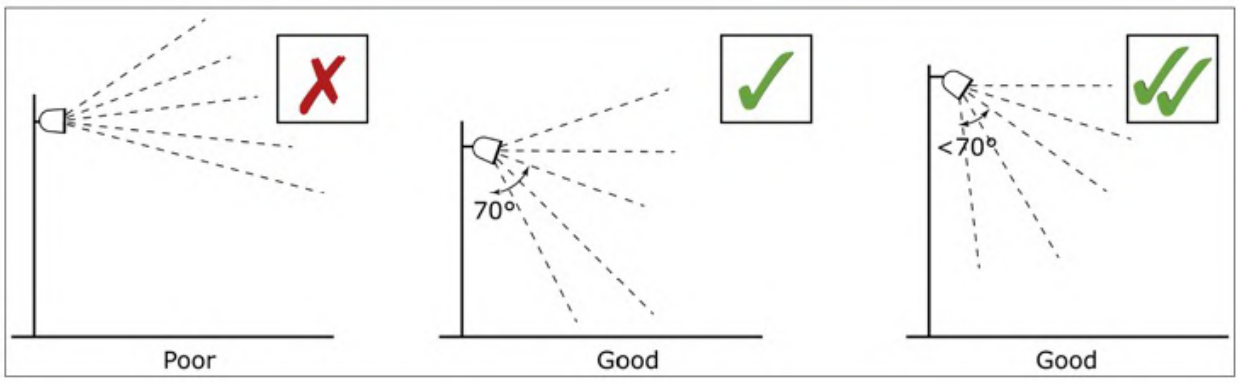

FIGURE 5.2 Luminaire lighting angles.

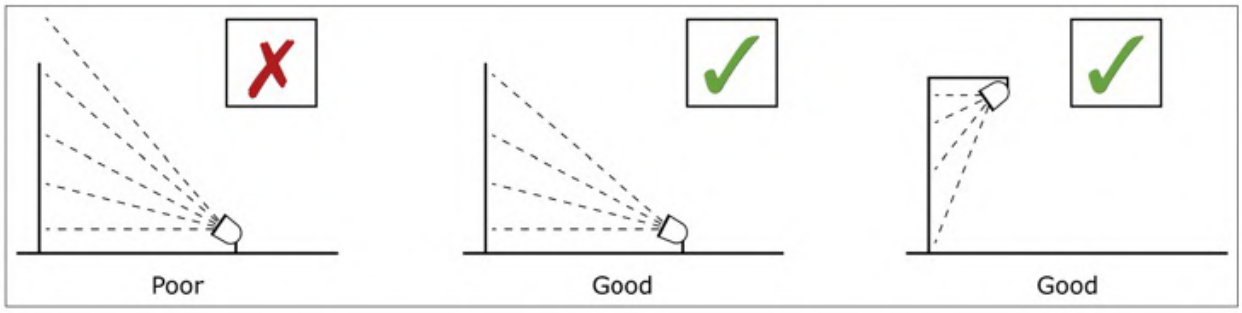

FIGURE 5.3 Façade illumination.

6. ASSESSMENT OF EFFECTS

Please refer to the full LVIA report for detailed explanations and descriptions of how the significance of project effects is determined. In summary, in order to determine effect significance on a landscape or visual receptor, the sensitivity of the receptor and the magnitude of the effect need to be combined.

This section presents a preliminary, qualitative assessment of the predicted lighting effects of the Viscaria development on previously identified landscape and visual receptors.

6.1 Receptor sensitivity

As described in the LVIA, the sensitivity of a landscape receptor is derived from a consideration of its landscape value and its susceptibility to change. The sensitivity of a visual receptor is a subjective determination based on the relationship between the value of the views and the susceptibility of the visual receptors to the proposed change.

6.1.1 Landscape receptor sensitivity

The four local landscape character areas (LLCAs) and their sensitivities are listed below (detailed descriptions are provided in the LVIA report):

- Kiruna Mining LLCA – low sensitivity
- Kiruna Urban LLCA – low sensitivity
- Mountain Birch Forest/ Fjällbjörkskogen LLCA – medium sensitivity
- Coniferous Forest/ Barrskogen LLCA – medium sensitivity

6.1.2 Visual receptor sensitivity

The main visual receptors are located in Figure 3.2 and their sensitivities are listed below (full descriptions are provided in the LVIA report):

- Ädnamvaara Cottage – high sensitivity
- Ädnamvaara Trail – high sensitivity
- Ädnamvaara Trail car-park – low sensitivity
- E10 north of Kiruna – medium sensitivity
- Máttaráhkká Northern Lights Lodge – medium sensitivity
- Maria Taavenikkus Gata (new residential area) – high sensitivity
- Loussavaara car-park – high sensitivity
- Loussavaara summit – high sensitivity
- Dübengatan – medium sensitivity
- Nordkalottvägen – medium sensitivity
- Kiruna railway station – low sensitivity
- Porfyrvägen – medium sensitivity
- Rallarvägen car-park – medium sensitivity
- Scandic Ferrum hotel – medium sensitivity
- Gruvstadsparken – low sensitivity
- Högalidskolan – low sensitivity
- Triangelskolan – negligible/ low sensitivity

A preliminary analysis was conducted on each visual receptor for each of the four project phases. For each phase, the predicted visual effects were considered together and an overall magnitude and significance is presented, with accompanying brief commentary.

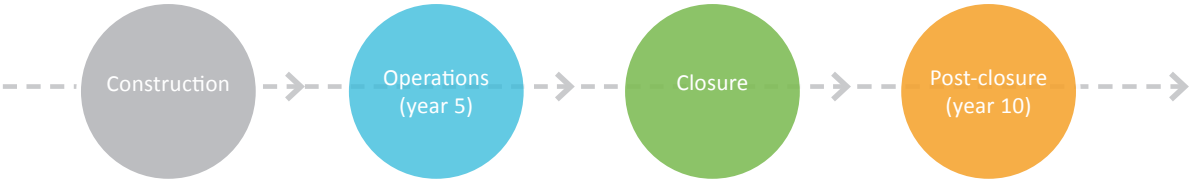

FIGURE 6.1 The four mine activity phases that the lighting effects are considered for.

6.2 Potential Viscaria project lighting effects

The significance of Viscaria's potential lighting effects for each receptor and project is tabulated below. This is a preliminary analysis and assumes that all of the suggested mitigations have been employed. Note that residual effects are considered to be significant if they are determined to be adverse and moderate/ minor or above.

6.2.1 Construction lighting effects

Most construction lighting will be temporary and supplied by mobile lighting towers. Mitigations should ensure that these use luminaires that light only the working area and are shielded to reduce glare. There will be a large element of mobile lighting related to construction equipment and vehicles. Mitigations include shielding headlamps to reduce glare and constructing bunds to shield areas where glare is unavoidable. The analysis assumes the height of construction activities and that construction will be happening 24 hours per day, seven days per week. The preliminary analysis and significance of the lighting effects on landscape and visual receptors for the construction phase are presented in Tables 5.1 and 5.2, respectively.

The main lighting effects of significance during the construction phase will be glare caused by temporary lighting stands in work areas and direct upward light, including reflected light. The large number of vehicles moving around site with their flashing safety lights and heavy equipment, will increase visibility of the site and impinge on tranquillity and distract from dark skies. Relatively early during construction, road lighting along the main access road into site will also be installed, so the lighting of this and other internal roads will present linear patterns of light, which will also impinge on the sense of remoteness from some perspectives and draw the eye from viewpoints.

TABLE 5.1 Preliminary residual lighting effects on landscape receptors during the construction phase (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above)

Landscape Receptor Value & Sensitivity	Lighting Effects	Construction	
		Effect Magnitude	Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Light spill**	Small	Minor
	Glare	Large	Moderate/ Adverse
	Direct upward light	Medium	Moderate/ Minor/ Adverse
	Moving and flashing lights	Large	Moderate/ Adverse
	Emissions plumes	None	None
	Sky glow	Medium	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Small	Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	
Kiruna Urban LLCA Value: medium Sensitivity: low	**Light spill**	None	None
	Glare	Small	Minor/ Adverse
	Direct upward light	Small	Minor/ Adverse
	Moving and flashing lights	Small	Minor/ Adverse
	Emissions plumes	None	None
	Sky glow	Small	Minor/ Adverse
	Lighting in patterns or straight lines	Small	Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	

Landscape Receptor Value & Sensitivity	Lighting Effects	Construction	
		Effect Magnitude	Significance
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Light spill**	Small	Moderate/ Minor/ Adverse
	Glare	Medium	Moderate/ Adverse
	Direct upward light	Medium	Moderate/ Adverse
	Moving and flashing lights	Medium	Moderate/ Adverse
	Emissions plumes	None	None
	Sky glow	Small	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Small	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Light spill**	None	None
	Glare	Small	Moderate/ Minor/ Adverse
	Direct upward light	Small	Moderate/ Minor/ Adverse
	Moving and flashing lights	Small	Moderate/ Minor/ Adverse
	Emissions plumes	None	None
	Sky glow	Small	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Small	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	

TABLE 5.2 Preliminary residual lighting effects on visual receptors during the construction phase (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above).

ID	Viewpoint Name (Sensitivity)	Constructions		Comments
		Overall Magnitude	Significance	
1	**Ädnamvaara cottage** (High sensitivity)	Medium	Major/ Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights
2	**Ädnamvaara Trail** (High sensitivity)	Medium	Major/ Moderate/ Adverse	
3	**Ädnamvaara car-parkl** (Low sensitivity)	Small	Minor/ Adverse	N/A
4	**E10 north of Kiruna** (Medium sensitivity)	Small	Moderate/ Minor/ Adverse	Main effects: glare, direct upward light, moving & flashing lights
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Small	Moderate/ Minor/ Adverse	
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Medium	Major/ Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, lighting in patterns & straight lines
7	**Loussavaara carpark** (High sensitivity)	Medium	Major/ Moderate/ Adverse	
8	**Loussavaara summit** (High sensitivity)	Medium	Major/ Moderate/ Adverse	
9	**Dübengatan** (Medium sensitivity)	Medium	Moderate/ Adverse	
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Moderate/ Adverse	
11	**Kiruna railway station** (Low sensitivity)	Small	Minor/ Adverse	N/A
12	**Porfyrvägen** (Medium sensitivity)	Medium	Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, lighting in patterns & straight lines
13	**Rallarvägen carpark** (Medium sensitivity)	Medium	Moderate/ Adverse	
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium	Moderate/ Adverse	
15	**Gruvstadsparken** (Low sensitivity)	Small	Minor/ Adverse	N/A
16	**Högalidskolan** (Low sensitivity)	Small	Minor/ Adverse	N/A
17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Negligible	N/A
	Triangelskolan (Predicted: low sensitivity)	Not applicable at this stage		

6.2.2 Operations (Year 5) Lighting Effects

The analysis assumes operations at year 5, which is the estimated period of maximum on-site disturbance, prior to the start of the main rehabilitation and restoration works. Fixed lighting installations will predominate, with some mobile lighting associated with vehicle movements. Emissions plumes will exacerbate light scatter and intrusion. Mitigations will include preparation of a lighting plan that complies with the good international industry practice mentioned above, including the least detrimental light colour/ wavelength options; mounting heights that reduce vertical illuminance and light spill. Light sources should be concealed to reduce glare and direct upward light that could cause sky glow. The lighting plan should be regularly reviewed, while effects on the ground should be monitored and should include consultation with stakeholders. The plan should be adapted accordingly.

The preliminary analysis and significance of the lighting effects on landscape and visual receptors for the operations in year five are presented in Tables 5.3 and 5.4, respectively.

The fifth year of operations are predicted to be the period of maximum lighting effects. This phase will include all of the key effects described in particular, plus sky glow and emissions plumes, which will be highly visible for large parts of the year from most of Kiruna and the surrounding area.

TABLE 5.3 Preliminary residual lighting effects on landscape receptors during operations (year 5) (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above)

Landscape Receptor Value & Sensitivity	Lighting Effects	Operations (Year 5)	
		Effect Magnitude	Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Light spill**	Small	Minor/ Adverse
	Glare	Large	Moderate/ Adverse
	Direct upward light	Small	Minor/ Adverse
	Moving and flashing lights	Large	Moderate/ Adverse
	Emissions plumes	Medium	Moderate/ Minor/ Adverse
	Sky glow	Medium	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Medium	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	
Kiruna Urban LLCA Value: medium Sensitivity: low	**Light spill**	Negligible	Negligible
	Glare	Small	Minor/ Adverse
	Direct upward light	Medium	Moderate/ Minor/ Adverse
	Moving and flashing lights	Small	Minor/ Adverse
	Emissions plumes	Large	Moderate/ Adverse
	Sky glow	Medium	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Small	Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	

Landscape Receptor Value & Sensitivity	Lighting Effects	Operations (Year 5)	
		Effect Magnitude	Significance
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Light spill**	Medium	Moderate/ Adverse
	Glare	Large	Major/ Moderate
	Direct upward light	Large	Major/ Moderate
	Moving and flashing lights	Medium	Moderate/ Adverse
	Emissions plumes	Large	Major/ Moderate
	Sky glow	Medium	Moderate/ Adverse
	Lighting in patterns or straight lines	Small	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Light spill**	None	None
	Glare	Small	Moderate/ Minor/ Adverse
	Direct upward light	Small	Moderate/ Minor/ Adverse
	Moving and flashing lights	Small	Moderate/ Minor/ Adverse
	Emissions plumes	Medium	Moderate/ Adverse
	Sky glow	Medium	Moderate/ Adverse
	Lighting in patterns or straight lines	Small	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	

TABLE 5.4 Preliminary residual lighting effects on visual receptors during operations (year 5) (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above). Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been greyed out with a darker grey.

ID	Viewpoint Name (Sensitivity)	Operations (Year 5)		Comments
		Overall Magnitude	Significance	
1	**Ädnamvaara cottage** (High sensitivity)	Large	Major/ Adverse	Main effects: light spill, glare, direct upward light, moving & flashing lights, emissions plumes, sky glow
2	**Ädnamvaara Trail** (High sensitivity)	Large	Major/ Adverse	
3	**Ädnamvaara car-parkl** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, emissions plumes, sky glow
4	**E10 north of Kiruna** (Medium sensitivity)	Medium	Moderate/ Adverse	Main effects: direct upward light, emissions plumes, sky glow
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Moderate/ Adverse	Main effects: glare, moving & flashing lights, direct upward light, emissions plumes, sky glow
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Major/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, emissions plumes, sky glow, lighting in patterns & straight lines
7	**Loussavaara carpark** (High sensitivity)	Large	Major/ Adverse	
8	**Loussavaara summit** (High sensitivity)	Large	Major/ Adverse	
9	**Dübengatan** (Medium sensitivity)	Large	Major/ Moderate/ Adverse	
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Moderate/ Adverse	
11	**Kiruna railway station** (Low sensitivity)	Small	Minor/ Adverse	N/A
12	**Porfyrvägen** (Medium sensitivity)	Large	Major/ Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, emissions plumes, sky glow, lighting in patterns & straight lines
13	**Rallarvägen carpark** (Medium sensitivity)	Medium	Moderate/ Adverse	
14	**Scandic Ferrum hotel** (Medium sensitivity)	Medium		
15	**Gruvstadsparken** (Low sensitivity)	Small		
16	**Högalidskolan** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, emissions plumes, sky glow, lighting in patterns & straight lines
17	**Triangelskolan** (Now: negligible sensitivity)	Negligible	Negligible	N/A
	Triangelskolan (Predicted: low sensitivity)	Not applicable at this stage		

6.2.3 Mine Closure Lighting Effects

The preliminary analysis below assumes maximum closure activity. Emissions plumes will end during this phase and the amount of fixed lighting will decrease, but vehicular and equipment lighting will increase, exacerbating visibility through movement. This will be temporary, for the period of mine closure activities, but mitigations should be designed/ applied wherever feasible. The preliminary analysis and significance of the lighting effects on landscape and visual receptors during mine closure are presented in Tables 5.5 and 5.6, respectively.

During the maximum period of mine closure activity, there will be lighting around and in buildings that remain to be demolished and in carparks and along roads that are still to be removed. This will combine with temporary lighting in relation to work areas for demolition, etc. and a large number of moving and flashing lights associated with vehicles and equipment preparing the final, geomorphic landforms. Overall these effects will be noticeable for a relatively short period, before diminishing quickly towards the end of the closure phase.

TABLE 5.5 Preliminary residual lighting effects on landscape receptors during mine closure (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above)

Landscape Receptor Value & Sensitivity	Lighting Effects	Mine Closure	
		Effect Magnitude	Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Light spill**	Small	Minor/ Adverse
	Glare	Medium	Moderate/ Minor/ Adverse
	Direct upward light	Small	Minor/ Adverse
	Moving and flashing lights	Large	Moderate/ Adverse
	Emissions plumes	None	None
	Sky glow	Medium	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Medium	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	
Kiruna Urban LLCA Value: medium Sensitivity: low	**Light spill**	None	None
	Glare	Small	Minor/ Adverse
	Direct upward light	Small	Minor/ Adverse
	Moving and flashing lights	Medium	Moderate/ Minor/ Adverse
	Emissions plumes	None	None
	Sky glow	Negligible	Negligible
	Lighting in patterns or straight lines	Small	Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	

Landscape Receptor Value & Sensitivity	Lighting Effects	Mine Closure	
		Effect Magnitude	Significance
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Light spill**	Medium	Moderate/ Adverse
	Glare	Negligible	Negligible
	Direct upward light	Small	Moderate/ Minor/ Adverse
	Moving and flashing lights	Medium	Moderate/ Adverse
	Emissions plumes	None	None
	Sky glow	Small	Moderate/ Minor/ Adverse
	Lighting in patterns or straight lines	Small	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Light spill**	None	None
	Glare	Small	Moderate/ Minor/ Adverse
	Direct upward light	Negligible	Negligible
	Moving and flashing lights	Small	Moderate/ Minor/ Adverse
	Emissions plumes	None	None
	Sky glow	Negligible	Negligible
	Lighting in patterns or straight lines	Small	Moderate/ Minor/ Adverse
	Light colour/ wavelength	Requires analysis by specialist	

TABLE 5.4 Preliminary residual lighting effects on visual receptors during mine closure (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above). Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been greyed out with a darker grey.

ID	Viewpoint Name (Sensitivity)	Mine Closure		Comments
		Overall Magnitude	Significance	
1	**Ädnamvaara cottage** (High sensitivity)	Large	Major/ Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights
2	**Ädnamvaara Trail** (High sensitivity)	Large	Major/ Moderate/ Adverse	
3	**Ädnamvaara car-parkl** (Low sensitivity)	Medium	Moderate/ Minor/ Adverse	
4	**E10 north of Kiruna** (Medium sensitivity)	Medium	Moderate/ Minor/ Adverse	
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Medium	Moderate/ Adverse	
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Large	Major/ Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, lighting in patterns & straight lines
7	**Loussavaara carpark** (High sensitivity)	Large	Major/ Moderate/ Adverse	
8	**Loussavaara summit** (High sensitivity)	Large	Major/ Moderate/ Adverse	
9	**Dübengatan** (Medium sensitivity)	Large	Moderate/ Adverse	
10	**Nordkalottvägen** (Medium sensitivity)	Medium	Moderate/ Minor/ Adverse	
11	**Kiruna railway station** (Low sensitivity)	Small	Minor/ Adverse	N/A
12	**Porfyrvägen** (Medium sensitivity)	Large	Moderate/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, lighting in patterns & straight lines
13	**Rallarvägen carpark** (Medium sensitivity)	Medium	Moderate/ Adverse	
14	**Scandic Ferrum hotel** (Medium sensitivity)	N/A		
15	**Gruvstadsparken** (Low sensitivity)	N/A		
16	**Högalidskolan** (Low sensitivity)	Small	Minor/ Adverse	N/A
17	**Triangelskolan** (Now: negligible sensitivity)	N/A		
	Triangelskolan (Predicted: low sensitivity)	Small	Minor/ Adverse	Main effects: glare, direct upward light, moving & flashing lights, lighting in patterns & straight lines

6.2.4 Post-Closure (Year 10) Lighting Effects

Ten years after mine closure, fixed lighting should be non-existent, if all buildings and roadway lighting are removed. There will be a requirement for post-closure monitoring and aftercare for several years, which may require a minimal amount of fixed lighting during site visits with attendant vehicular lighting at times. The preliminary analysis and significance of the lighting effects on landscape and visual receptors at ten years post-closure are presented in Tables 5.7 and 5.8, respectively.

Ten years post-closure, the impacts of project lighting effects will be minimal and, most of the time there will be none, assuming all of the operational and closure phase lighting has been removed from site.

TABLE 5.5 Preliminary residual lighting effects on landscape receptors during mine closure (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above)

Landscape Receptor Value & Sensitivity	Lighting Effects	Post Closure (Year 10)	
		Effect Magnitude	Significance
Kiruna Mining LLCA Value: medium Sensitivity: Low	**Light spill**	None	None
	Glare	Negligible	Negligible
	Direct upward light	None	None
	Moving and flashing lights	Negligible	Negligible
	Emissions plumes	None	None
	Sky glow	None	None
	Lighting in patterns or straight lines	None	None
	Light colour/ wavelength	None	None
Kiruna Urban LLCA Value: medium Sensitivity: low	**Light spill**	None	None
	Glare	Negligible	Negligible
	Direct upward light	None	None
	Moving and flashing lights	Negligible	Negligible
	Emissions plumes	None	None
	Sky glow	None	None
	Lighting in patterns or straight lines	None	None
	Light colour/ wavelength	None	None
Mountain Birch Forest/ Fjällbjörkskogen LLCA Value: high Sensitivity: medium	**Light spill**	None	None
	Glare	Negligible	Negligible
	Direct upward light	None	None
	Moving and flashing lights	Negligible	Negligible
	Emissions plumes	None	None
	Sky glow	None	None
	Lighting in patterns or straight lines	None	None
	Light colour/ wavelength	None	None

Landscape Receptor Value & Sensitivity	Lighting Effects	Post Closure (Year 10)	
		Effect Magnitude	Significance
Coniferous Forest/ Barrskogen LLCA Value: high Sensitivity: medium	**Light spill**	None	None
	Glare	Negligible	Negligible
	Direct upward light	None	None
	Moving and flashing lights	Negligible	Negligible
	Emissions plumes	None	None
	Sky glow	None	None
	Lighting in patterns or straight lines	None	None
	Light colour/ wavelength	None	None

TABLE 5.4 Preliminary residual lighting effects on visual receptors during mine closure (effects are considered to be significant if they are determined to be adverse and moderate/ minor or above). Viewpoints predicted to no longer exist by 2029/30 due to encroaching LKAB subsidence have been greyed out with a darker grey.

ID	Viewpoint Name (Sensitivity)	Post Closure (Year 10)		Comments
		Overall Magnitude	Significance	
1	**Ädnamvaara cottage** (High sensitivity)	Negligible	Minor/ Negligible/ Adverse	Main effects: glare, moving & flashing lights, but only very occasionally in relation to post-closure site monitoring and aftercare. Even this negligible effect diminishes with increasing distance from the and site lower elevations.
2	**Ädnamvaara Trail** (High sensitivity)	Negligible	Minor/ Negligible/ Adverse	
3	**Ädnamvaara car-parkl** (Low sensitivity)	Negligible	Negligible	
4	**E10 north of Kiruna** (Medium sensitivity)	Negligible	Negligible	
5	**Máttaráhkká Northern Lights Lodge** (Medium sensitivity)	Negligible	Negligible	
6	**Maria Taavenikkus Gata** (new residential area) (High sensitivity)	Negligible	Minor/ Negligible/ Adverse	
7	**Loussavaara carpark** (High sensitivity)	Negligible	Minor/ Negligible/ Adverse	
8	**Loussavaara summit** (High sensitivity)	Negligible	Minor/ Negligible/ Adverse	
9	**Dübengatan** (Medium sensitivity)	Negligible	Negligible	
10	**Nordkalottvägen** (Medium sensitivity)	Negligible	Negligible	
11	**Kiruna railway station** (Low sensitivity)	Negligible	Negligible	
12	**Porfyrvägen** (Medium sensitivity)	Negligible	Negligible	
13	**Rallarvägen carpark** (Medium sensitivity)	Negligible	Negligible	
14	**Scandic Ferrum hotel** (Medium sensitivity)	N/A		
15	**Gruvstadsparken** (Low sensitivity)	N/A		
16	**Högalidskolan** (Low sensitivity)	None	None	Too distant from site to be affected by the effects outlined above.
17	**Triangelskolan** (Now: negligible sensitivity)	N/A		
	Triangelskolan (Predicted: low sensitivity)	None	None	Too distant from site to be affected by the effects outlined above.

7. CUMULATIVE LIGHTING EFFECTS

Cumulative effects are the additional changes caused by a proposed development in conjunction with other similar developments, or as the combined effect of a set of developments, taken together. In most cases the focus of a cumulative effects assessment is on the additional effect of the project in conjunction with other developments of a similar type; however, in Kiruna, there are substantial industrial and development projects underway, or planned, in which the lighting effects they cause will be of interest from the perspective of landscape or visual receptors. This section briefly discusses the potential likely cumulative lighting effects of the Viscaria project. Only those effects considered to be likely and significant are described. Some potential cumulative effects include:

- **Easy visual access to dark skies.** Views of the aurora borealis and dark Arctic night skies from the Kiruna area are promoted to the tourism industry, both nationally and internationally. Dark skies are already being eroded by urban and industrial development and the winter lighting of the Luossavaara ski slopes. The sky over Viscaria constitutes a large, dark patch between the light-affected skies over LKAB, Kiruna and the floodlit Luossavaara ski-slope. Cumulatively, the Viscaria development risks diminishing the dark sky resource for residents and visitors to Kiruna by light pollution emanating from this site in combination with light pollution from neighbouring LKAB.
- **Glare.** Substantial glare is emanating from LKAB is visible from viewpoints in Kiruna. LKAB sits adjacent to the currently dark Viscaria site. As the Viscaria mine develops, increasing on-site lighting will increase glare and interact with the existing glare from LKAB to create a close, extended horizon of pinpoints of stationary and moving lights to the west of Kiruna. Similarly, when viewed from Ädnamvaara and its environs, glare from Kiruna and LKAB will interact with glare from Viscaria, making the city and LKAB feel closer, or conversely, making Ädnamvaara feel less remote or wild.

- **Interacting emissions plumes.** The emissions plumes emanating from LKAB are already highly visible on cold nights and reflect light that emanates – primarily – from LKAB's activities. Their movement also increases visibility. Similar plumes emanating from neighbouring operations at Viscaria would combine to produce a much larger, combined effect over the Viscaria area too, which currently presents dark skies. This will dominate views from Kiruna on cold nights.
- **Sky glow.** Increased light pollution emanating from the Viscaria site will interact with light emissions from Kiruna town and LKAB and, in winter, the intensely-lit ski slopes of Luossavaara, to increase the general sky glow over the area. This will increase sky glow visibility from outside the Kiruna/ LKAB area, including from the valued Mountain Birch Forest/ Fjällbjörkskogen and Coniferous Forest/ Barrskogen LLCAs and diminish visual access to dark skies form Kiruna and its immediate vicinity.
- **Linear lighting patterns.** The railway to LKAB around Luossajärvi is lit in a linear fashion, which forms a highly noticeable pattern. The proposed road lighting along the Viscaria access road and on-site roads will interact visually with the existing linear lighting to produce a broader, more noticeable cumulative effect.
- **'Corridor of darkness'.** In winter nights, as one leaves north Kiruna along the E10, the brightly-lit city and Luossavaara ski slopes are highly visible; but to an extent this is balanced by the dark Viscaria site to the west. Similarly, when driving south on the E10 towards Kiruna, the eastern side of the road is relatively dark because of the undeveloped Viscaria site, which also shields much of the direct light pollution from LKAB. This will change as Viscaria develops, with lights then filling this dark void and cumulatively impacting on the night-time visual experience as one leaves or approaches Kiruna.
- **Light colour/ wavelength ecological effects on wild animals.** The ecological effects of artificial light may be important in the Viscaria context. How lighting on the site will interact ecologically with existing lighting conditions is not currently known, but should be examined by a specialist in this field in relation to the Viscaria site, given its proximity to highly valued ecological systems.

8. CONCLUSIONS

The Viscaria site occupies a transition zone between intense landscape degradation and highly valued wilderness. It also offers a valued, perceptual and physical 'window' or 'corridor' between Kiruna's population centre and the extensive, surrounding wilderness that forms a cornerstone of the local sense of identity. Dark skies, easily visible from Kiruna and that continue into the dark wilderness beyond, are an important aspect of the sense of place for may local people. As well as their cultural importance, there is a growing economic value associated with easy visitor access to views of the aurora borealis and its associated wilderness.

Artificial lighting is an important factor in ensuring security and safety on mine sites and in society; however, this should not be always at the expense of human health and the cultural and ecological values associated with dark skies. Currently, a detailed lighting plan for Viscaria is not available, so a preliminary light impact assessment was conducted.

The predicted light pollution effects were identified as: light spill, glare, direct upward light, moving and flashing lights, emissions plumes, sky glow, lighting in patterns or straight lines and – as yet undetermined – ecological effects of light colour/ wavelength. This preliminary analysis shows that even if best practice mitigations are employed to reduce or avoid light pollution, there will still be significant adverse project effects on the night-time environment.

Mobile lighting and movement will predominate in the construction and closure phases, with the operational phase having the most significant adverse effects overall. The landscape receptor that will be most affected will be the

Mountain Birch Forest/ Fjällbjörkskogen LLCA, because artificial lighting will diminish the perception of its 'wilderness' values of remoteness and tranquillity. Visually, significant lighting effects will adversely impact Kiruna residents with good views to the west and those closest to the site and with elevation and for which Viscaria currently offers a dark sky juxtaposition to the visually predominant LKAB.

Cumulative effects will be particularly important, given the proximity of other significant sources of light pollution, in particular LKAB, and in the winter months, the Luossavaara ski slopes. Kiruna city also emanates light, but in less impactfully. The main cumulative effects identified were:

- Easy visual access to dark skies,
- Glare,
- Interacting emissions plumes,
- Sky glow,
- Linear lighting patterns,
- 'Corridor of darkness' along the E10 to and from north Kiruna, and
- Light colour/ wavelength ecological effects on wild animals.

As this study was only at a preliminary level, it is recommended that a more detailed lighting assessment is carried out by a lighting specialist, once a more detailed lighting plan is available. Also, several references to best practice are highlighted in this report. It is recommended that this – and similar – guidance is used by Copperstone to prepare a lighting management system for the Viscaria project that sets a best practice benchmark for mining projects in northern Sweden.

REFERENCES

Maps

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COPPERSTONE