Document Front Sheet

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LOWER CHURCHILL PROJECT

NE-LCP Contractor/Supplier

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Lower Churchill Project

ENGINEERING REPORT
North Spur Stabilization Works – Construction Report

SLI Document No. 505573-3281-4GER-0009-PA

Nalcor Reference No. MFA-SN-CD-2800-GT-RP-0009-01 Rev. A1

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1 INTRODUCTION

The North Spur is a deposit of marine and estuarine sediments which naturally provides a partial closure of the Churchill River valley at the Muskrat Falls site. The North Spur closes the left side of the reservoir in the area of the project.

This natural dam is about 1 kilometer long between the rock knoll in the south and the kettle lakes in the north, which represent natural boundaries of the North Spur in terms of both, seepage and stability.

From a construction management point of view, the stabilization works package was broken into different Work Breakdown Structures (WBS) as follows:

- Clearing;
- Upstream Cut Off Wall;
- Upstream Embankments;
- Downstream Embankments;
- Northwest Cut Off Wall;
- Kettle Lakes;
- Instrumentation;
- Hydroseeding;
- Permanent Access Road.

Design of the works was performed by SNC Lavalin Inc. and the Construction Management by the Lower Churchill Project Delivery Team (LCP Delivery Team).

Construction of the stabilization works was performed by Gilbert Newfoundland and Labrador Contracting (GNLC) under the contract “CH0008-0001, North Spur Stabilization Works” with the subcontractors JP Deschènes, Inquip Associates Inc., Solmatech Inc. and Gazon Savard Saguenay Inc. (Clearing, Cut-off walls, Instrumentation and Hydroseeding works respectively).

Quality Control (QC) was performed by the Contractor while Quality Assurance (QA) was performed by the LCP Delivery Team. Laboratory services were provided by Nalcor.

The stabilization works were performed mainly between April 2015 and November 2016. Final restoration works and repairs and hydroseeding were completed in 2017.

The main objective of this report is to present the progression of the works, and to gather the technical information related to the stabilization works and the foundations which could influence the behaviour of the structure during and after the first and final impoundments.

Certain specific construction methods used during the works are also presented in this report.

2 NORTH SPUR STABILIZATION WORKS DESCRIPTION

2.1 DESIGN

The design of the stabilization works of the North Spur followed state-of-the-art methods and complied with appropriate standards and guidelines. The guidelines published by the Canadian Dam Association (CDA) were used as a basis for the design and constituted the primary framework. In the context of the Lower Churchill Project, the North Spur was treated as a dam as far as design criteria are concerned.

The final design called for complete control of the groundwater in the North Spur; erosion control in both sides, upstream and downstream of the spur and local unloading of the crest of the spur.

The design of the stabilization works is presented in the document entitled "North Spur Stabilization Works – Design Report, MFA-SN-CD-2800-GT-RP-0004-01, dated March 2016.

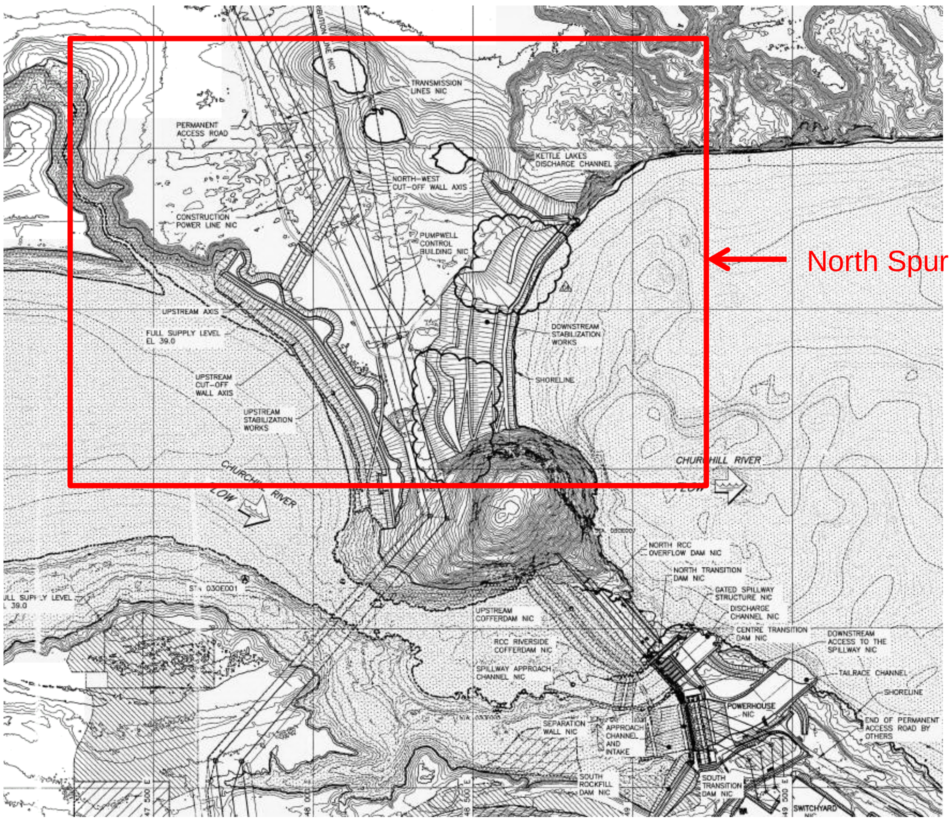
The reference water levels used for design of the structure are as follows:

- Maximum Diversion Head Pond Level = 25 m
- Full Supply Level (FSL) = 39 m;
- Low Supply Level (LSL) = 38.5 m;
- Probable Maximum Flood (PMF) (Upstream) – without Gull Island project = 45.1 m;
- Probable Maximum Flood (PMF) (Upstream) – with Gull Island project = 44.3 m;
- Normal Maximum Water Level Downstream = 3.9 m.

2.2 NORTH SPUR WORKS CHARACTERISTICS

The location of the North Spur relative to the Muskrat Falls Hydroelectric Project is presented in Figure 2-1.

Figure 2-1 – North Spur Location



The main characteristics of the North Spur and the stabilization works are presented in Table 2-1

Table 2-1 : North Spur – Main Characteristics

Crest elevation	60.0 m
Upstream crest elevation	43.0 m
Downstream lowest crest elevation	8.5 m
Length of the upstream crest	960 m
Length of the downstream crest	720 m
Upstream slopes	2.0; 2.5; 3.0; 3.5 and 4.5H:1V
Downstream slopes	2.0; 2.5; 3.0; 4.0 and 7.0H:1V
Excavations total volume	1 167 510 m^3
Embankments total volume	1 272 560 m^3

2.2.1 UPSTREAM WORKS

The works on the upstream side of the North Spur have the dual purpose of creating an impervious barrier against infiltration from the reservoir and stabilizing the natural slopes to prevent landslides.

The impervious barrier consists of two different components. The lower part includes a cement-bentonite cut-off wall (Upstream Cut-Off Wall) excavated through the pervious silty sandy foundation (stratified drift) from elevation 20.5 m and anchored at least 2.0 m into the lower clay layer unit.

The upper part of the impervious barrier is comprised of an inclined till blanket. The upper limit of the till blanket is at least 3 m higher than the FSL, thus preventing reservoir water overtopping the impervious blanket. The till blanket is placed against the excavated/graded overburden foundation.

The base of the till blanket (zone 1) is connected to the top of the cut-off wall by means of a trench excavated to elevation 18.0 m. The upper contact between the cut-off wall and the till blanket is constructed of zone 1C to assure full bonding between these materials.

The till blanket is protected on the external (upstream) side with successive layers of granular and rock materials, including a granular transition (zone 2C) at the contact with the till, a rockfill transition (zone 3C) and finally an external rockfill shell (zone 3D).

For the loading case identified as “during construction and to the final impoundment of the reservoir” (temporary condition), a factor of safety of 1.1 against uplift was considered assuming a piezometric level of 36 m behind the till blanket. The total weight of the fill materials counteracts the potential uplift pressures beneath the till blanket created by water trapped behind (downstream) the till blanket during construction, and before the reservoir is filled to FSL.

The toe of the rockfill embankment, in contact with the foundation, is reinforced by means of a small berm, 1.8 m wide x 1.8 m high at elevation 20.0 m, constructed with rockfill (zone 3D above water level and zone 3E below water level) to prevent erosion of the embankment during the construction period.

Riprap protects the rockfill embankment against wave action and ice. In the lower part of the slope, the riprap protection (zone 4 class 2 material) extends from elevation 23 to 27 m, to cater for the period when the river water level will be raised to elevation 24 (free water) to 25 m (winter) to form a temporary headpond during diversion. During permanent operation at FSL (el. 39.0 m), the upstream slope is protected against waves and ice with a riprap layer (zone 4 class 1 material) from elevation 35.8 m to the crest of the embankment at elevation 43.0 m. A rockfill layer (zone 3C) is placed above elevation 43.0 m up to elevation 47.0 m to complete the protection of the upstream slope in the event of the PMF.

The crest of the embankment is 7.5 m wide at elevation 43.0 m. This crest serves as a permanent access road and the surface layer is constituted of crushed stone (maintenance grade No 3 material).

The stabilization works at the north part of the upstream side, beyond the upstream cut-off wall are the same as described above except that no prevision is made for seepage infiltration from the reservoir. The till blanket is replaced by granular fill material (zone 2G), a product of the overburden excavations.

A permanent access road was constructed on the upstream slope to link the top of the North Spur at elevation 60 m with the access road at elevation 43.0 m.

Upstream typical cross-sections are presented in Figure 2-2 and Figure 2-3.

Figure 2-2 : Upstream Typical Cross Section – Cut

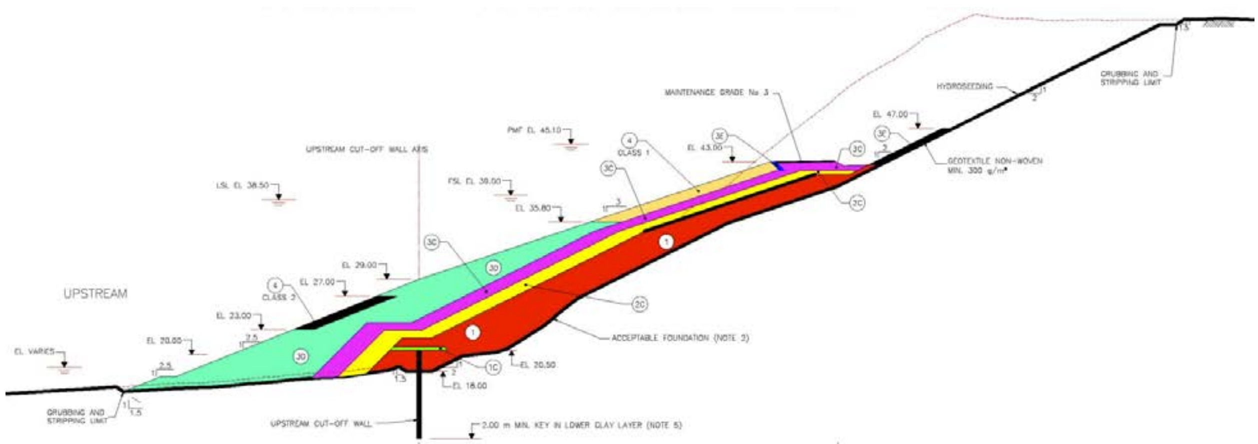
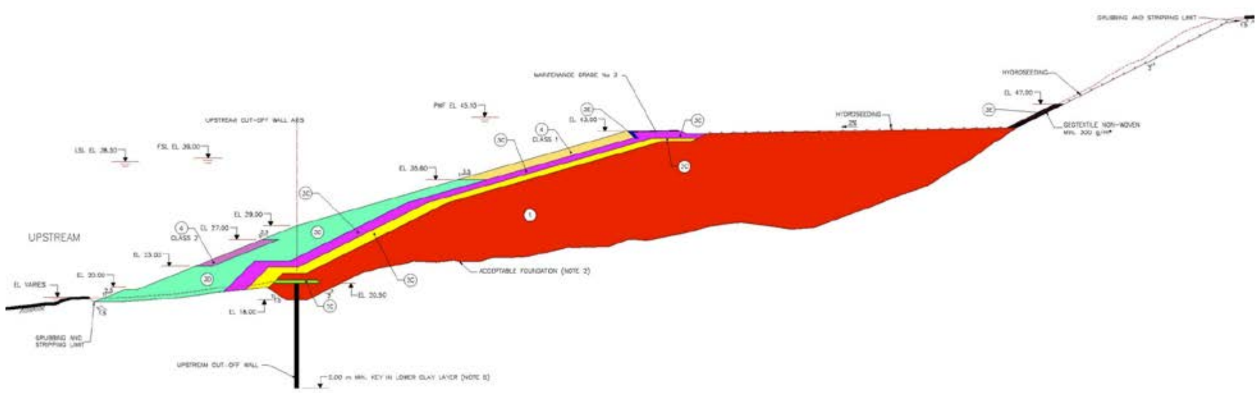


Figure 2-3 : Upstream Typical Cross Section – Fill



2.2.2 NORTHWEST CUT-OFF WALL

The main objective of the northwest (NW) cut-off wall is to diminish ground water seepage from the Northwest side of the North Spur in order to prevent unfavourable effects on the stability of the downstream slopes.

The NW cut-off wall was excavated from a temporary granular platform at elevation 50.5 m, located at the bottom of a 10 m deep trench excavated in the overburden from the natural ground surface at an average elevation of 60 m. The excavation slopes are 2H:1V and the width of the bottom of the trench is 20 m to accommodate the construction equipment during the works.

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Nalcor
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The NW cut-off wall was excavated from elevation 50.0 m and anchored at least 2.0 m in the lower clay layer. The extreme westerly portion of the NW cut-off wall was excavated from a temporary platform at elevation 28.5.

2.2.3 DOWNSTREAM WORKS

The main objective of the downstream stabilization works is to improve internal and surface drainage in order to control and minimize the piezometric levels and thus increase the factors of safety of the slopes against sliding.

The stabilization works between elevation 8.5 m and 1.0 m above water level consist of a layer of riprap (zone 4 class 3) placed over successive layers of rockfill transition (zone 3C), drain materials (zone 3A) and granular filter (zone 2A). Below this elevation, the embankment is constructed of dumped materials of zones 3E and 2E. The toe of the embankment, in contact with the foundation, is reinforced by means of a berm 1.3 m wide. The external slope of the embankment is 3H:1V below elevation 8.5 m. A zone 3E berm of 6.0 m width was built up to 0.50 m above the water level at the time of construction works. This berm acts as a protection of the embankment toe against scour.

Two main areas (south and north) have been considered for the stabilization works above elevation 8.5 m. In the south, from the rock knoll, at station 0+000 to 0+420, the stabilization works from elevation 8.5 m to elevation 35.0 m consist of a layer of granular filter (zone 2A) overlain by a layer of drain material (zone 3A) and 2 layers of rockfill (zones 3C and 3D) to prevent surface erosion. The filter material was placed either on graded in-situ overburden or on graded backfill built with semi-pervious clean sand (zone 2F) obtained from the required excavations.

Between elevations 8.5 and 35.0 m, the thickness of the filter material (zone 2A) is 900 mm and the thickness of the drain and rockfill layers are 450, 450 and 900 mm respectively. Between elevations 35.0 and 40.0 m, a 3E rockfill, 600 mm wide, was placed against the graded slope.

In order to avoid migration of fine particles of the foundation, a geotextile was placed between the graded slope (acceptable foundation) and all rockfill materials.

An internal drainage system, below the existing downstream slopes was designed to collect and evacuate seepage occurring in the bottom of the main gullies previously formed by the landslides and filled with unstructured, remoulded soils. The internal drainage system on the downstream slope was designed with deep finger drains located mainly in the center of the natural depressions formed following the old landslides. These finger drains consist of selected crushed stone drain material (zone 3A) wrapped in a granular filter (zone 2A), all embedded in a semi-pervious sand (zone 2F) (Details of finger drains are shown in drawings MFA-SN-CD-2800-CV-SE-0002-01 to 03. Seepage water is evacuated through the riprap placed along the river shore.

The slope of the embankment is 7H:1V between elevations 8.5 m and 25.0 m and from elevation 25.0 m to elevation 35.0 m, the slope of the embankment varies from 2.5H:1V to 7H:1V to take advantage of the actual topography and minimize the volume of excavation and backfill works. Above elevation 35.0 m, the natural ground was regraded at 2H:1V and protected with placed rockfill (zone 3E) placed over a geotextile up to elevation 40.0 m.

Berms are located at nominal elevations 8.5 m, 14 m and 25 m. The lowest berm at elevation 8.5 m serves as permanent access road along the river shore. The berm at elevation 14 m serves as an access road to piezometers installed from that level to ensure their protection in the event of the PMF. The berm at elevation 25 m gives access for inspection. A permanent access road was constructed on the downstream slope to link the top of the North Spur at elevation 60 m to the shore line road at elevation 8.5 m.

For the north part of the downstream shore, from stations 0+420 to 0+740, the stabilization works consist of grading the natural ground, above elevation 8.5 m, to a slope of 2.0 to 2.5H:1V and protecting it with a layer of placed rockfill (zone 3E) over a geotextile up to elevation 14.0 m, thus ensuring the protection of the overburden slope in the event of the PMF. At the toe of the 2.0 to 2.5H:1V slope, a ditch along the longitudinal berm (or road) at elevation 8.5 m will collect and evacuate seepage exiting from the slope.

Downstream typical cross-sections are presented in Figure 2-4, Figure 2-5 and Figure 2-6.

Figure 2-4 : Downstream Typical Cross-Section – Cut Above Elevation 25 m

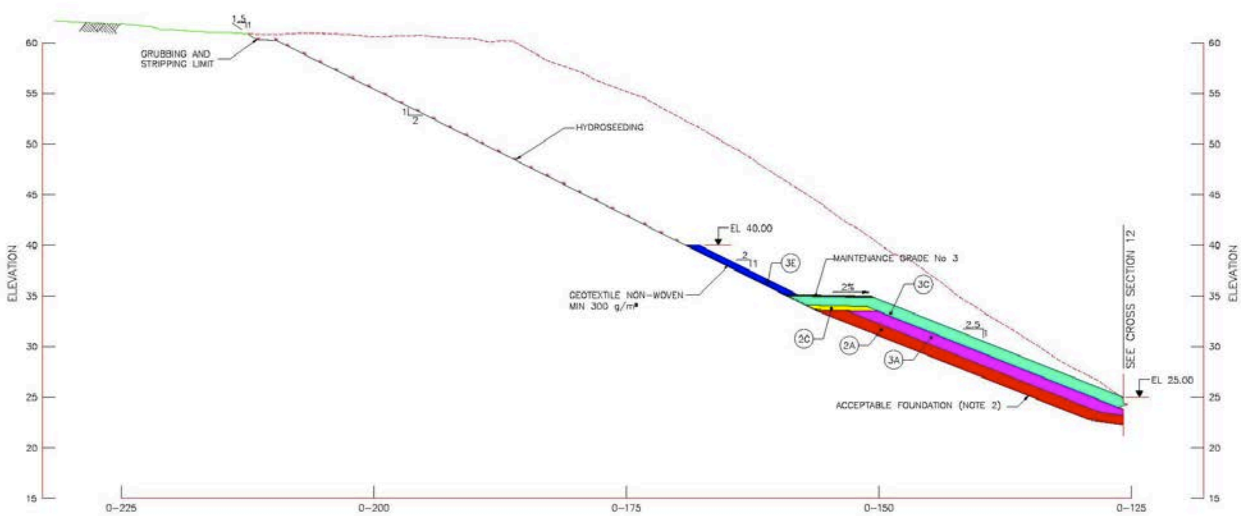


Figure 2-5 : Downstream Typical Cross-Section – Fill Above Elevation 25 m

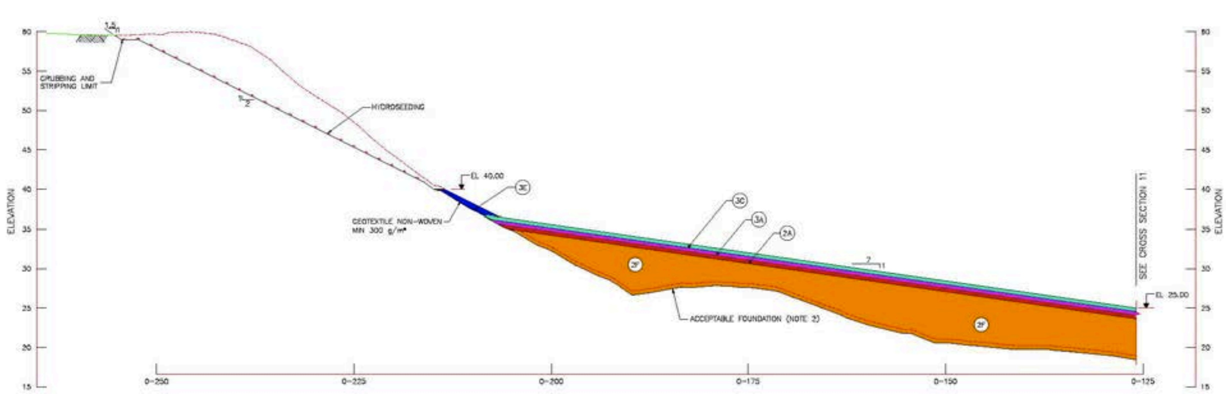
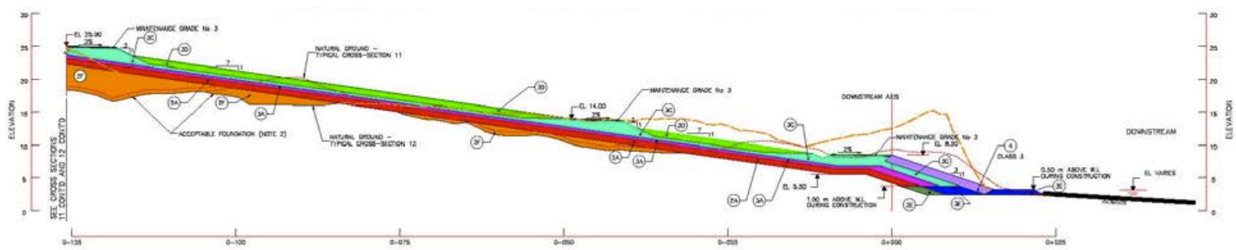


Figure 2-6 : Downstream Typical Cross-Section – Cut and Fill Below Elevation 25 m



2.2.4 KETTLE LAKES AREA WORKS

The purpose of the construction works in this area is to stabilize the natural slopes and to facilitate the flow of water in the kettle lakes outlet channel.

The slopes of the valley, from the outlet of the lower kettle lake down to the river bank, were regraded and stabilized with an embankment constructed at the bottom of the valley, from the river shore. The embankment was constructed over a geotextile placed against the acceptable foundation after grubbing and stripping operations. The thickness and particle size of the erosion protection on the slopes of the channel was defined with consideration for the longitudinal slopes of the discharge channel and the anticipated flow. The lateral slopes of the discharge channel were regraded at 2H:1V. A stilling basin was built at the exit of the channel to prevent erosion of the materials.

2.2.5 NORTH SPUR FOUNDATIONS

All embankments were constructed over overburden or bedrock foundations.

Prior to the excavation to reach the acceptable foundation levels, grubbing and stripping, which consisted of the removal of organic matter and contaminated materials, were required.

2.2.6 PERMANENT ACCESS ROAD

Permanent access to the North Spur is gained by a road from the Trans-Labrador Highway to the crest of the Spur and from there to the upstream and downstream areas of the Spur.

The road was constructed with a running surface of Maintenance Grade No. 3 material.

2.2.7 INSTRUMENTATION

Instrumentation of the North Spur includes:

- Standpipe and vibrating wire piezometers;
- Inclinometers;
- Flowmeter.

All piezometers permit remote parameter monitoring by transducers and cables which are connected to the main data acquisition system located in the Pumpwell Control Building on the crest of the North Spur. The data acquisition system is remotely accessed from the Nalcor server via the existing optical fiber converter.

Inclinometers and flowmeter require manual reading.

2.2.8 HYDROSEEDING

Hydroseeding works are designed to prevent erosion of the upper sand and silty sand layer on the upstream and downstream slopes, and in the kettle lakes exit channel above the limit of the embankment fill.

2.3 SCOPE OF WORK

The work related to the construction of the stabilization measures of the North Spur included:

- Construction and removal of all temporary construction roads to borrow pits, quarries and spoil disposal areas;

- Construction and removal on completion of the Company and Contractor's laydown area, including construction facilities for the Contractor and office and related facilities for the Company;
- Relocation and maintenance of the existing portage trail, installation of signage and communications and operation of escort procedures for portage users;
- Clearing, grubbing and stripping of borrow areas, quarries and their access roads. Clearing of the spoil disposal area;
- Clearing, grubbing and stripping inside the footprint of all excavations and embankments;
- Development and exploitation of borrow areas and quarries including processing, and transportation of materials and restoration of the sites at the end of the works;
- Supply, installation, operation and removal of all required dewatering systems during the construction period;
- Construction, operation and maintenance of all surface water control systems;
- Installation and maintenance of environmental protection measures to prevent sediment discharge into the Churchill River on the upstream and downstream sides of the North Spur or into any other watercourse located inside the work area, during excavation and embankment works;
- Excavation and zoned earth and rock fill embankment construction works;
- Overburden foundation preparation;
- Bedrock foundation preparation;
- Construction of the upstream and north-west cement bentonite (CB) cut-off walls;
- Supply and installation of geotextiles;
- Construction and upgrading of the permanent access road from the Trans-Labrador Highway to the southern limit of the North Spur (elevations 43 on the upstream slope and 40 on the downstream slope) and construction of the permanent access roads to the upstream and downstream sides of the North Spur (below elevations 43 and 40 respectively);
- Installation of drainage culverts;

- Construction of the log boom debris removal platforms and associated access roads;
- Application of hydroseeding;
- Installation, maintenance and operation during the construction works of the geotechnical instrumentation;
- Site restoration at completion of the works.

3 MODIFICATIONS TO TECHNICAL REQUIREMENTS

3.1 ENGINEERING CHANGE NOTICE (ECN)

The elevation and thickness of the embankment in cross-sections 9, 10, 11 and 12 in the downstream area was adjusted (ECN-CH0008001-0001).

The final slope of the downstream cross-section 13 was modified and the upper part of the finger drains was removed (ECN-CH0008001-0002).

The frequency and type of embankment quality tests were updated (ECN-CH0008001-0003).

The permanent road design parameters were adjusted and upstream road cross-section was updated (ECN-CH0008001-0004).

Drainage in the Northwest cut-off wall trench was added (ECN-CH0008001-0005).

The location and type of instruments was changed (ECN-CH0008001-0006).

The gradation of Zone 4 material on the downstream area was modified (ECN-CH0008001-0007).

3.2 CONCESSION REQUEST (CON)

Some concession requests were presented by the Contractor during the construction works and approved by Engineering.

Some of them related to relaxation of the gradation requirement for different embankment materials.

The fines content of zone 1C was changed from 25-60% to 22.5-60% (CON-CH0008001-0007), zone 2F was changed from 0-5% to 0-10% (CON-CH0008001-

0011) and maintenance grade No. 3 was changed from 6-10% to 5-10% (CON-CH0008001-0019).

The gradation requirements were adjusted for the zone 2A for the sieve sizes 1.25 mm, 0.315 mm and 0.08 mm (CON-CH0008001-0014).

The gradation requirements were adjusted for the zone 2C for the sieve sizes 1.25 mm and 0.315 mm (CON-CH0008001-0015).

The use of 270 g/m^2 geotextile in lieu of 300 g/m^2 was accepted (CON-CH0008001-0005 and 0020).

Splicing of the instrument cables was accepted (CON-CH0008001-0016).

Compaction of embankment materials in the trench and shelter instruments was adjusted to fit with available compactors (CON-CH0008001-0018).

The liquid fertilizer and application rate were modified (CON-CH0008001-0017).

Some concession requests dealt with changes in the mix and tests of the cut-off wall slurry.

The mix design was accepted based on permeability tests conducted at 28 days (CON-CH0008001-0002). The compressive strength at 7 days was modified (CON-CH0008001-0006). Adjustments to the cement bentonite cut-off wall technical specifications are captured in CON-CH0008001-0010, including change in the type of cement, accepted type was a mix of slag cement (90%) and Portland GU cement (10%).

4 ADVANCEMENT OF THE WORKS

The majority of the works was completed in 2015 and 2016.

2015

Clearing, partial upstream and downstream excavation and upstream and downstream embankment, the construction of the upstream cut-off wall and a section of the northwest cut-off wall were performed in 2015.

2016

In 2016, excavation in both areas (upstream and downstream) was completed. Almost all embankment works were also completed in this period and the construction of the northwest cut-off wall and the instrumentation installation were completed in 2016. Construction of the permanent access road and hydroseeding works started late in 2016 season and was suspended until 2017.

2017

All embankment construction, permanent access road and hydroseeding works were completed in 2017.

The main milestones for the different construction activities are presented in Table 4-1.

Table 4-1: Work Milestones

Works	Dates		Quantities		
	Start	End	Unit	Planned	Realized
Overburden Excavation	16-Apr-2015	27-11-2016	m^3	740 000	764 961
Overburden Excavation Zones 2F/2G	16-Apr-2015	19-10-2016	m^3	335 000	402 548
Zone 1	30-Jun-2015	30-Sep-2016	m^3	255 000	290 155
Zone 1C	11-Sep-2015	16-Jul-2016	m^3	9 500	3 366
Zone 2A	03-Aug-2015	18-Oct-2016	m^3	103 000	73 725
Zone 2C	08-Jul-2015	18-Oct-2016	m^3	81 400	77 243
Zone 2E	27-08-2015	23-08-2016	m^3	6 500	3 038
Zone 2F	26-Aug-2015	19-Oct-2016	m^3	146 500	127 490
Zone 2G	18-Jul-2015	08-Oct-2016	m^3	187 000	175 957
Zone 3A	06-Sep-2015	04-Oct-2016	m^3	62 000	43 514
Zone 3C	16-06-2015	06-08-2017	m^3	212 000	184 371
Zone 3D	17-06-2015	27-09-2016	m^3	152 000	149 274
Zone 3E	09-08-2015	25-07-2017	m^3	44 000	46 185
Zone 4	27-08-015	16-05-2017	m^3	59 450	50 181
Upstream Cut-Off Wall	02-Aug-1015	07-Oct-2015	m^2	8 100	5 914
Northwest Cut-Off Wall	06-Oct-2015	23-Oct-2015	m^2	19 000	22 633
	11-Jun-2016	12-Sep-2016			

5 FOUNDATIONS

All embankment materials were placed on acceptable foundation in the upstream and downstream areas, comprised of stratified drift and partially on the lower clay layer in the downstream area and on bedrock in the southern area of the North Spur.

5.1 DEWATERING AND WATER MANAGEMENT

Dewatering and water management were considered critical during the construction works. A complex hydrogeological regime is present in the North Spur. All dewatering and water management were planned in conjunction with the construction operations (clearing, grubbing and stripping, excavations, embankment construction, etc.).

The objective of the dewatering and water management operations was to permit the execution of all works related to excavation, foundation preparation, embankment and other construction operation in dry conditions and to ensure the stability of excavated slopes and prevent erosion of materials during the work period.

Dewatering and water management works consisted mainly of the construction of temporary ditches and installation of pumps at low points or in places upstream of the ongoing activity in order to control the water entering the work area.

In areas prone to erosion, especially in the sandy materials in the upper part of the spur, temporary excavations before reaching the final excavation limits were performed in order to facilitate the drawdown of the existing ground water tables.

5.2 FOUNDATION TREATMENT

After clearing, grubbing and stripping operations, the overburden not complying with the criteria for acceptable foundation was excavated. No compaction of the foundations was performed after excavation and grubbing operations due to the inclination of the foundation.

The excavation limits shown on the drawings were adjusted on site based on the conditions encountered after clearing, grubbing and stripping and during excavation works. Final foundation limits are shown in drawing MFA-SN-CD-2800-CV-PL-0009-02.

All foundations had to be accepted before placement of any embankment material. The foundation approvals are included in the Construction Record Books (MFA-GB-SD-2800-CV-R02-0002-01, MFA-GB-SD-2800-CV-R02-0004-01 and MFA-GB-SD-2800-CV-R02-0006-01).

Excavation procedures were planned to take account of conditions that could potentially affect stability, such as spring thaw of the ground, water table fluctuations and the sensitive nature of some of the soils.

No bedrock excavations were performed.

Foundation preparation on bedrock comprised rock foundation scaling and cleaning with water and air jets of the rock surface Footprint of the bedrock foundation is shown in drawing MFA-SN-CD-2800-CV-PL-0014-01. The type and extent of the foundation treatment were defined by the Engineer on site (site queries SQY-CH0008001-0028 and 0029).

The main objectives of the foundation preparation of the bedrock were to ensure the watertightness of the contact with the embankment to avoid migration of till materials and to obtain a uniform profile to allow effective compaction of the embankment materials over the foundation and an acceptable stress distribution in the embankment. At the south side of the North Spur, the embankment was founded on bedrock at the abutment with the rock knoll, on both upstream and downstream areas. Bedrock preparation operations in the downstream area were less restrictive, as no till material was placed against the bedrock.

On the upstream side, rock surface treatment started with excavation of overburden down to solid rock within the footprint of the embankments. At the contact of the impervious blanket, rock treatment included:

- Cleaning of the rock surface with a light excavator equipped with a smooth lipped bucket;
- Cleaning with water/air jets of the rock surface;
- Placement of slush grout on fissured bedrock immediately prior to placement of till.

After assessment of the exposed bedrock foundation and regarding the quality of the bedrock and the general site conditions, topography, foundation treatment, hydraulic head and embankment design, it was decided that drilling and grouting of the bedrock was not required.

In the downstream area only cleaning of the bedrock surface using a backhoe with a smooth lipped bucket of 0.5 m^3 capacity was required.

Detailed foundation mapping is presented in Appendix C.

6 BORROW AREAS AND QUARRY EXPLOITATION

6.1 GENERAL

The field investigation works permitted assessment of the quality and quantities of the different construction materials destined for the stabilization works.

The designated borrow areas and rockfill sources exploited for the embankment works of the North Spur stabilization works are presented in Table 6-1

Table 6-1 : Material Sources

Material	Source	
	Designated	Exploited
Till Material	T-4B	T-4B
Filter and Granular Materials	GR-2, GR-3	GR-2
Common fill Material	Required Excavations	Required Excavations
Rock Material	Q-1, Q-6	Q-6

As the borrow sources are located on the opposite side of the Trans Labrador Highway, a crossing was necessary and was prepared in accordance with the Department of Transportation and Works requirements.

The depth of the borrow area exploitation was limited by the groundwater level. The preparation and exploitation of the borrow areas were carried out in stages. The exploited areas of the borrow pits and quarry were first surveyed and then approved by LCP. Clearing, grubbing and stripping operations were performed prior to pit excavation operations.

The location of the borrow areas and quarry are presented in drawing MFA-SN-CD-2800-CV-PL-0013-01.

6.2 TILL DEPOSIT

The Zone 1 and 1C materials (till) used for the construction of the impermeable blanket were obtained from the designated deposit T-4B, located at about 7 km from the site.

Screening operations of the till were performed in order to comply with the gradation requirements of the embankment materials. Moisture content in the pit was monitored during the exploitation.

For drainage of wet areas of the till deposit, deep trenches were excavated in the southern part of the pit, during the exploitation of the borrow pit.

6.3 GRANULAR DEPOSIT

Granular materials (Zones 2A and 2C/2E) were obtained from the designated granular deposit GR-2, located at about 11 km from the site. Selection, screening and mixing and operations were deemed necessary to obtain materials complying with the gradation requirements. The Contractor progressively moved the screening plant within the pit in order to optimize the embankment materials production.

Fine sandy materials (zone 2F/2G) were obtained from the on-site required excavations. The 2F material was stockpiled in the Contractor Laydown Area until used in the embankments.

6.4 QUARRY

All rock materials were produced in the designated quarry Q-6.

7 EMBANKMENT CONSTRUCTION

7.1 GENERAL

The embankment construction works were performed in 2015 and 2016 with the exception of the final placement of materials 3C, 3D and 4 and the materials used for the construction of the permanent access road which were finalized in 2017.

Quality control of the works was assured by the Contractor, and tests were performed by a third party laboratory (AMEC-Stantec).Tests on the embankments were performed by the laboratory as per the minimum frequency established in the technical specifications.

All quality control test results are included in the Construction Records Books MFA-GB-SD-2800-CV-R02-0002-01, MFA-GB-SD-2800-CV-R02-0004-01 and MFA-GB-SD-2800-CV-R02-0006-01. Summary tables and graphs are provided in this report in sections 7.2 to 7.5.

Hauling of rock materials to the works was done with off road trucks from the quarry. Crushing of zone 3A and rockfill type 1 materials was done in the quarry and stockpiled in the laydown area, while the other crushed materials (Granular B and Maintenance Grade 3 materials) were crushed on the crest of the spur. Selection of rip rap materials was done in the quarry and in the rip rap stockpile area on the crest of the spur.

Till material was hauled from the deposit directly to the embankments. Screening of the zone 1C material was done in the deposit.

Granular materials coming from GR-2 deposit were hauled on road trucks to the laydown area and stockpiled until hauling to the embankments, which was done with off road trucks.

Zone 2F/2G materials were excavated and placed in the embankments or hauled and stockpiled in the laydown area.

7.2 TILL MATERIAL

The zone 1 till material is a mix of clay, silt, sand, gravel and cobbles and the zone 1C till material a mix of clay, silt, sand and gravel. Fines content (particle size < 0.08 mm) for the materials are between 15 and 60% and between 22.5 and 60% respectively).

Spreading of the zone 1 material was performed with a bulldozer or excavators in 450 mm thick layers before compaction. Compaction was performed with loaded 50 ton trucks as per approved alternate compaction method.

Placement of the zone 1C material was performed with excavators in 150 mm thick layers and compacted with special compactors.

Due to the nature of the foundations and the existing ground water table over the upstream cut-off wall, the zone 1C material was placed in one layer of 450 mm thickness and compacted with the loaded 50 ton trucks.

During placement the moisture content of the materials was required to be between optimum-1% and +2.5% for zone 1 material and between the optimum moisture content and +2% for zone 1C material.. The optimum moisture content as obtained by the Standard Proctor test ASTM D698 or the Modified Proctor ASTM D1557 where appropriate.

Required compactness of the till material was at least equal to 98% of the maximum dry density as determined by the ASTM D698 Standard and at least 98% of the maximum dry density as determined by the ASTM D1557 for the till material placed over the cut-off walls.

The in-situ density was measured as per ASTM D6938 with the nucleodensimeter. Scarification with aeration or moistening operations were performed when required to adjust the moisture content before compaction.

During rainy periods, the till surface was sealed with the smooth roller and at the resumption of embankment works all unsuitable wet material was excavated before placement of the new embankment.

At the end of the 2015 season, a winter protection consisting of at least 2 m of sand material was placed over the till. The protective layer was removed in the spring 2016 before resuming the embankment construction.

Main characteristics of the embankment zone 1 and zone 1C materials are presented in Figures 7-1 to 7.6.

Figure 7-1 : Zone 1 – Summary of Grain Size Analyses

Statistical Parameters	Sieve Size (mm)																Sed.
	300	150	100	80	50	40	20	14	10	5	2.5	1.25	0.630	0.315	0.160	0.080	0.002
Number	251	200	200	251	243	250	251	243	250	251	250	251	250	251	250	251	8
Average	100	100	100	96	93	90	85	83	82	78	75	71	65	53	37	25	4
Std. deviation	0	1	2	5	6	6	6	6	6	6	6	6	5	4	4	3	1
Minimum	96	91	89	79	74	68	64	62	62	59	57	54	49	40	27	15	4
Maximum	100	100	100	100	100	100	99	97	98	92	88	84	77	65	53	44	7
Conformity	99.6	-	-	99.6	-	-	99.6	-	-	100.0	-	100.0	-	100.0	-	100.0	-
Requirement	**100**	**-**	**-**	**80-100**	**-**	**-**	**65-100**	**-**	**-**	**50-95**	**-**	**37-85**	**-**	**26-75**	**-**	**15-60**	**-**

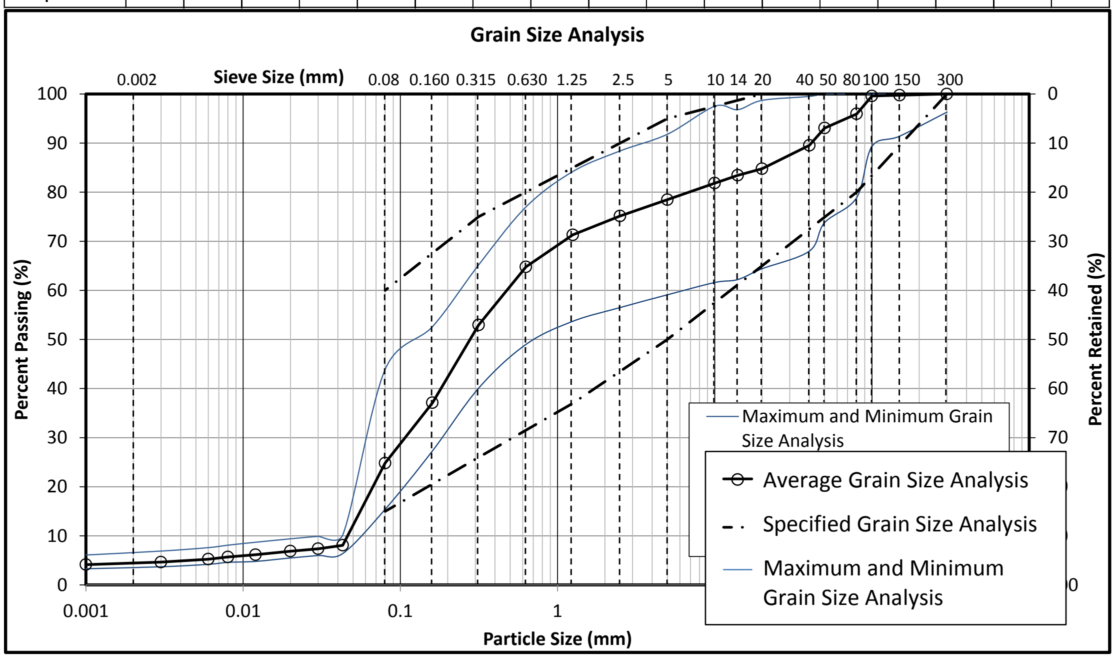


Figure 7-2 : Zone 1 –In Situ Compaction Degree

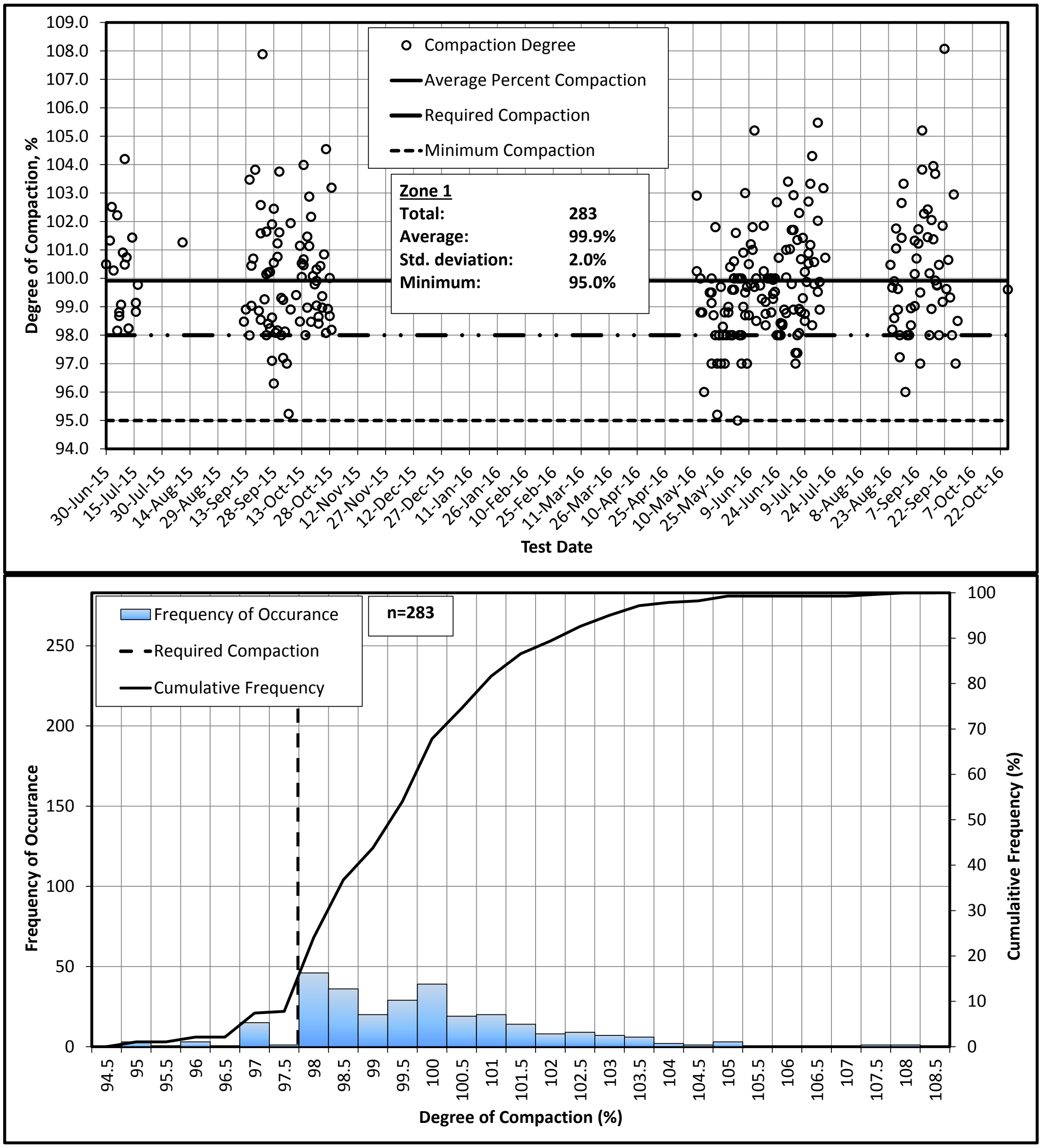


Figure 7-3 : Zone 1 –Compaction and Optimum Moisture Content

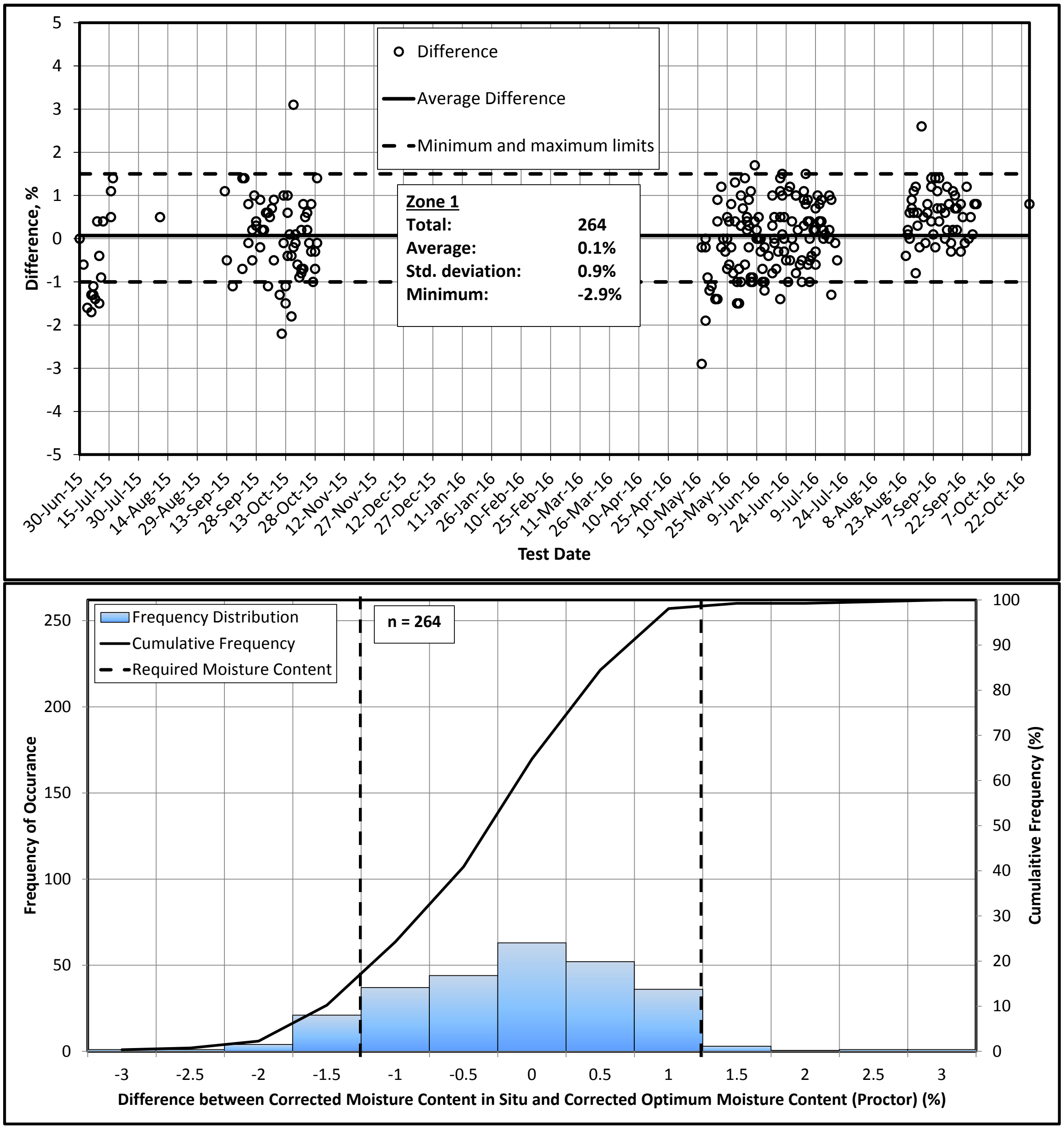


Figure 7-4 : Zone 1C – Summary of Grain Size Analyses

Statistical Parameters	Sieve Size (mm)													
	300	80	50	40	20	14	10	5	2.5	1.25	0.630	0.315	0.160	0.080
Number	31	34	34	34	34	31	34	34	34	34	34	34	34	34
Average	0	100	98	95	90	88	86	82	79	75	68	56	39	26
Std. deviation	0	1	2	3	3	3	3	4	4	3	4	3	3	2
Minimum	0	95	92	89	83	82	80	77	74	70	58	51	33	23
Maximum	0	100	100	99	96	93	93	90	87	82	76	62	45	30
Conformity	100.0	97.1	-	-	100.0	-	-	100.0	-	100.0	-	100.0	-	100.0
Requirement	**100**	**100**	**-**	**-**	**80-100**	**-**	**-**	**63-95**	**-**	**48-85**	**-**	**35-70**	**-**	**22.5-60**

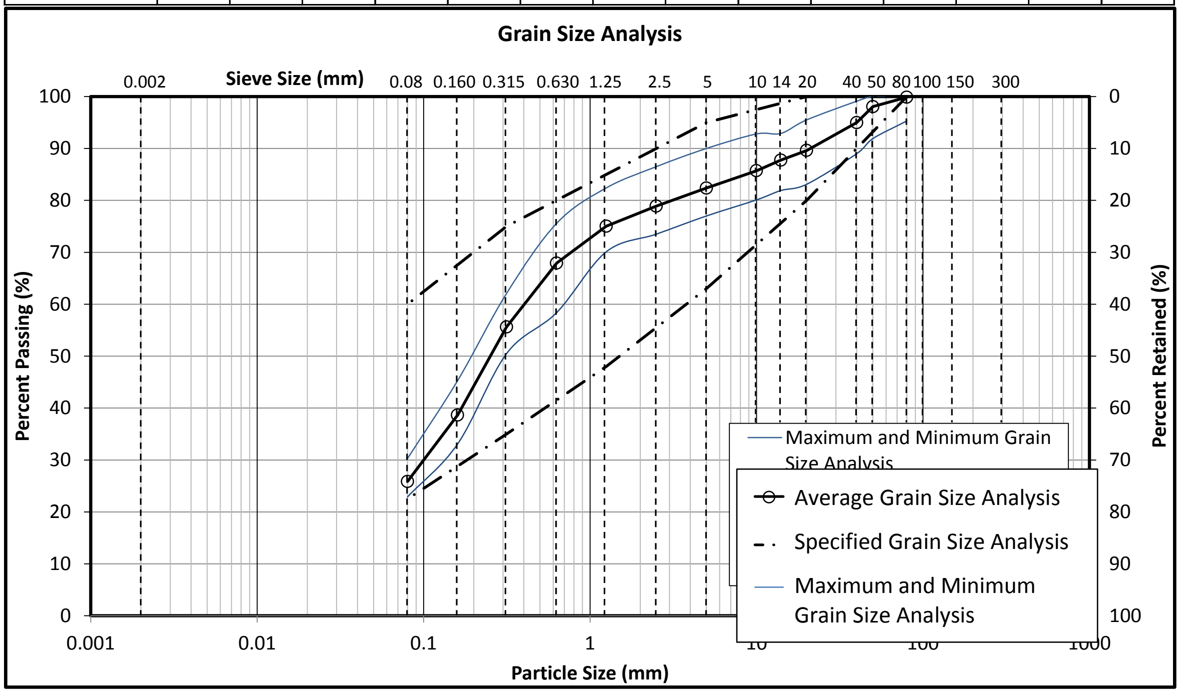


Figure 7-5 : Zone 1C –In Situ Compaction Degree

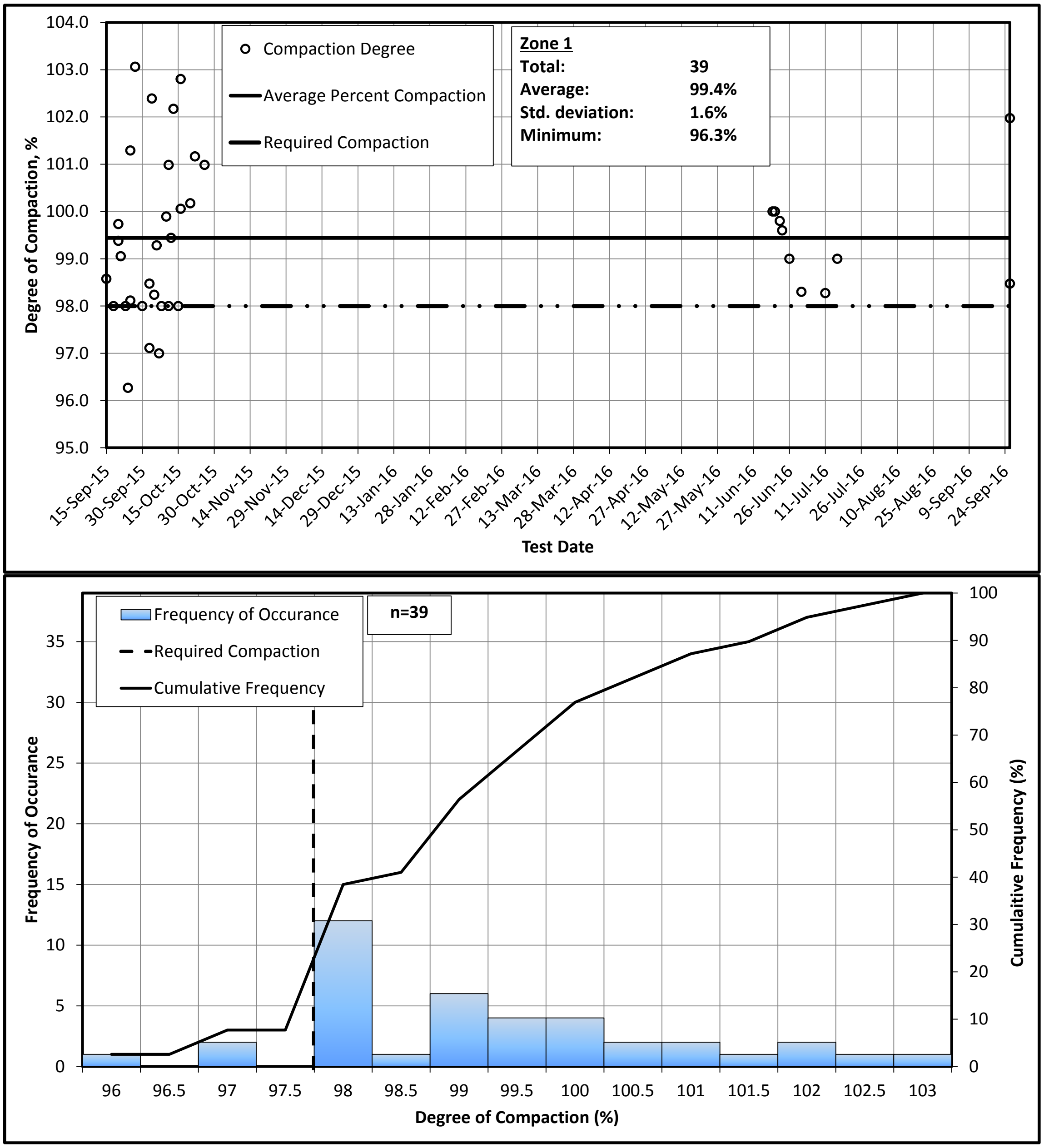


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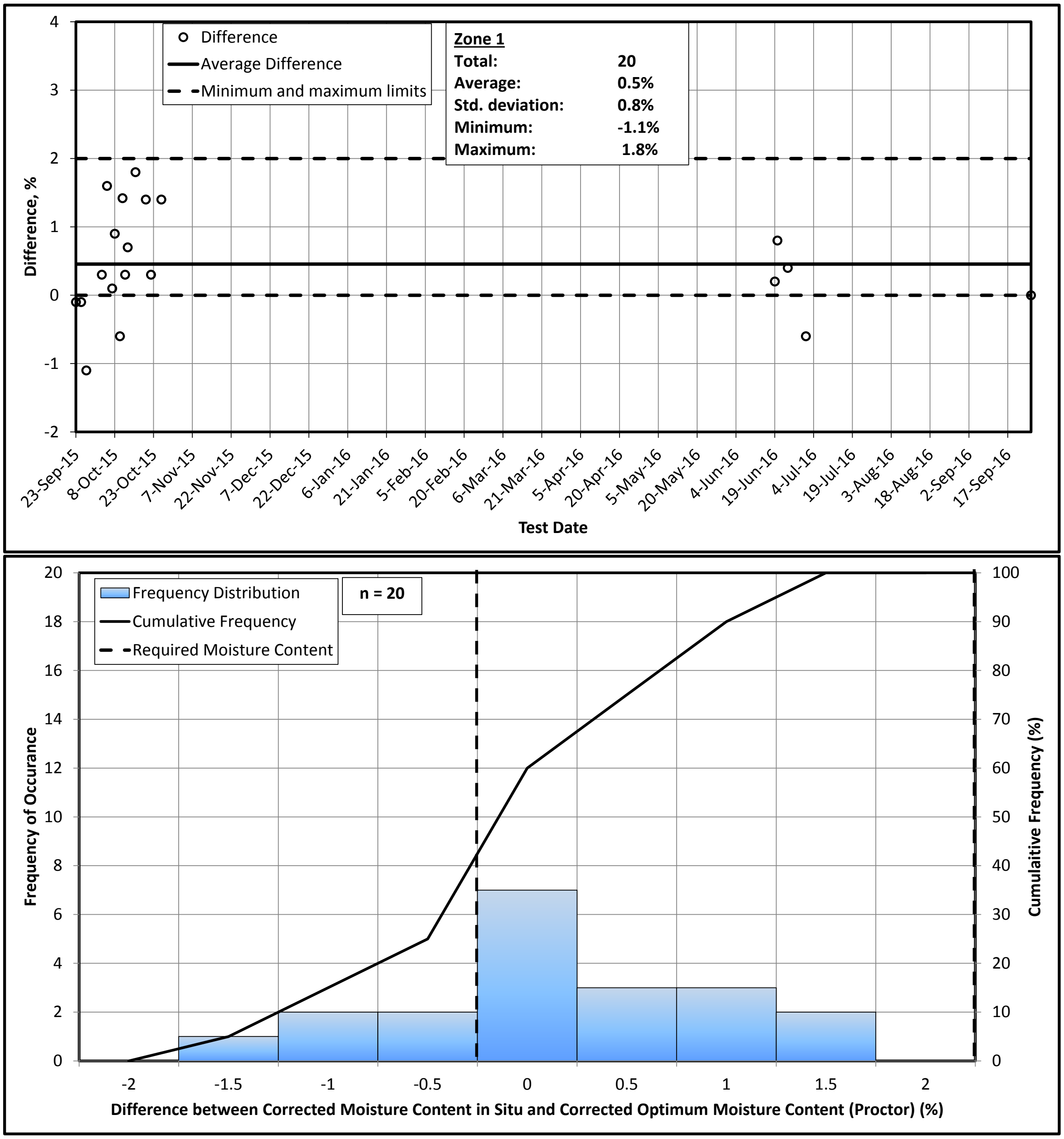
Figure 7-6 : Zone 1C – Compaction and Optimum Moisture Content



7.3 ZONE 2A MATERIAL

The zone 2A material is sand and gravel to sand, with traces of gravel and silt and less than 5% of fine particles. On slopes of 4H:1V or flatter, the material was placed, at the same slope, by bulldozer or excavator, in 450 mm thick layers before compaction. On steeper slopes, the material was placed with bulldozer or excavator in horizontal layers of 450 mm thickness before compaction.

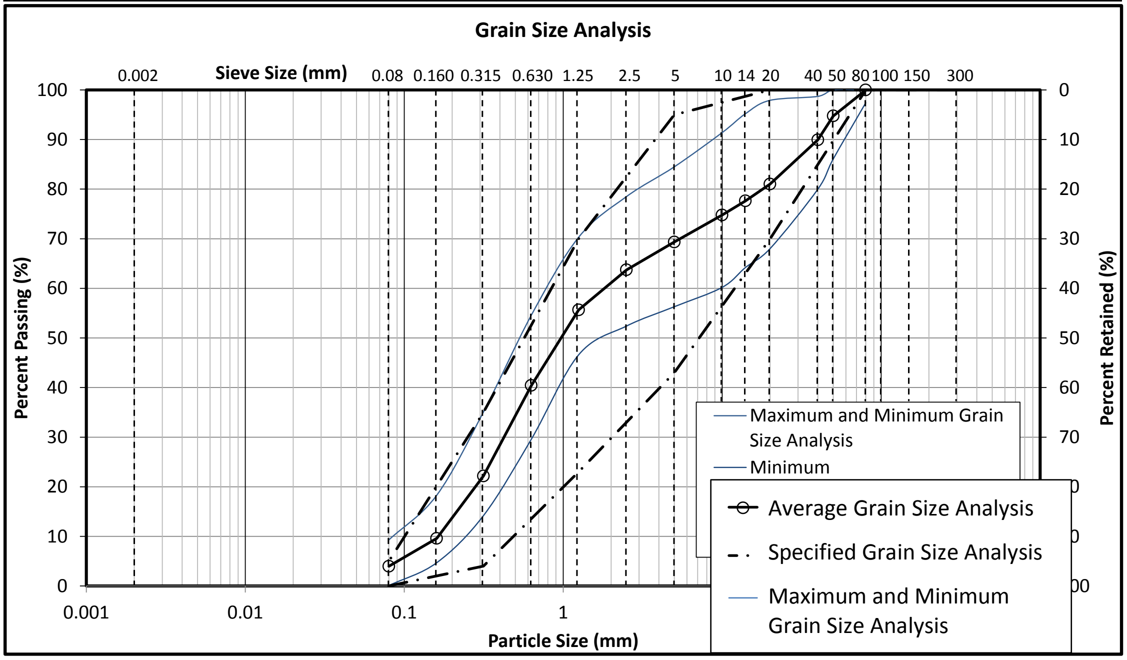
The required compactness of the zone 2A material was at least 93% of the maximum dry density as determined by ASTM 4253 (Vibratory table). In-situ density was verified as per ASTM D5030 (water displacement).

The material was compacted by at least 3 passes of a 10 tonne vibratory roller.

The results of the laboratory tests for grain size distribution and compaction control are shown in Figure 7.7.

Figure 7-7 : Zone 2A –Grain Size Analyses

Statistical Parameters	Sieve Size (mm)													
	300	**80**	**50**	**40**	**20**	**14**	**10**	**5**	**2.5**	**1.25**	**0.630**	**0.315**	**0.160**	**0.080**
Number	102	114	114	114	114	108	114	114	114	114	114	114	114	114
Average	100	100	95	90	81	78	75	69	64	56	40	22	10	4
Std. deviation	0	0	3	4	5	5	5	5	5	5	5	4	2	1
Minimum	100	97	86	80	68	64	60	56	52	47	30	14	5	0
Maximum	100	100	100	99	98	95	91	85	79	70	55	35	18	9
Conformity	100.0	99.1	-	-	99.1	-	-	100.0	-	100.0	-	100.0	-	100.0
Requirement	**100**	**100**	**-**	**-**	**70-100**	**-**	**57-100**	**43-95**	**33-81**	**23-70**	**-**	**4-35**	**-**	**0-5**



7.4 ZONE 2C/2E MATERIAL

The zone 2C/2E material is a sandy gravel to a gravelly sand, with traces of silt and less than 5% of fine particles, and a percentage of cobbles varying between 0 and 40%. The zone 2C material was placed in horizontal layers of 450 mm thickness before compaction with excavators while zone 2E material was placed in uniform thickness as shown in the drawings.

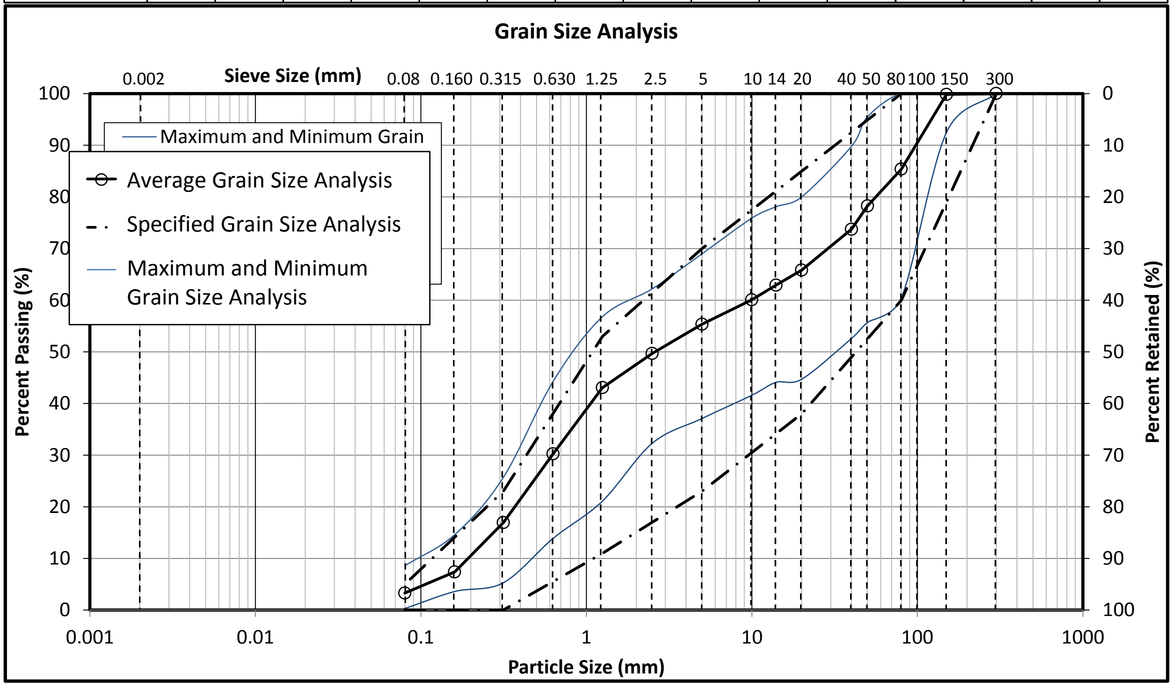
The required compactness of the zone 2C material was at least 93% of the maximum dry density as determined by ASTM 4253 (Vibratory table). In-situ density was measured as per ASTM D5030 (water displacement).

Each layer of the zone 2C material was compacted by at least 3 passes of a 10 tonne vibratory roller. No compaction was required for the zone 2E material.

Quality control test results are presented in Figure 7-8.

Figure 7-8 : Zone 2C –Grain Size Analyses

Statistical Parameters	Sieve Size (mm)														
	300	150	80	50	40	20	14	10	5	2.5	1.25	0.630	0.315	0.160	0.080
Number	152	84	152	144	144	152	121	144	152	144	152	143	152	142	152
Average	100	100	85	78	74	66	63	60	55	50	43	30	17	7	3
Std. deviation	0	1	8	8	8	7	7	7	7	6	6	6	4	2	1
Minimum	100	93	60	56	53	45	44	42	37	32	21	14	5	4	0
Maximum	100	100	100	96	90	80	78	76	69	62	57	44	26	15	9
Conformity	100.0	-	100.0	-	-	100.0	-	-	100.0	-	97.4	-	94.7	-	94.7
Requirement	100	-	60-100	-	-	38-85	-	-	23-70	-	11-53	-	0-23	-	0-5



7.5 ZONE 3A MATERIAL

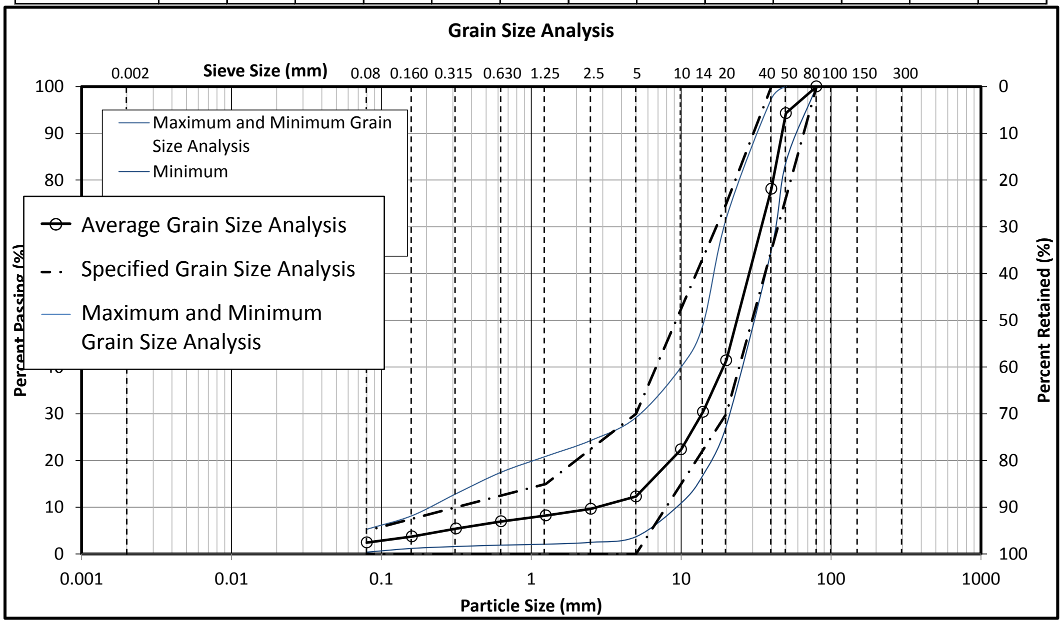
The zone 3A material is a crushed stone obtained from quarried rock. The maximum size is 80 mm with less than 5% of fine particles. On slopes of 4H:1V or flatter, the material was placed, at the same slope, by bulldozer or excavator in 450 mm thick layers before compaction. On steeper slopes the material was placed by bulldozer or excavator in horizontal layers of 450 mm thickness before compaction.

Each layer of the zone 3A material was compacted by at least 3 passes of a 10 tonne vibratory roller.

The main characteristics of the embankment zone 3A material are presented in Figure 7-9.

Figure 7-9 : Zone 3A –Grain Size Analyses

Statistical Parameters	Sieve Size (mm)												
	80	**50**	**40**	**20**	**14**	**10**	**5**	**2.5**	**1.25**	**0.630**	**0.315**	**0.160**	**0.080**
Number	68	68	68	68	67	68	68	68	68	68	68	68	68
Average	100	94	78	41	30	22	12	10	8	7	5	4	2
Std. deviation	0	3	6	8	8	7	6	5	4	3	2	2	1
Minimum	100	84	65	27	17	11	4	3	2	2	2	1	0
Maximum	100	100	97	72	49	40	29	24	21	18	13	8	5
Conformity	100.0	-	100.0	97.1	-	100.0	100.0	-	94.1	-	97.1	-	98.5
Requirement	**100**	**-**	**65-100**	**30-75**	**-**	**12-50**	**0-30**	**-**	**0-15**	**-**	**0-10**	**-**	**0-5**



7.6 ZONE 3C/3E AND 3D MATERIAL

These materials are random rockfill materials with a maximum size of 450 mm (3C/3E) and 900 mm (3D).

No qualitative tests were required for these materials. Quality control was made visually to control the maximum size of particles, the gradation and the concentration of particles of a particular size. The embankment zone had to be homogeneous. Identified areas of segregation were corrected during works.

On slopes of 4H:1V or flatter, the zone 3C and 3D materials were placed, at the same slope, by bulldozer or excavator, in 450 or 900 mm thick layers before compaction On steeper slopes, the materials were placed, by bulldozer or excavator, in horizontal layers of 450 or 900 mm thickness before compaction.

Each layer of the zone 3C material was compacted by at least 3 passes of a 10 tonne vibratory roller and zone 3D material by at least 4 passes of the vibratory roller.

7.7 ZONE 4 MATERIAL

The zone 4 material, classes 1, 2 and 3 was comprised of selected boulders coming from the quarry Q-6 and varying in sizes from 400 to 750 mm. Oversized boulders were accepted in the embankment provided that the minimum thickness of the layer was composed of at least 2 boulders.

Zone 4 material was dumped on a horizontal surface prior to being placed by excavators on the slopes. The position of the boulders was adjusted to ensure stability and interlocking. Visual inspection of the riprap was made during works, deficient areas were identified and then corrected before the final acceptance of the embankment.

All riprap approvals are included in the Construction Records Books (MFA-GB-SD-2800-CV-R02-0002-01 and 0004-01.

8 CEMENT BENTONITE CUT-OFF WALLS

8.1 GENERAL

Two cement bentonite cut-off walls (Upstream and Northwest) were constructed as part of the stabilization works of the North Spur. The upstream cut-off wall was completed in October 2015. The west part of the northwest cu-off wall between stations 0+000 to 0+062 was also constructed in 2015. Between stations 0+060 and 0+472.5 the northwest cu-off wall constructed in 2016.

The design depth of the wall was determined from the existing geotechnical investigations. Both walls were designed to be anchored at least 2 meters in the lower clay unit. The final key elevation of the cut-off wall was established and approved by the Engineer on site based on visual inspection of the excavated materials.

The subcontractor for the construction of the cement bentonite cut-off walls (Inquip Associates Inc.) began mobilization on site in mid-June 2015.

Early works comprised the construction and preparation of the batch plant which was located on the crest of the North Spur beside the permanent access road north of the excavated NW trench.

The mixing of the slurry was a 2 phase process: bentonite and water and then cement and additives prior to delivery of the slurry to the trench.

The batch plant included hydrated bentonite ponds, baker tanks for bentonite slurry storage, slurry mixer, cement silo and a CB plant (cement silo, averaging slurry tanks, weight batcher and mixers) and high pressure pump for water supply.

Two excavators (CAT385 and Komatsu 1250PC) equipped with long sticks were provided by the main Contractor (GNLC).

A small excavator (CAT320 with a 640 mm bucket) also provided by GNLC was used intermittently in the upstream cut-off wall and permanently in the NW cut-off wall to perform pre-trenching from the work platforms.

In 2015, a 120 ton Bauer crane and two 16 ton, 3.6 m long x 0.6 m wide, Leffer mechanical clamshells were mobilized by Inquip. The Bauer crane was demobilized at the end of excavation in 2015.

In 2016, three cranes were mobilized to site; a Liebherr 883 with a clamshell 3.6 m long x 0.60 m wide, a Liebherr 855 equipped with a clamshell 3 m long x 0.60 m wide and a 100 ton Casagrande B300 equipped with a clamshell 3 m long x 0.60 m wide.

In 2015, the high pressure pump for the water supply was located in the river near the north end of the upstream cut off wall and in the 2016 season, the pump was installed in the south part in order to avoid further displacement of the pump due to the decrease of the river water level.

Quality control procedures included inspection, sampling and testing and survey (depth, alignment, overlaps, continuity and verticality of the walls). Equipment and batch plant verification and calibrations were carried out and transmitted by the Contractor prior to commencement of excavation works.

Complete daily reports were issued during the works.

Testing was performed as per the requirements of the technical specifications. Viscosity, density and temperature of the bentonite slurry plus bleeding of the cement bentonite slurry were measured and controlled.

Mechanical tests on the hardened cement bentonite slurry were also performed.

All quality control test results are included in the Construction Records Books. (MFA-GB-SD-2800-CV-R02-0003-01 and MFA-GB-SD-2800-CV-R02-0005-01).

8.2 UPSTREAM CUT-OFF WALL

Prior to commencement of the works and as required by the technical specifications, the mix design (MFA-GB-CD-2800-GT-F99-0005-01), the construction method (MFA-GB-SD-2800-CV-K24-0012-01) and the quality control plan (MFA-GB-SD-2800-QM-Q99-001-01) were issued by the Contractor and approved by the Engineer.

The approved mix for the upstream cut-off wall was labelled Mix No. 11 and comprised the following: 35 kg of bentonite, 260 kg of cement (cement/water ratio: c/w = 26%) and 0.05% of additive (Aquafix) for each 1000 liters of water.

The cement water ratio was adjusted during the works resulting in ratios of 30 and 28% (SQY-CH0008001-0025 and SQY-CH0008001-0026).

The excavation of the cut-off wall started on August 2nd, 2015 and the last panel was excavated on October 7th, 2015.

Since the cut-off wall was constructed at the toe of the existing/excavated slopes and due to potential for slope instability problems during the excavations, the type of excavation approved was the alternate panel method (primary and secondary panels).

Stability analyses were performed by the subcontractor to define the length of the panels. Maximum defined and retained length was 13.5 m. The minimum period between primary and secondary panels was established as 2 days, depending on shear resistance tests performed by the subcontractor and the setting of the slurry inside the excavated panels.

Construction of the wall was performed in double 10 hour shifts (day and night).

The wall was constructed between stations 0+180 and 0+801, starting from the north and advancing to the south. The sequence was adjusted according to embankment construction constraints.

The selection of final wall depth and anchor acceptance was carried out by the Engineer for all panels. Samples of the lower clay layer unit were retrieved from the base of the excavation.

At the southern limit of the wall, during the overburden excavation, the lower clay unit was identified to be overlying the bedrock (foundation mapping included in Appendix C) and leading to the end of the wall being established at station 0+180. The limits of this layer were compared against the existing CPT data available (CPTs 1A-13, 1B-13, 2A-13, 2B-13 and 3-13).

During excavation in the proximity of station 0+410, it was observed that the lower clay unit started to deepen and to be out of the reach of the planned equipment. New CPT tests were performed between the 11th and 15th of September in order to determine the elevation of the clay layer. Based in the results, the Bauer crane was mobilized to the upstream area to excavate the cut-off wall between approximately stations 0+370 and 0+410.

After hardening of the slurry, all dried, altered or fissured cement-bentonite was removed using a toothless bucket. The foundation was then approved for embankment placement.

During the works, quality tests of the fresh and hardened slurry were performed, the results of which are presented in Figures 8-1 and 8-2.

Figure 8-1 : Upstream Cut-Off Wall – Density, Bleed and Viscosity at the Exit of Conduit at Different Stations

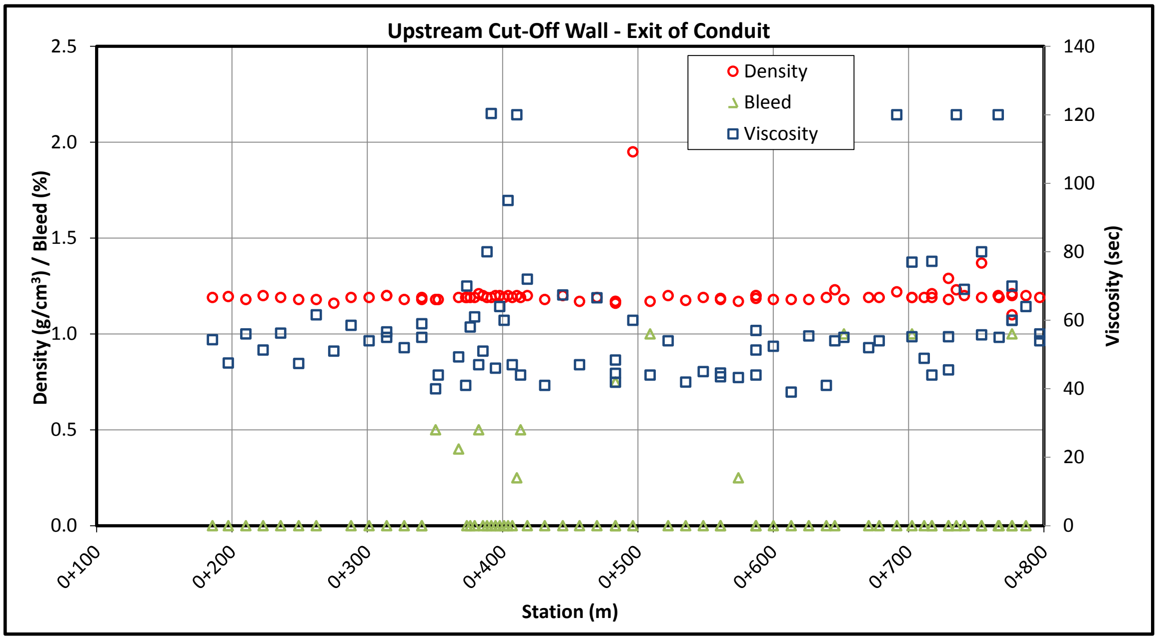
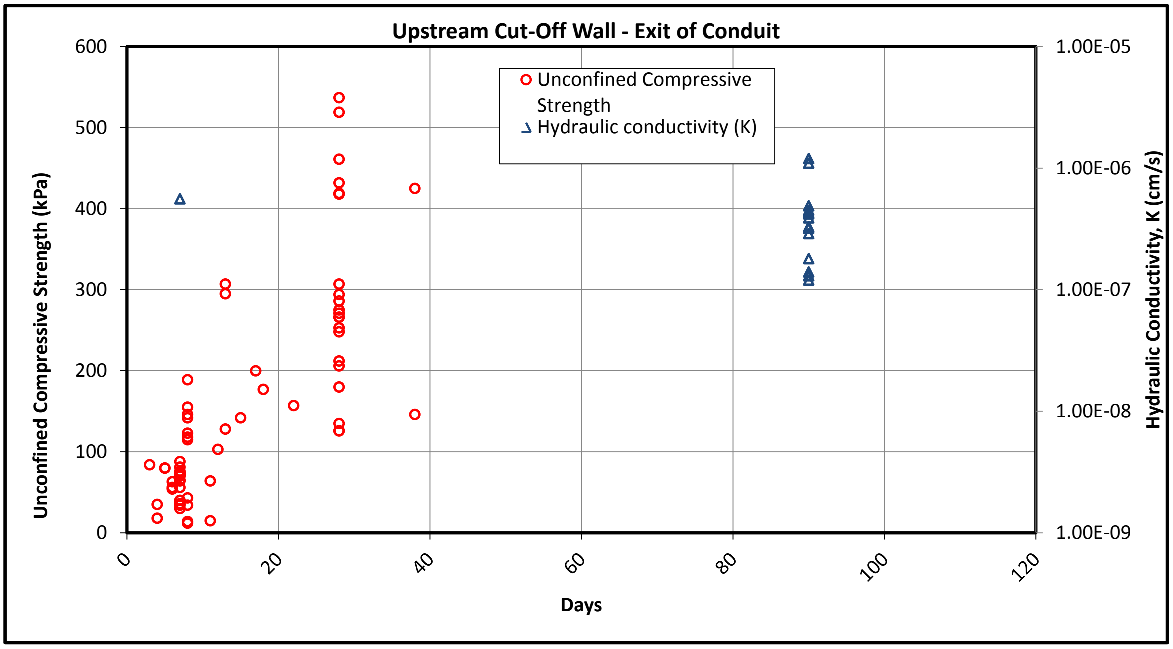


Figure 8-2 : Upstream Cut-Off Wall – Unconfined Compressive Strength and Hydraulic Conductivity at the Exit of Conduit for Different Stations



Profile of the as built Upstream cut-off wall is shown in drawings MFA-SN-CD-2800-CV-SE-0004-02 to 04.

8.3 NORTHWEST CUT-OFF WALL

Prior to commencement of the works and as required in the technical specifications the mix design (MFA-GB-CD-2800-GT-F99-0032-01), the construction method (MFA-GB-SD-2800-CV-K24-0015-01) and the quality control plan (MFA-GB-SD-2800-QM-Q99-002-01) were issued by the Contractor and approved by the Engineer.

The approved mix 9.5 was used in the west part of the northwest cut-off wall (transition zone, stations 0+000 to 0+062.5).

Approved mix for the northwest cut-off wall between stations 0+062.5 and 0+472.5 was labelled as Mix No. 22 with 35 kg of bentonite, 140 kg of cement (c/a=14%; 126

kg of slag cement and 14 kg of GU cement) and 0.02 to 0.1% of additive (Aquafix) for each 1.000 liters of water.

The excavation of the first portion of the cut-off wall (0+000 to 0+062.5) started on October 6th, 2015 and finished on October 23rd, 2015 from working platforms at elevations 24.3 and 29.0 m. The Komatsu 1250PC excavator was used in the west side of the transition zone at elevation 24.3 while the Bauer crane was used to excavate the cut-off wall from the 29.0 m elevation working platform.

The remaining cut-off wall was excavated between June 11th, 2016 and September 12th, 2016 from working platforms at elevations 42 and 50.5 m.

The alternate panel method (primary and secondary panel) was used in the transition zone and the continuous or semi-continuous method in the cut-off wall built from the work platform at elevation 50.5 m.

Stability analyses were performed by the subcontractor to define the length of the panels. The maximum defined length for the transition zone was 10.7 m and 15.2 to 21.3 m for the wall constructed from the working platform at elevation 50.5 m; the actual maximum length used was 15.2 m. The period between primary and secondary panels, when applied, was established depending on shear resistance tests performed by the subcontractor (minimum of 15 kPa at 3 days).

Additional CPT tests were performed in 2015 on the axis of the northwest cut-off wall in the trench at elevation 50.5 m to better define the upper limit of the lower clay unit.

Construction of the wall was performed in double 10 and 12 hour shifts (day and night).

In the 2016 construction season, at the working platform at elevation 50.5 m, the Liebherr crane excavated between stations 0+130 and 0+410 approximately and the Casagrande crane between stations 0+060 and 0+130, and between 0+410 and 0+472.5. The sequences and locations of the cranes during excavations changed to accommodate the availability of the equipment and embankment construction works.

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A pre excavated trench of about 4 m depth (CAT 320 excavator) and mobile steel guides were installed in advance for excavation by the Liebherr crane.

The selection of final wall depth and anchor acceptance was carried out by the Engineer for all panels. Samples of the lower clay layer unit were retrieved from the base of the excavation.

After hardening of the slurry, all dried, altered or fissured cement-bentonite was removed using a toothless bucket. The foundation was then approved for embankment placement.

During the works, quality tests of the fresh and hardened slurry were performed, the results of which are presented in Figures 8-3 and 8-4.

Figure 8-3 : North West Cut-Off Wall – Density, Bleed and Viscosity at the Exit of Conduit for Different Stations

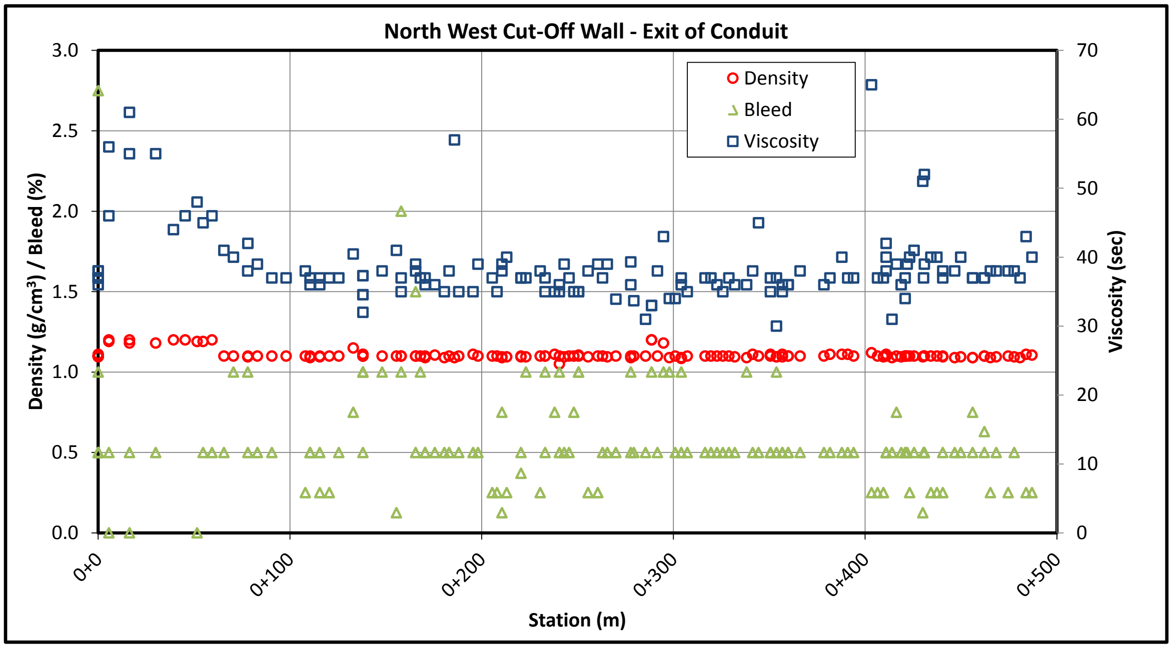
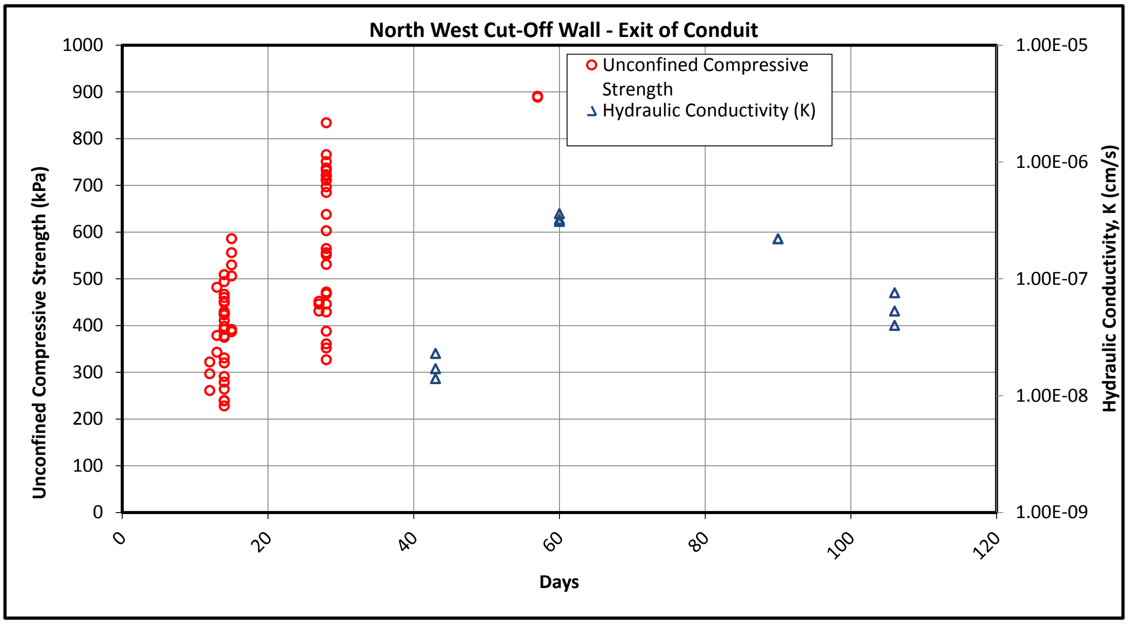


Figure 8-4 : North West Cut-Off Wall – Unconfined Compressive Strength and Hydraulic Conductivity at the Exit of Conduit for Different Stations



Profile of the as built Northwest cut-off wall is shown in drawing MFA-SN-CD-2800-CV-SE-0004-05.

9 INSTRUMENTATION

9.1 GENERAL

Instrumentation works were completed in 2016. Installation reports are included in the Geotechnical Instrumentation Installation, Commissioning, Operation and Maintenance Manual, MFA-GB-SD-2800-GT-R01-0001-01. Plan views and sections of the installed instruments are included on the as built drawings.

9.2 PIEZOMETERS

In total, 41 vibrating wire (VW) piezometers were installed and connected to the automatic data acquisition system (ADAS) in the pumpwell house on the North Spur. Data is then accessed through LoggerNet Software.

Of the 41 installed VW piezometers, 37 were installed inside a pneumatic piezometer permitting manual readings when needed.

Two daily readings are programmed for the installed piezometers.

9.3 INCLINOMETERS

In total, 6 inclinometers were installed, 5 in the downstream area and 1 on the upstream side.

Readings are being performed manually and the results downloaded and plotted using the GTilt Plus Software.

9.4 FLOWMETER

One flowmeter was installed inside a culvert at the exit of the third kettle lake.

10 REFERENCES

1. North Spur Stabilization Works – Design Report, MFA-SN-CD-2800-GT-RP-0004-01, March 2016
2. North Spur Stabilization Works – Construction Records Book – Site Clearing, MFA-GB-SD-2800-CV-R02-0001-01, November 2016.
3. North Spur Stabilization Works – Construction Records Book – Upstream Embankments, MFA-GB-SD-2800-CV-R02-0002-01, December 2017
4. North Spur Stabilization Works – Construction Records Book – Upstream Cut-Off Wall, MFA-GB-SD-2800-CV-R02-0003-01, September 2016.
5. North Spur Stabilization Works – Construction Records Book – Downstream Embankments, MFA-GB-SD-2800-CV-R02-0004-01, December 2017.
6. North Spur Stabilization Works – Construction Records Book – Northwest Cut-Off Wall, MFA-GB-SD-2800-CV-R02-0005-01, December 2017.
7. North Spur Stabilization Works – Construction Records Book – Three Kettle Lakes Area, MFA-GB-SD-2800-CV-R02-0006-01, August 2016.
8. North Spur Stabilization Works – Construction Records Book – Hydroseeding, MFA-GB-SD-2800-CV-R02-0007-01, December 2017
9. North Spur Stabilization Works – Construction Records Book – Instrumentation, MFA-GB-SD-2800-CV-R02-0008-01, December 2017.
10. North Spur Stabilization Works – Construction Records Book – Permanent Access Road, MFA-GB-SD-2800-CV-R02-0009-01, December 2017.
11. North Spur Stabilization Works – Geotechnical Instrumentation Installation, Commissioning, Operation and Maintenance Manual, MFA-GB-SD-2800-GT-R01-0001-01, October 2017.

Appendix A

LIST OF AS BUILT DRAWINGS

Drawing Number	Title
MFA-SN-CD-0000-CV-PL-0003-01	MUSKRAT FALLS - PROJECT LOCATION AND DRAINAGE BASINS - PLAN
MFA-SN-CD-0000-CV-PL-0004-01	MUSKRAT FALLS - LOWER CHURCHILL RIVER - PLAN AND PROFILE
MFA-SN-CD-2800-CV-GA-0002-01	MUSKRAT FALLS - GENERAL ARRANGEMENT OF WORKS - PLAN
MFA-SN-CD-2800-CV-GA-0003-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – ACCESS ROAD, ACCOMMODATIONS AND LAYDOWN AREAS - PLAN
MFA-SN-CD-2800-CV-PL-0010-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS- EXISTING CONDITIONS - PLAN
MFA-SN-CD-2800-CV-PL-0011-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - GENERAL ARRANGEMENT OF WORKS – COMPANY AND CONTRACTOR'S LAYDOWN AND SPOIL DISPOSAL AREAS - PLAN
MFA-SN-CD-2800-CV-DD-0005-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - HYDROMETEOROLOGICAL DATA
MFA-SN-CD-2800-CV-PL-0013-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – BORROW AREAS AND QUARRIES - PLAN
MFA-SN-CD-2800-GT-DD-0006-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - CLEARING - PLAN
MFA-SN-CD-2800-CV-PL-0014-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - ROCK FOUNDATION PREPARATION - PLAN, SECTION AND DETAILS
MFA-SN-CD-2800-GT-DD-0005-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - EMBANKMENT MATERIALS – GRAIN SIZE DISTRIBUTION
MFA-SN-CD-2800-CV-PL-0009-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - PLAN
MFA-SN-CD-2800-CV-PL-0009-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – ACCEPTABLE FOUNDATION – PLAN
MFA-SN-CD-2810-CV-SE-0001-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - UPSTREAM AREA - TYPICAL CROSS SECTIONS – SHEET 1 OF 4
MFA-SN-CD-2810-CV-SE-0001-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - UPSTREAM AREA - TYPICAL CROSS SECTIONS – SHEET 2 OF 4
MFA-SN-CD-2810-CV-SE-0001-03	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - UPSTREAM AREA - TYPICAL CROSS SECTIONS – SHEET 3 OF 4
MFA-SN-CD-2810-CV-SE-0001-04	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - UPSTREAM AREA - TYPICAL CROSS SECTIONS – SHEET 4 OF 4
MFA-SN-CD-2800-CV-SE-0004-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - NORTH-WEST AND UPSTREAM CUT-OFF WALLS – SECTIONS AND DETAIL
MFA-SN-CD-2800-CV-SE-0004-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - NORTH-WEST AND UPSTREAM CUT-OFF WALLS – PLAN VIEW AND PROFILE
MFA-SN-CD-2800-CV-SE-0004-03	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - NORTH-WEST AND UPSTREAM CUT-OFF WALLS – PLAN VIEW AND PROFILE
MFA-SN-CD-2800-CV-SE-0004-04	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - NORTH-WEST AND UPSTREAM CUT-OFF WALLS – PLAN VIEW AND PROFILE
MFA-SN-CD-2800-CV-SE-0004-05	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - NORTH-WEST AND UPSTREAM CUT-OFF WALLS – PLAN VIEW AND PROFILE
MFA-SN-CD-2800-CV-DD-0006-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - CUT-OFF WALLS - WORK PLATFORM AND CONSTRUCTION STAGES - SHEET 1 OF 3
MFA-SN-CD-2800-CV-DD-0006-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - CUT-OFF WALLS - WORK PLATFORM AND CONSTRUCTION STAGES - SHEET 2 OF 3
MFA-SN-CD-2800-CV-DD-0006-03	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - CUT-OFF WALLS - WORK PLATFORM AND CONSTRUCTION STAGES - SHEET 3 OF 3
MFA-SN-CD-2820-CV-SE-0001-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - DOWNSTREAM AREA – TYPICAL CROSS-SECTIONS – SHEET 1 OF 3
MFA-SN-CD-2820-CV-SE-0001-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - DOWNSTREAM AREA – TYPICAL CROSS-SECTIONS - SHEET 2 OF 3
MFA-SN-CD-2820-CV-SE-0001-03	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - DOWNSTREAM AREA – TYPICAL CROSS-SECTIONS - SHEET 3 OF 3
MFA-SN-CD-2820-CV-SE-0002-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - DOWNSTREAM AREA – FINGER DRAINS - SHEET 1 OF 3
MFA-SN-CD-2820-CV-SE-0002-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - DOWNSTREAM AREA – FINGER DRAINS - SHEET 2 OF 3
MFA-SN-CD-2820-CV-SE-0002-03	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - DOWNSTREAM AREA - FINGER DRAINS - SHEET 3 OF 3

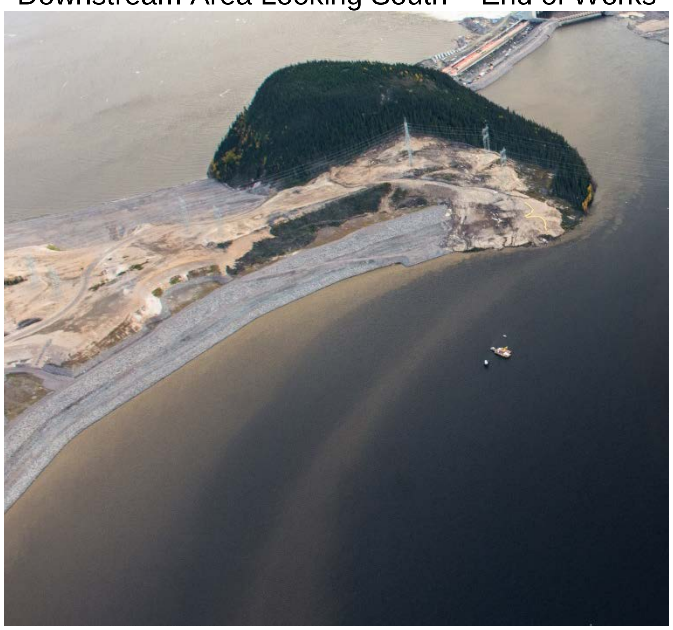
MFA-SN-CD-2800-GT-PL-0014-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - INSTRUMENTATION - PLAN
MFA-SN-CD-2800-GT-SN-0006-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - INSTRUMENTATION – SECTIONS AND DETAILS - SHEET 1 OF 2
MFA-SN-CD-2800-GT-SN-0006-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - INSTRUMENTATION – SECTIONS AND DETAILS - SHEET 2 OF 2
MFA-SN-CD-2800-GT-SE-0006-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS - INSTRUMENTATION – SECTIONS
MFA-SN-CD-2800-GT-PL-0013-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – PERMANENT ACCESS ROAD – PLAN
MFA-SN-CD-2800-GT-SN-0005-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – PERMANENT ACCESS ROAD - SECTIONS AND DETAILS
MFA-SN-CD-2800-GT-SN-0003-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – LOGBOOM PLATFORMS SECTIONS AND DETAILS
MFA-SN-CD-2800-GT-PL-0012-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – EXISTING GEOLOGICAL AND GEOTECHNICAL INFORMATION - PLAN
MFA-SN-CD-2800-GT-SE-0004-01	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – EXISTING GEOLOGICAL AND GEOTECHNICAL INFORMATION - SECTIONS - SHEET 1 OF 3
MFA-SN-CD-2800-GT-SE-0004-02	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – EXISTING GEOLOGICAL AND GEOTECHNICAL INFORMATION - SECTIONS - SHEET 2 OF 3
MFA-SN-CD-2800-GT-SE-0004-03	MUSKRAT FALLS - NORTH SPUR STABILIZATION WORKS – EXISTING GEOLOGICAL AND GEOTECHNICAL INFORMATION – SECTIONS - SHEET 3 OF 3

Appendix B

PHOTOGRAPHS

AERIAL VIEWS


Downstream Area Looking South – End of Works


Upstream Area Looking South – End of Works

Downstream Area Looking North – End of Works

Upstream Area Looking South – 2016 Construction Works


Downstream Area Looking North – 2016 Construction Works


Downstream Area Looking South – 2016 Construction Works


General View Looking South – 2016 Construction Works


General View Looking South – 2016 Construction Works


Upstream Area Looking South – 2016 Construction Works


Downstream Area Looking South – 2016 Construction Works


Downstream Area Looking North – End of Works


Downstream Area Looking North – End of Works

BORROW PITS

T4-B Till Deposit Looking West – After Rehabilitation Works

T4-B Till Deposit Looking East – After Rehabilitation Works


Quarry Q6 Looking North – After Rehabilitation Works


Quarry Q6 Looking West – After Rehabilitation Works


GR-2 Granular Deposit Looking West – After Rehabilitation Works


GR-2 Granular Deposit Looking North – After Rehabilitation Works

UPSTREAM LOOKING NORTH


After Clearing Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season


2015/07/08

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season


2015/07/21

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season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Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season


2016/06/02

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

UPSTREAM LOOKING SOUTH

After Clearing Works – 2015 Construction Season

After Clearing Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season


2015/06/29

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season


Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

DOWNSTREAM LOOKING NORTH

After Clearing Works – 2015 Construction Season

After Clearing Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation Works – 2015 Construction Season


19.09.2015 17:11

Excavation Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

DOWNSTREAM LOOKING SOUTH

After Clearing Works – 2015 Construction Season

After Clearing Works – 2015 Construction Season

Excavation Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2015 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

Excavation and Embankment Works – 2016 Construction Season

THREE KETTLE LAKES


After Clearing Works – Looking East

After Clearing Works – Looking East

Excavation Works – Looking East

Hydroseeding Works – Looking North

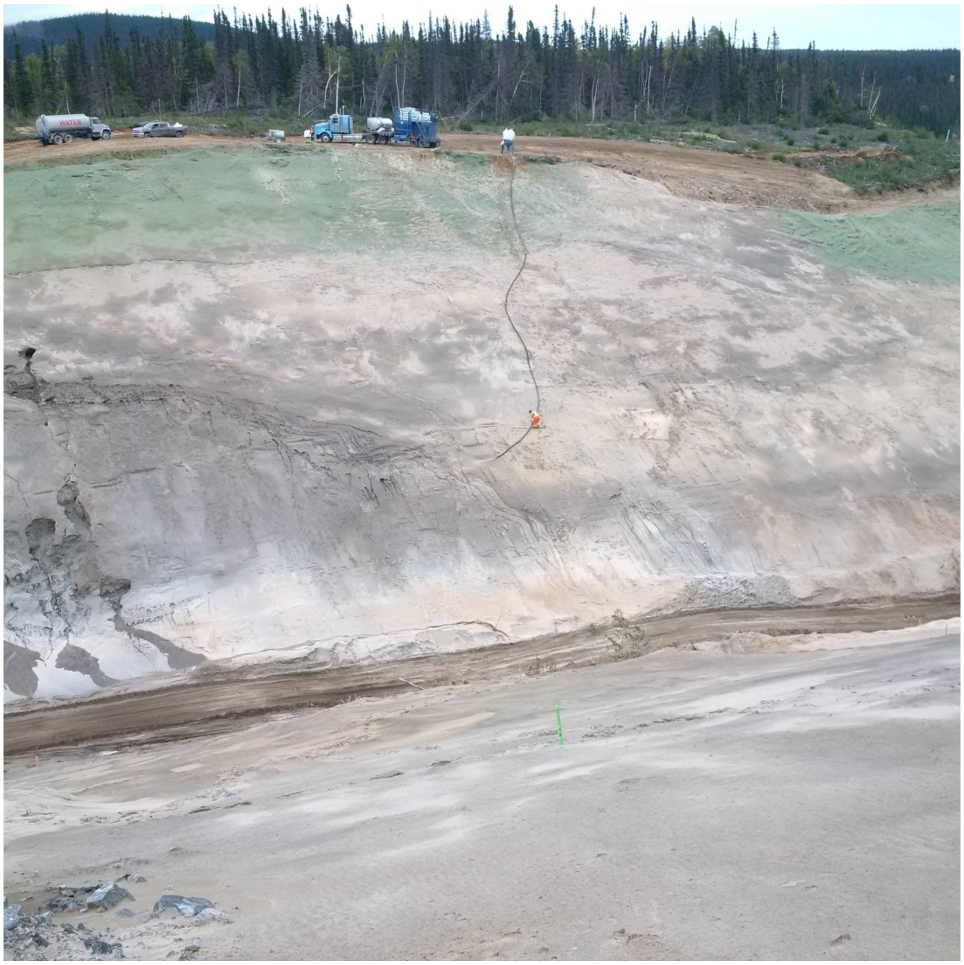

Embankment Works – Looking East


Excavation Works – Looking West


Embankment Works – Looking West


Embankment Works – Looking East


Embankment Works – Looking North



Hydroseeding Works – Looking North

Excavation Works – Looking North

Excavation Works – Looking South

Excavation Works – Looking South


Excavation Works – Looking South

CUT OFF WALLS

Upstream Cut-Off Wall Excavation – 2015 Construction Season

Upstream Cut-Off Wall Excavation – 2015 Construction Season

Upstream Cut-Off Wall Excavation – 2015 Construction Season


Upstream Cut-Off Wall Excavation – 2015 Construction Season


Upstream Cut-Off Wall Excavation – 2015 Construction Season

Cut-Off Wall Batch Plant


Cut-Off Wall – Batch Plant Assembling


Cut-Off Wall – Bentonite Ponds

Cut-Off Wall – Bentonite

Cut-Off Wall – Baker Tanks

Cut-Off Wall – Cement Silo, Mixer and CB Plang

Upstream Cut-Off Wall – Preparation of the Trench Top before Embankment Construction

Upstream Cut-Off Wall – Preparation of the Trench Top before Embankment Construction


Upstream Cut-Off Wall – Preparation of the Trench Top before Embankment Construction

Upstream Cut-Off Wall – Preparation of the Trench Top before Embankment Construction

Cut-Off Wall – Clamshell

Upstream Cut-Off Wall – Bauer Crane during Excavation Works – 2015 Construction Season

Upstream Cut-Off Wall – Bauer Crane during Excavation Works – 2015 Construction Season

Upstream Cut-Off Wall – Bauer Crane during Excavation Works – 2015 Construction Season

Excavation of the Upstream Cut-Off Wall – View from top of the Spur – 2015 Construction Season


Excavation of the Upstream Cut-Off Wall at the Junction of the Northwest Cut-Off Wall

Excavation of the Upstream Cut-Off Wall at the Junction of the Northwest Cut-Off Wall


Excavation of the Upstream Cut-Off Wall at the Junction of the Northwest Cut-Off Wall

Upstream Cut-Off Wall – Preparation of the Trench Top before Embankment Construction


Upstream Cut-Off Wall – Preparation of the Trench Top before Embankment Construction

Northwest Cut-Off Wall – Liebherr 883 crane, clamshell and steel guide – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 883 Crane, Clamshell and Steel Guide – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 883 crane – 2016 Construction Season

Northwest Cut-Off Wall – Casagrande crane – 2016 Construction Season


PETRIFOND

Northwest Cut-Off Wall – Casagrande crane – 2016 Construction Season

Northwest Cut-Off Wall – Casagrande crane – 2016 Construction Season

Northwest Cut-Off Wall – Casagrande crane – 2016 Construction Season

Northwest Cut-Off Wall – Casagrande crane – 2016 Construction Season


Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

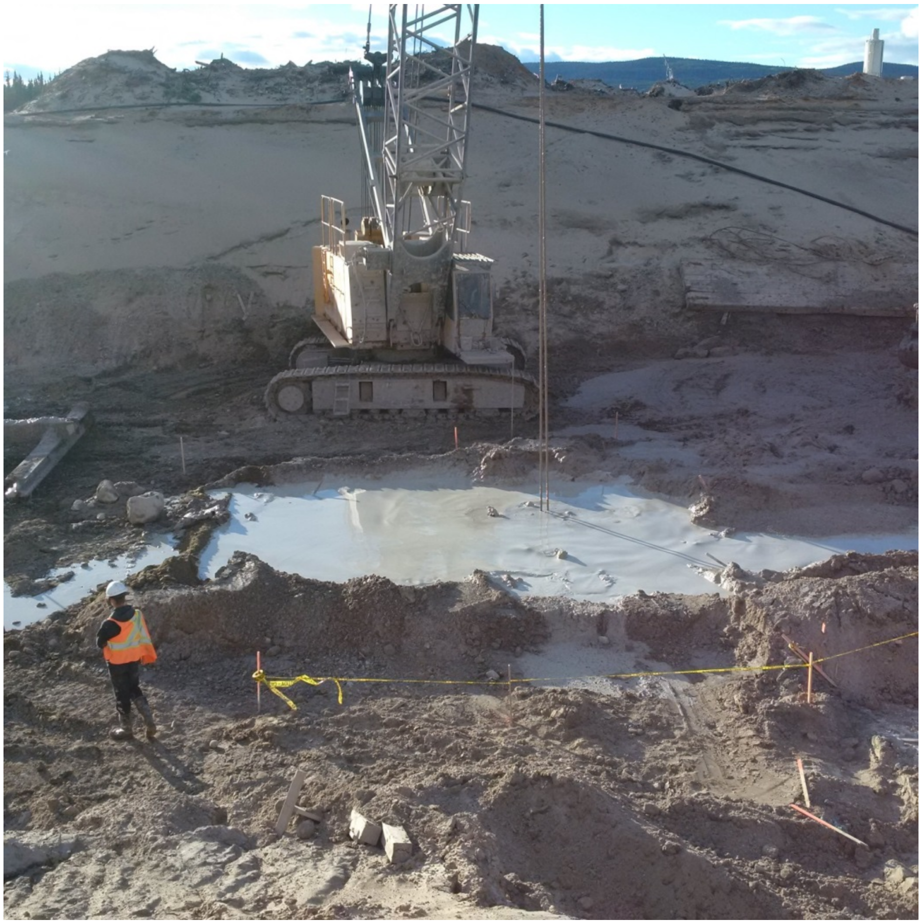

Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season


Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 855 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 855 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 855 Crane – 2016 Construction Season



Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

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Nalcor
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Northwest Cut-Off Wall – Liebherr 883 Crane – 2016 Construction Season

Northwest Cut-Off Wall – Trench Top Preparation – 2016 Construction Season

Northwest Cut-Off Wall – Trench Top Preparation – 2016 Construction Season

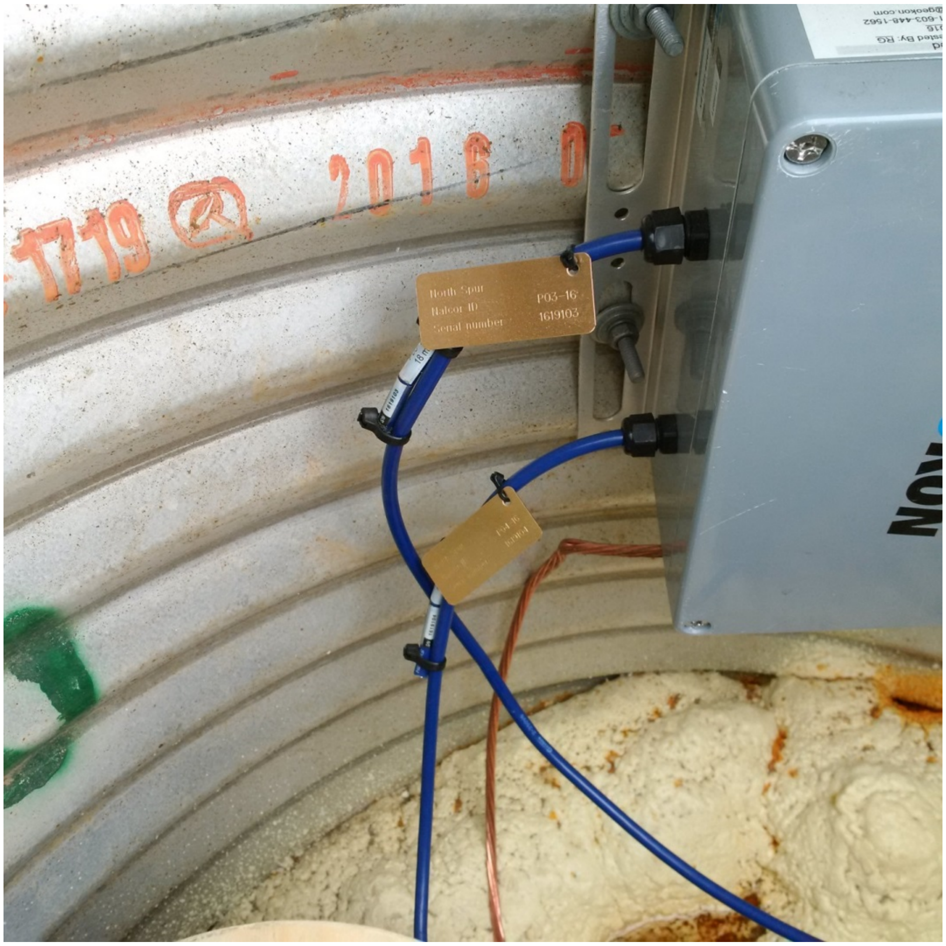
INSTRUMENTATION

Downstream Area – Trenching Works

Inclinometer inside Shelter


Flowmeter Shelter Looking West

Flowmeter Shelter Looking East



Piezometer Protection inside Shelter

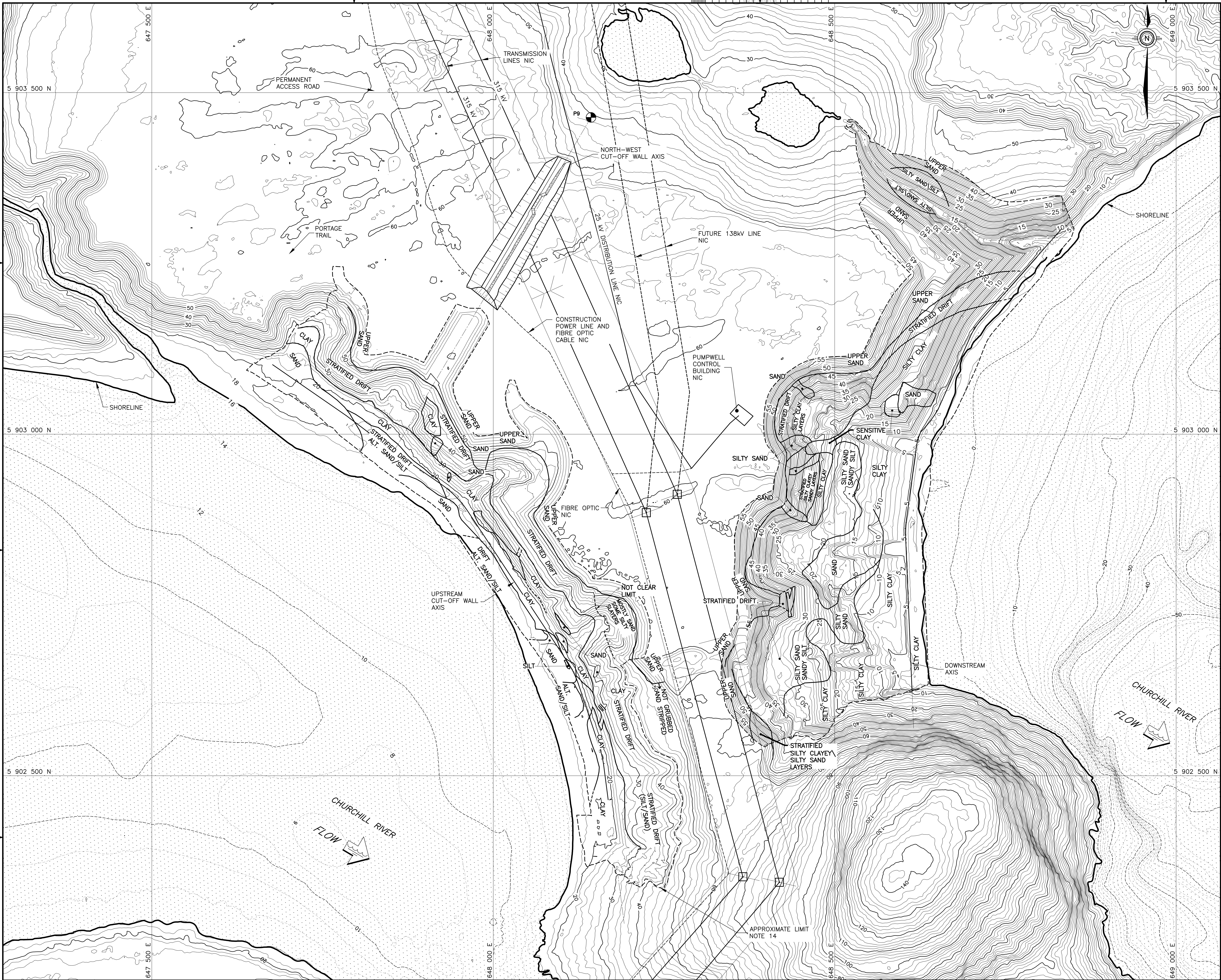
Piezometers Trenching


Piezometer Shelter

Boring Operations – Piezometer Installation

Appendix C

FOUNDATION MAPPING



PROFESSIONAL STAMP

SNC·LAVALIN

CLIENT: nalcor energy

DESIGNED BY	A. CEBALLOS
DRAWN BY	G. BOUTIN
VERIFIED BY	
DATE	12-AVR-2018
APPROVED Discipline Lead Engineer	R. BOUCHARD
APPROVED Engineering Manager	G. SNYDER
SCALE	1:1000

PROJECT: LOWER CHURCHILL PROJECT

TITLE: MUSKRAT FALLS
NORTH SPUR STABILIZATION WORKS
FOUNDATION MAPPING
PLAN

SLI DOC No.
NE DOC No. 505573-3281-4GDK-0057-00
Rev.

FORMAT A0 (mm)

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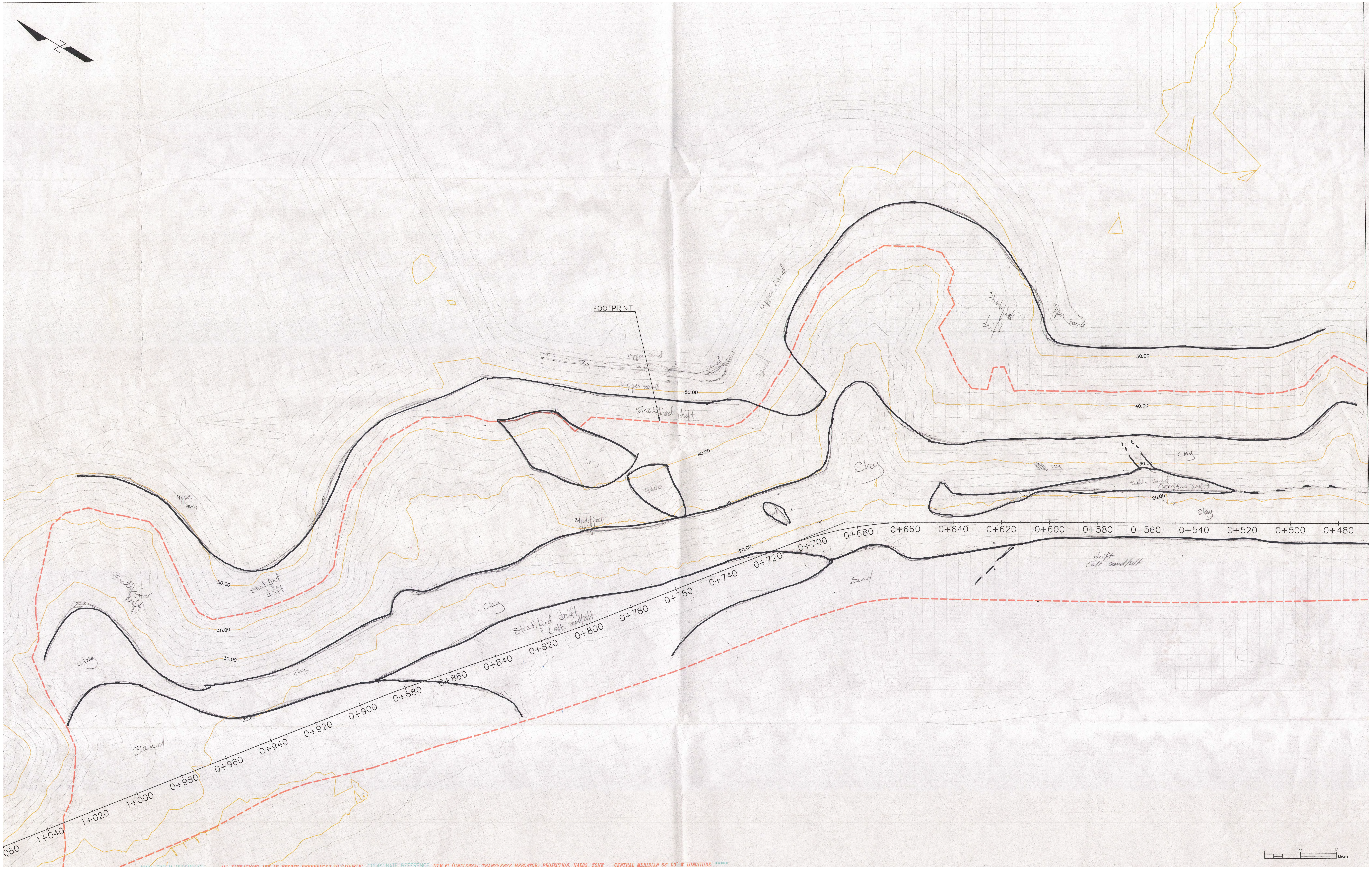
CH0008 – NORTH SPUR STABILIZATION WORKS

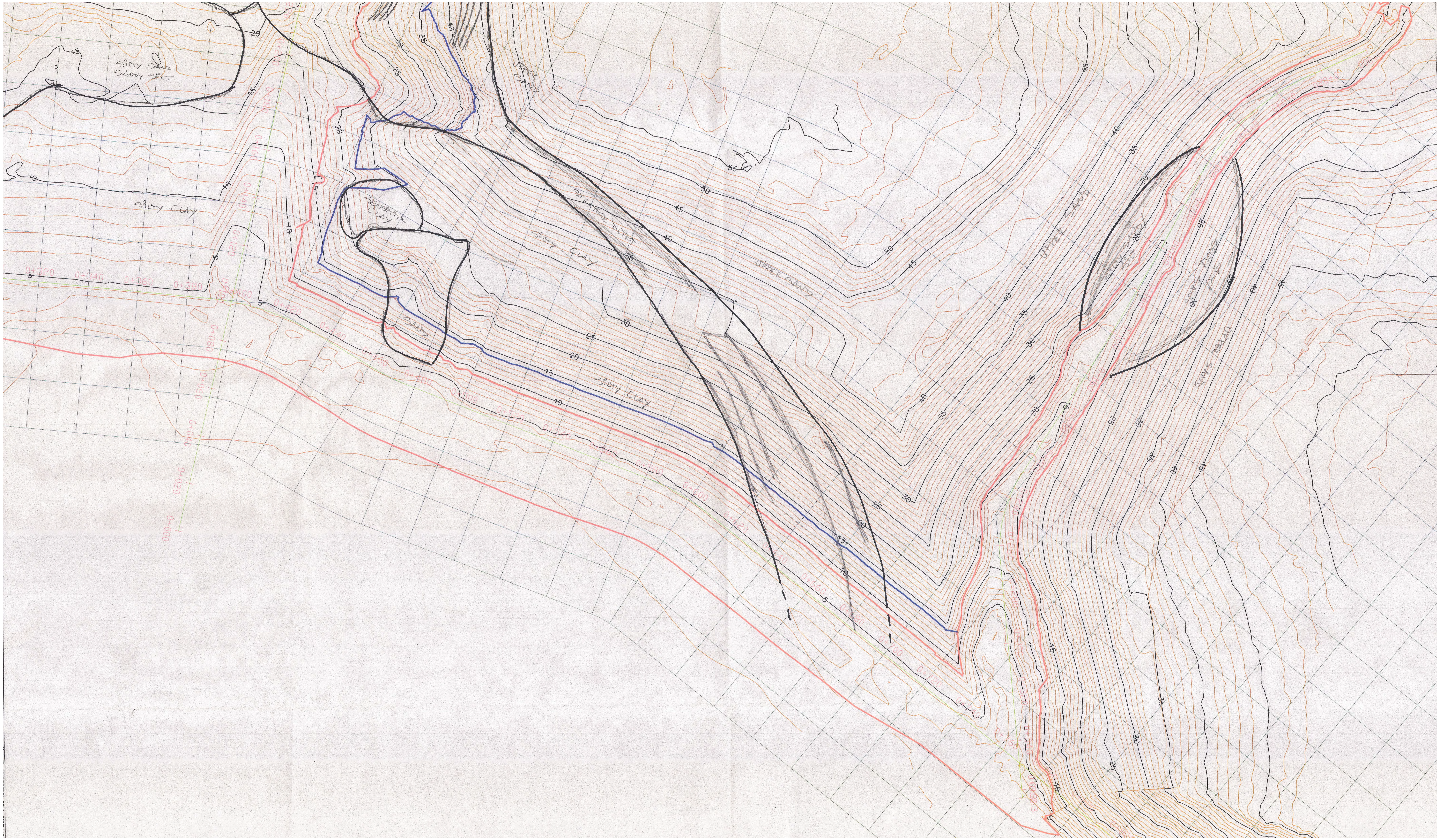
FOUNDATION MAPPING

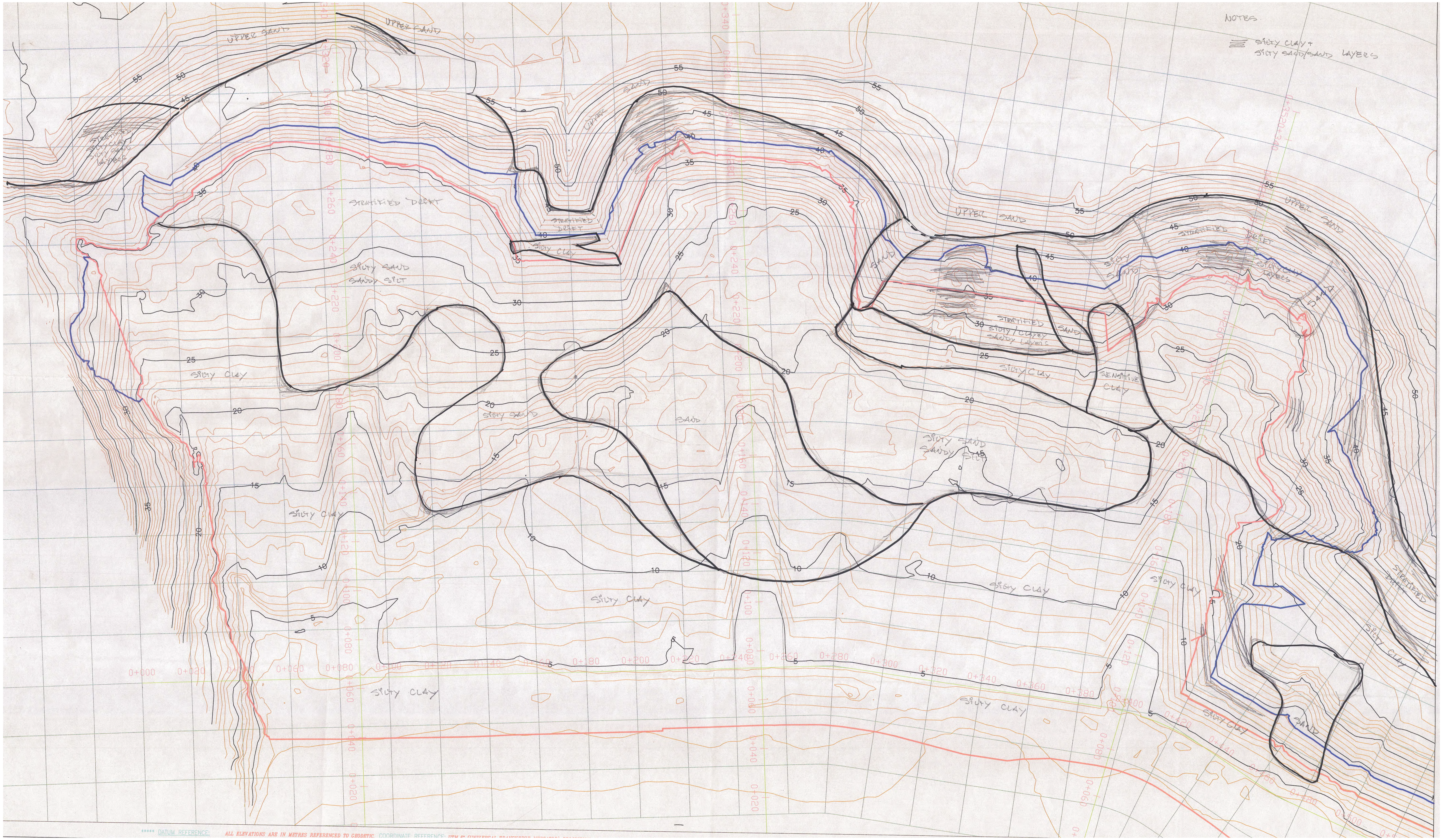
Notes:

- foundations shown in the pictures are before foundation approval pending of final excavation of unsuitable foundation.
- Stations and elevations depicted in the pictures are approximate.
- Limits of the different soil units are approximate.


FOOTPRINT
upper sand
stratified drift
clay
sand
Clay
silty sand (stratified drift)
drift (alt. sand/silt)
stratified drift (alt. sand/silt)
Sand
50.00
40.00
30.00
20.00
0+480
0+500
0+520
0+540
0+560
0+580
0+600
0+620
0+640
0+660
0+680
0+700
0+720
0+740
0+760
0+780
0+800
0+820
0+840
0+860
0+880
0+900
0+920
0+940
0+960
0+980
1+000
1+020
1+040
Meters


NOT GRUBBED AND STRIPPED
FOOTPRINT
BEDROCK
upper sand
mostly sand
stratified drift
stratified drift (silty sand)
clay
sand
all sand/silt
60.00
50.00
40.00
30.00
20.00
0+000
0+020
0+040
0+060
0+080
0+100
0+120
0+140
0+160
0+180
0+200
0+220
0+240
0+260
0+280
0+300
0+320
0+340
0+360
0+380
0+400
0+420
0+440
0+460
0+480
0+500
0+520
0+540
0+560
water @ el. 18 m when lower fondation approval done
Meters


SILTY SAND
SANDY SILT
SILTY CLAY
SENSITIVE CLAY
SAND
SILTY CLAY
STRATIFIED DRIFT
UPPER SAND
SILTY CLAY
UPPER SAND
UPPER SAND


NOTES
SILTY CLAY + SILTY SAND/SAND LAYERS
UPPER SAND
STRATIFIED DEPOSIT
SILTY SAND
SANDY SILT
SILTY CLAY
SAND
SENSITIVE CLAY
STRATIFIED SILTY/CLAYEY SANDY LAYERS
***** DATUM REFERENCE: ALL ELEVATIONS ARE IN METRES REFERENCED TO GEODETIC. COORDINATE REFERENCE:

PICTURES UPSTREAM

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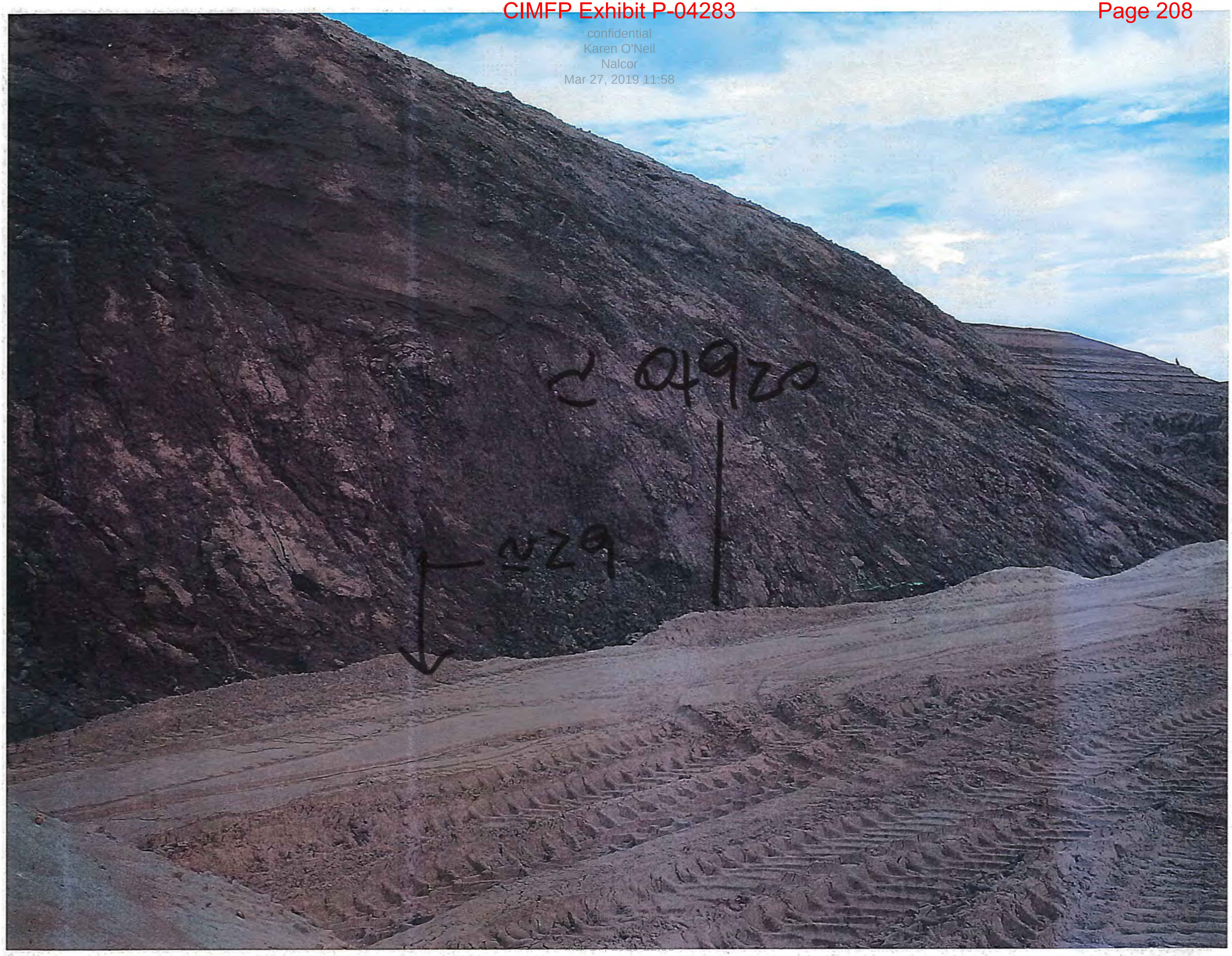
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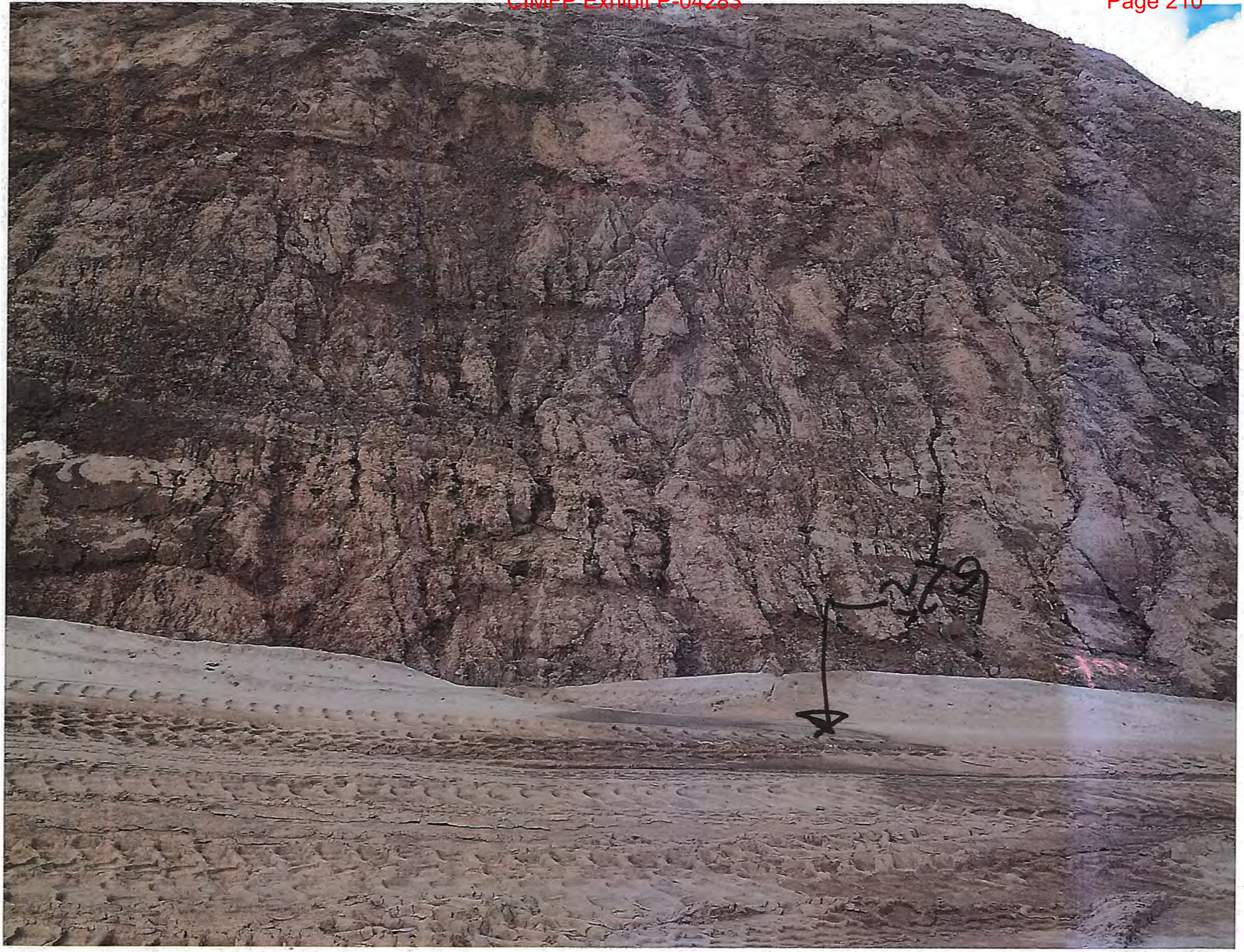
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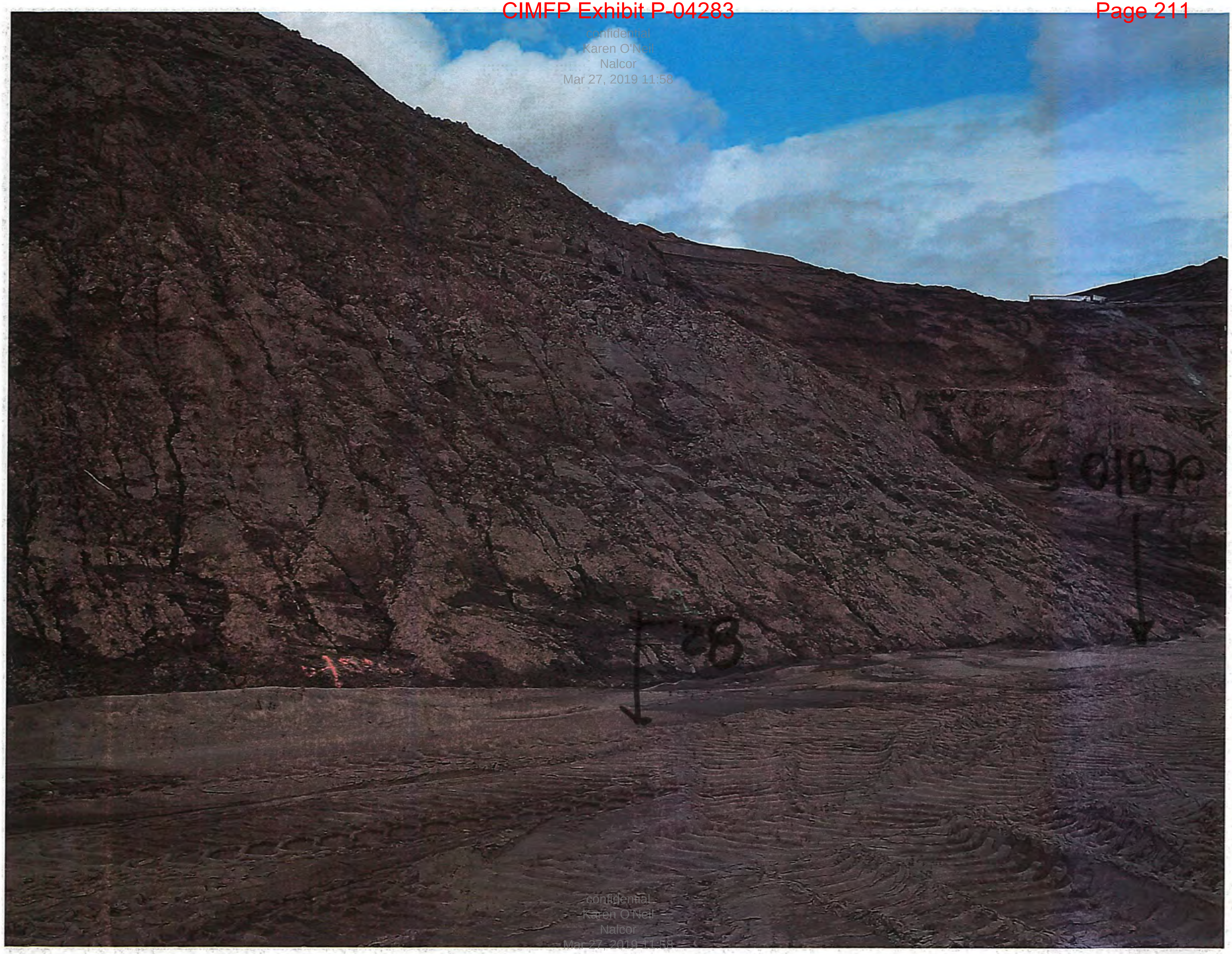

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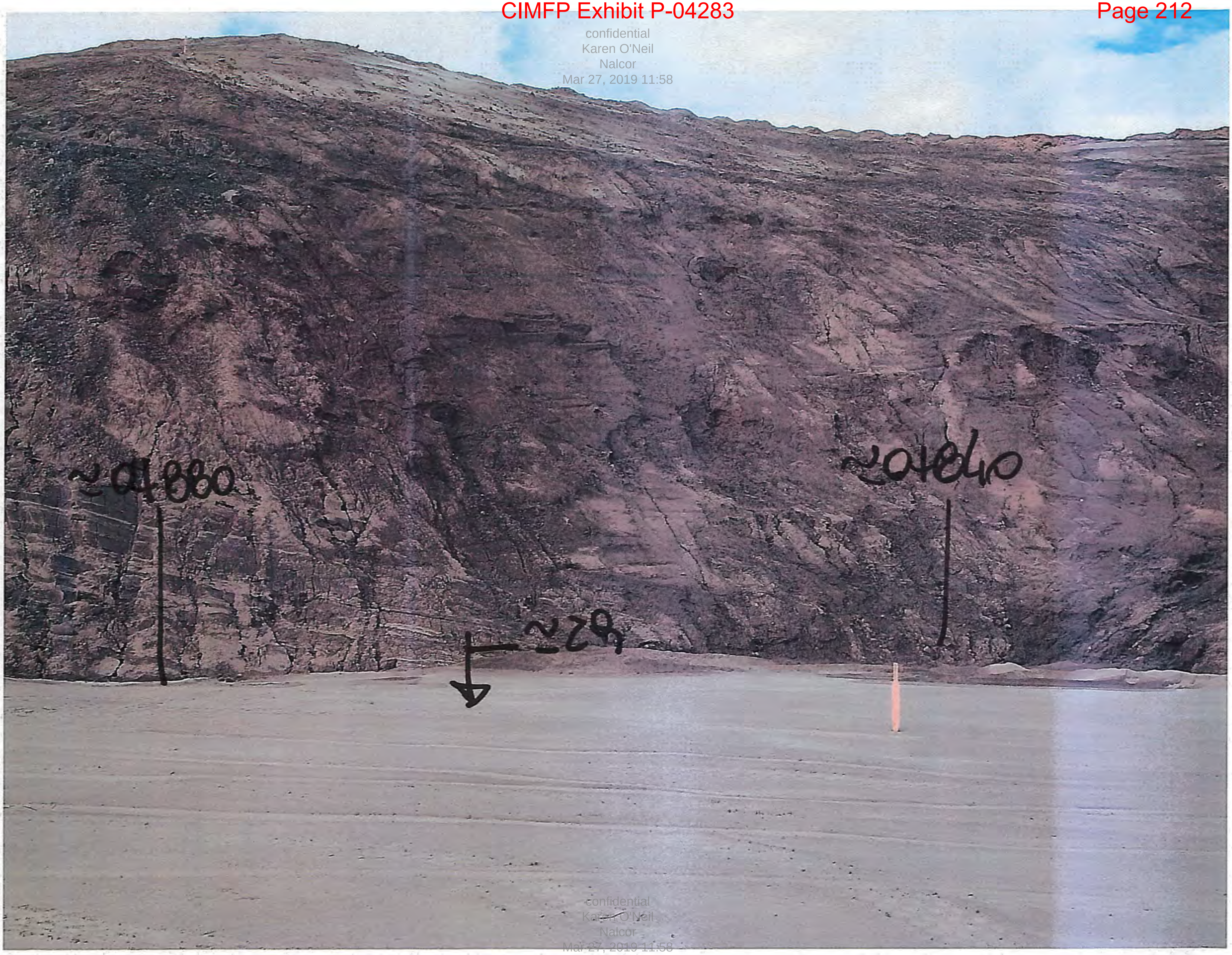
Nalcor
Mar 27, 2019 11:58



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Mar 27, 2019 11:58


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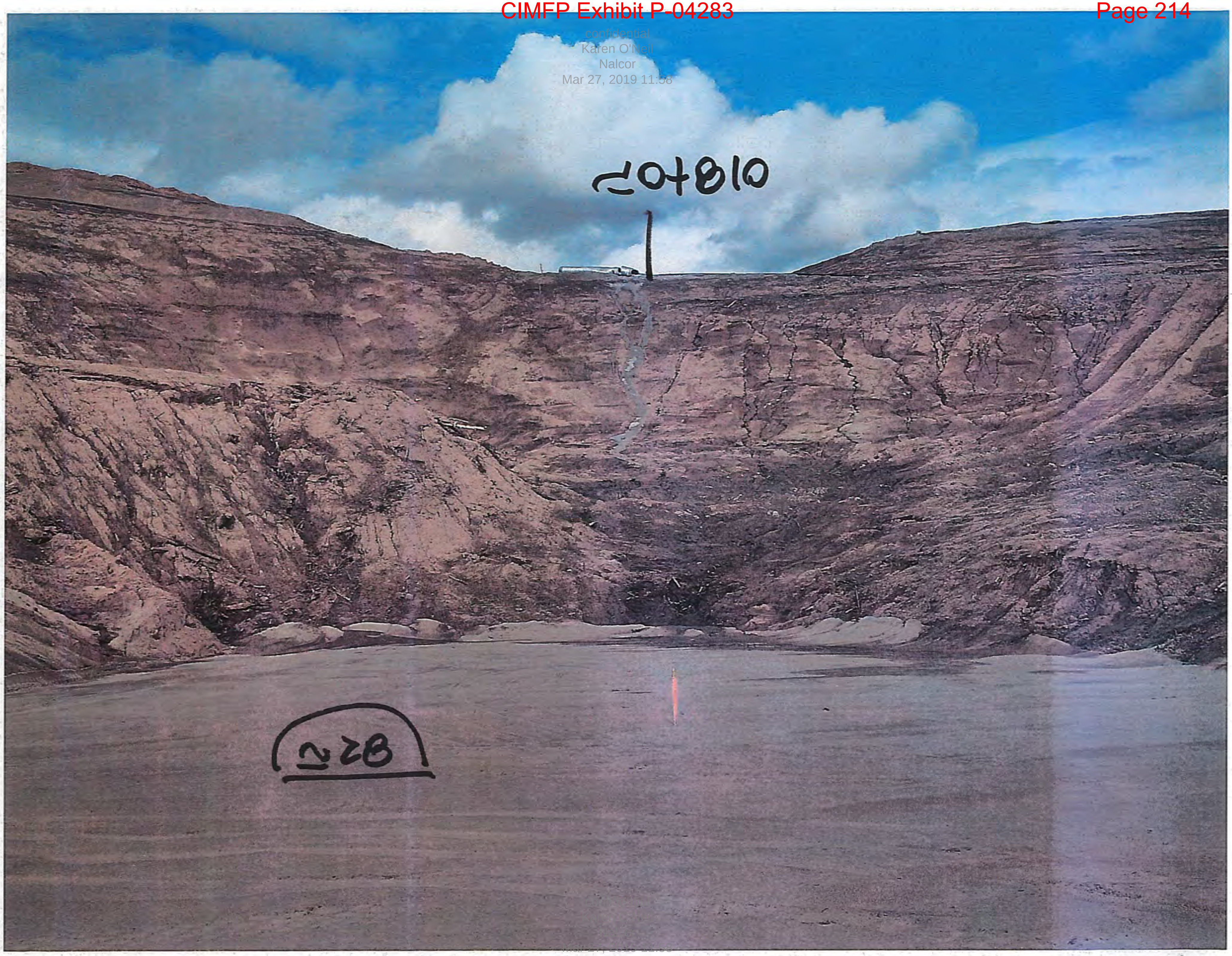

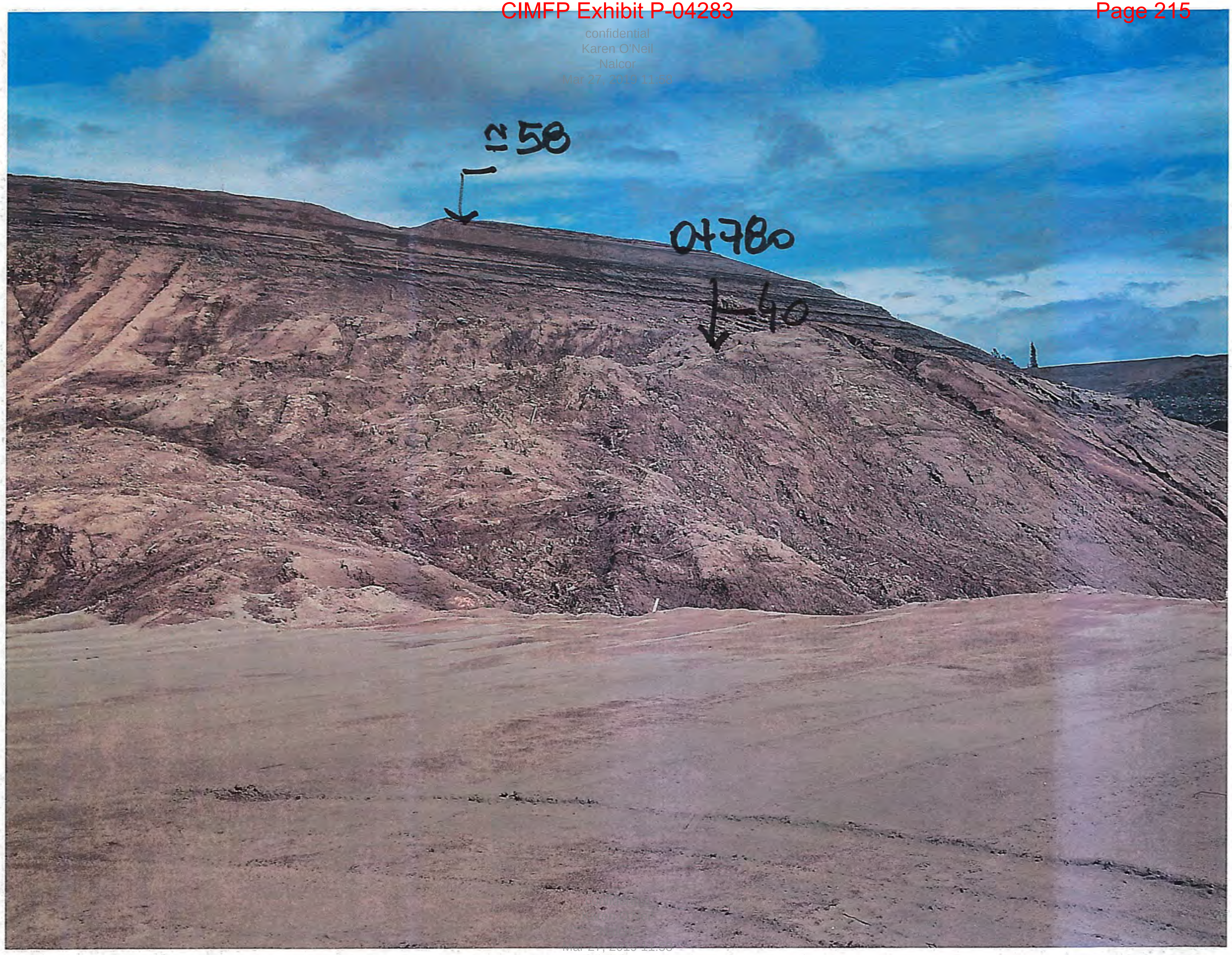
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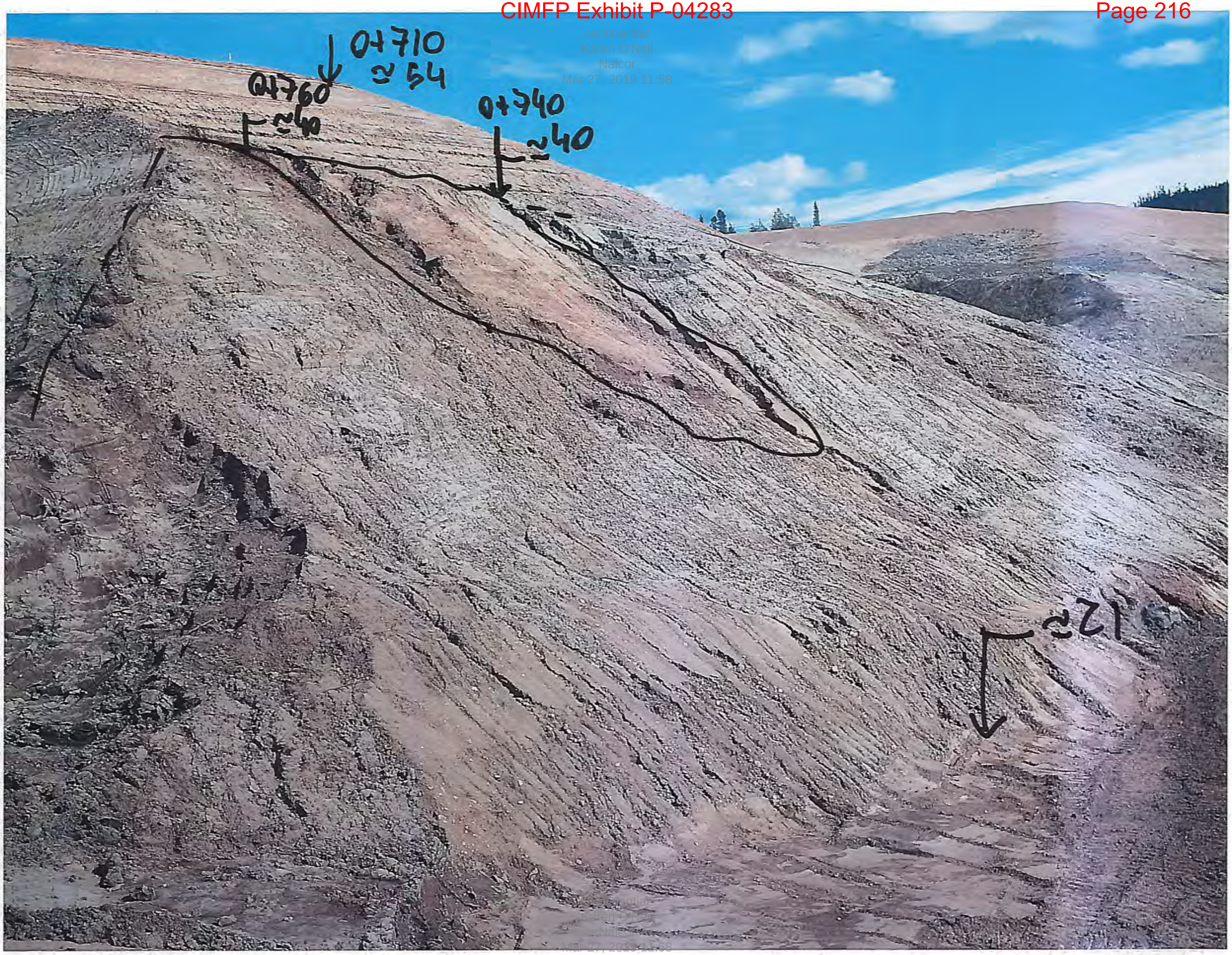
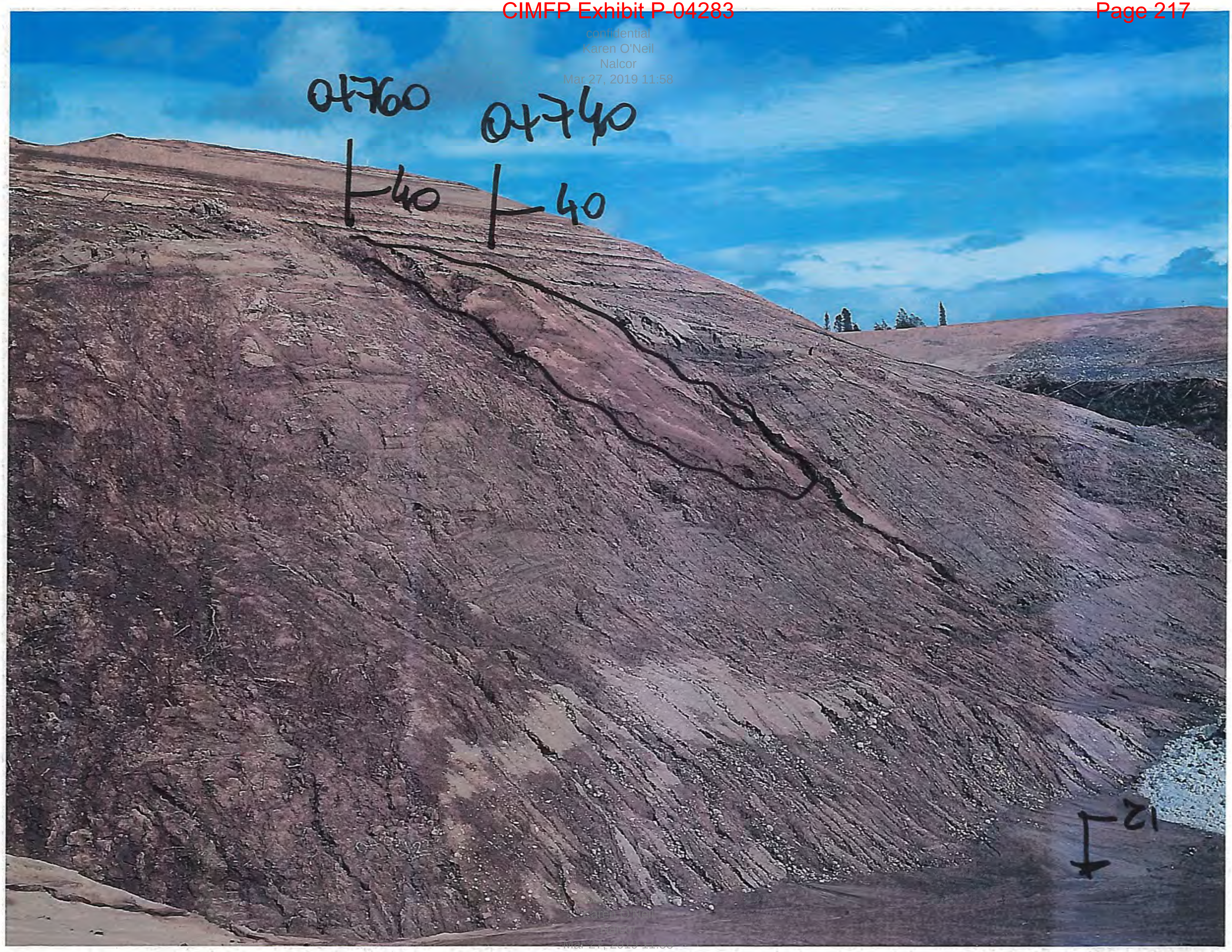
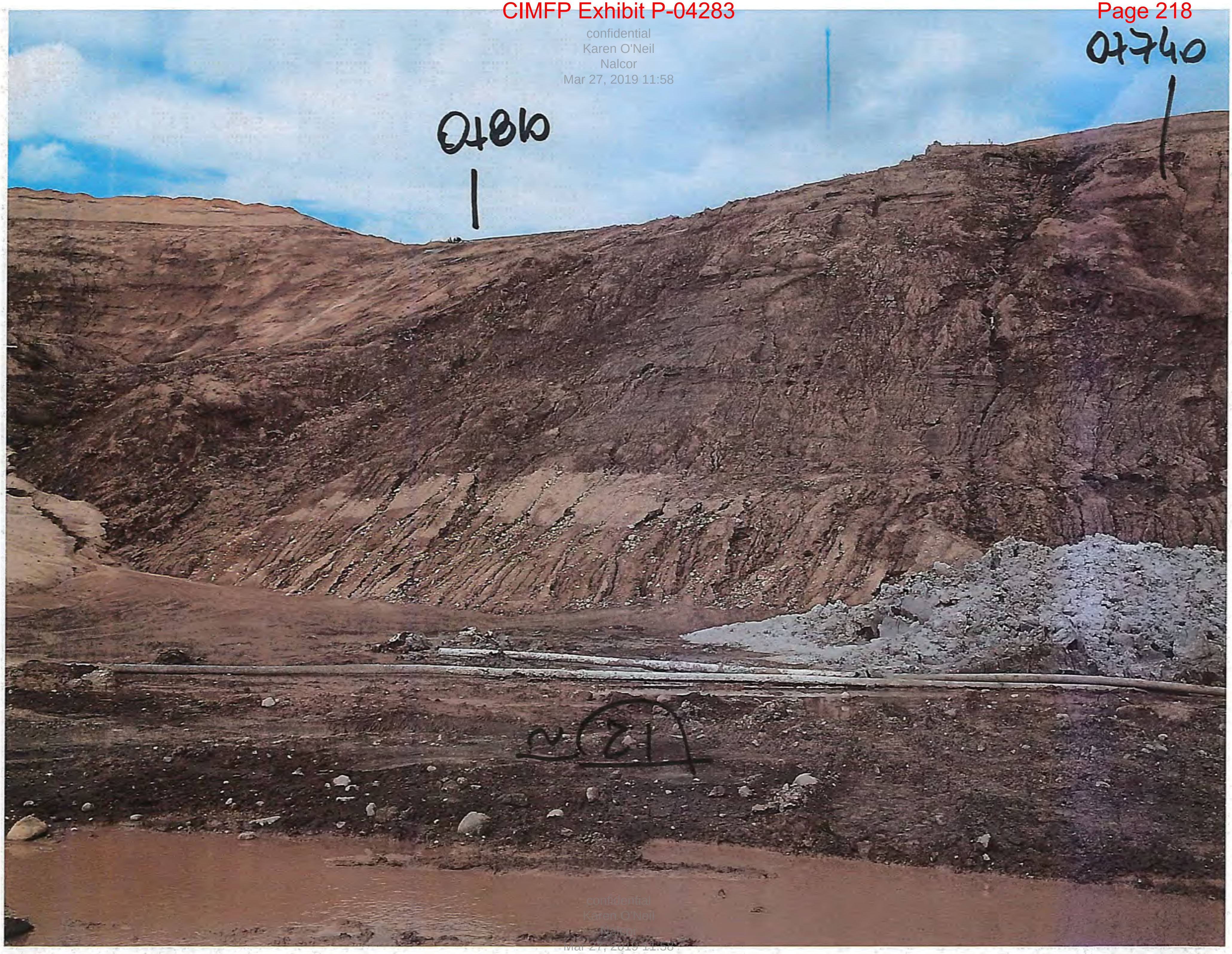

0+710
≃54
0+760
≃40
0+740
≃40
≃21


0+760
40
0+740
40



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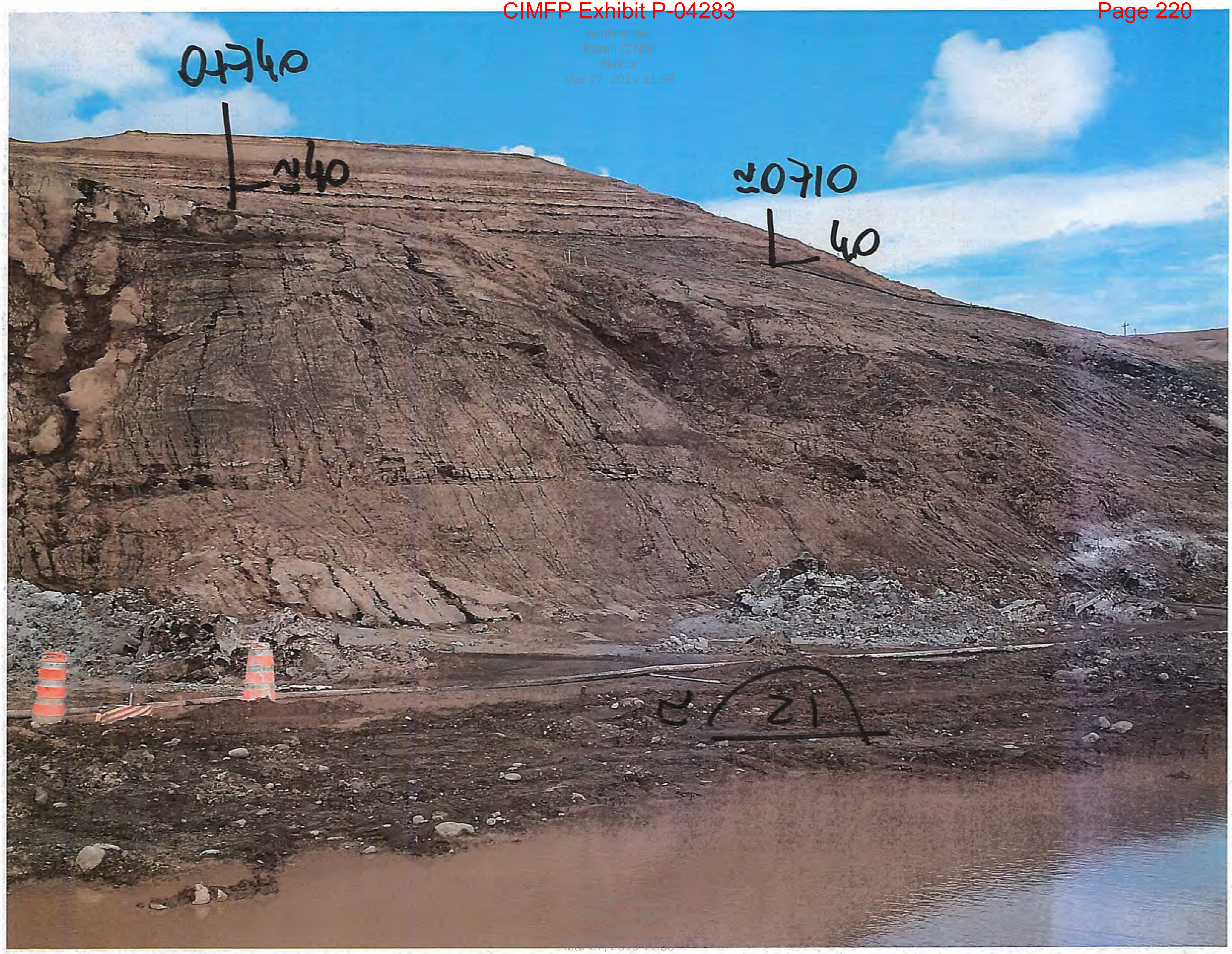
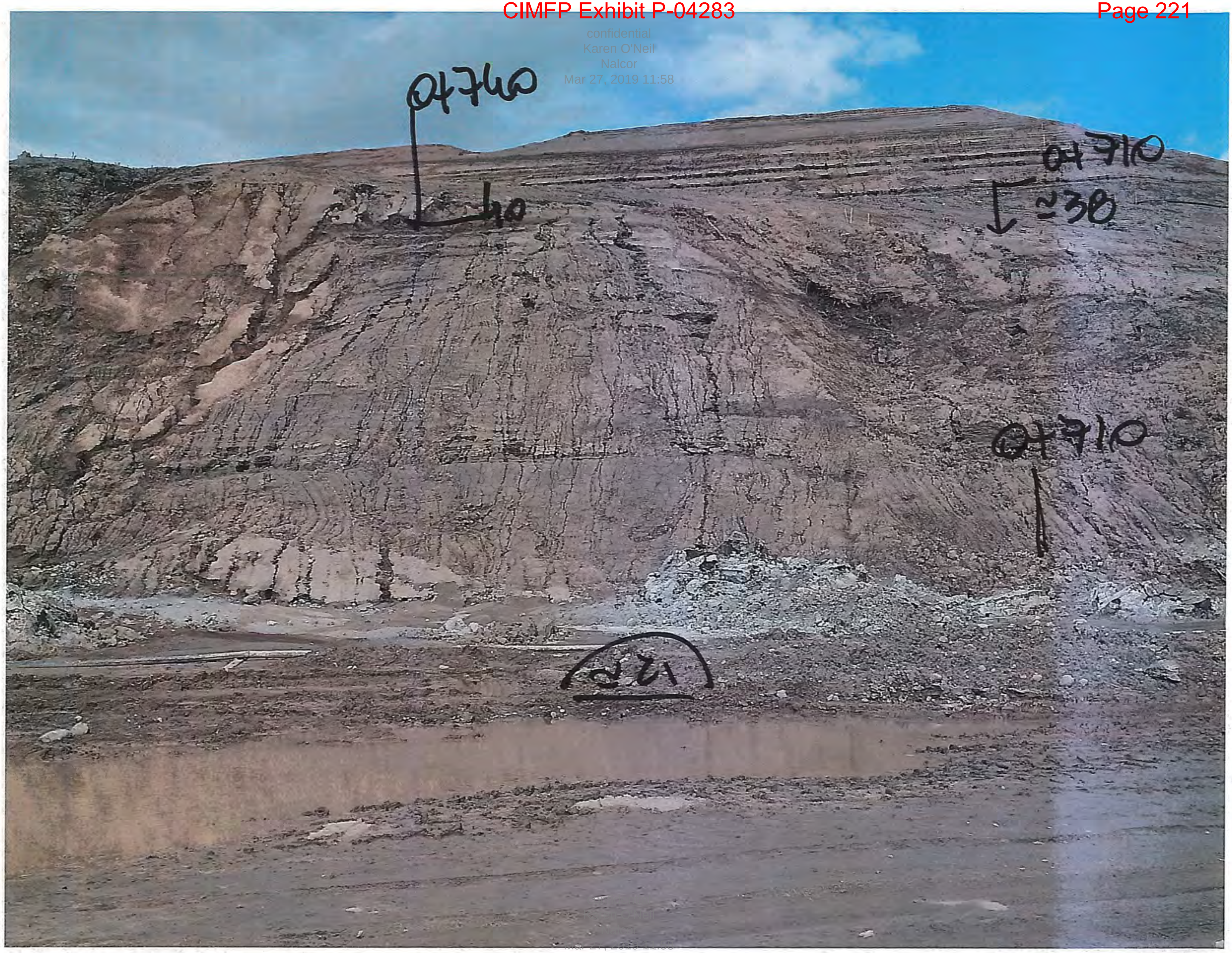
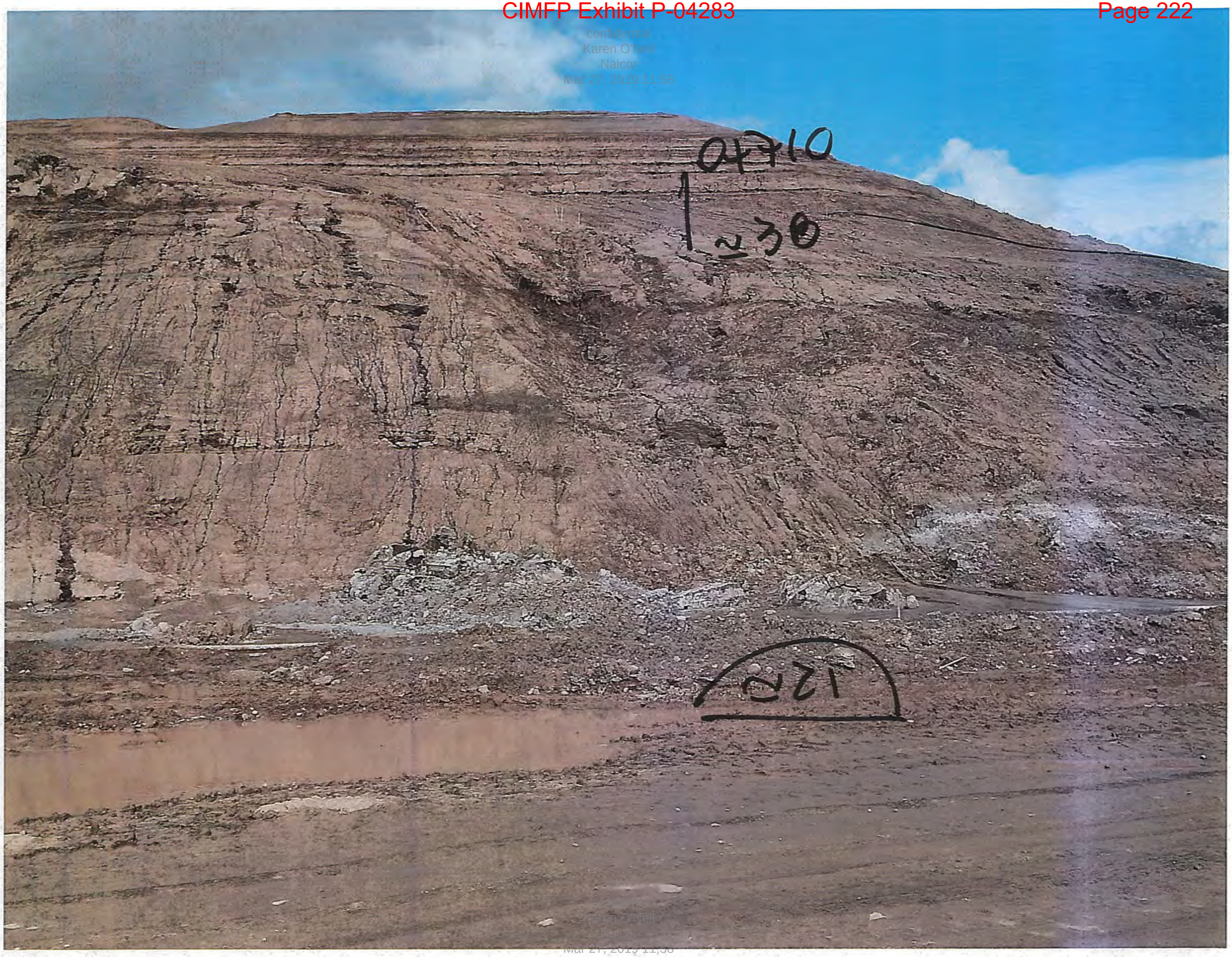
0+740
40
21


0+740
≈40
≈0+710
40


0+760
40
0+710
≈38
0+710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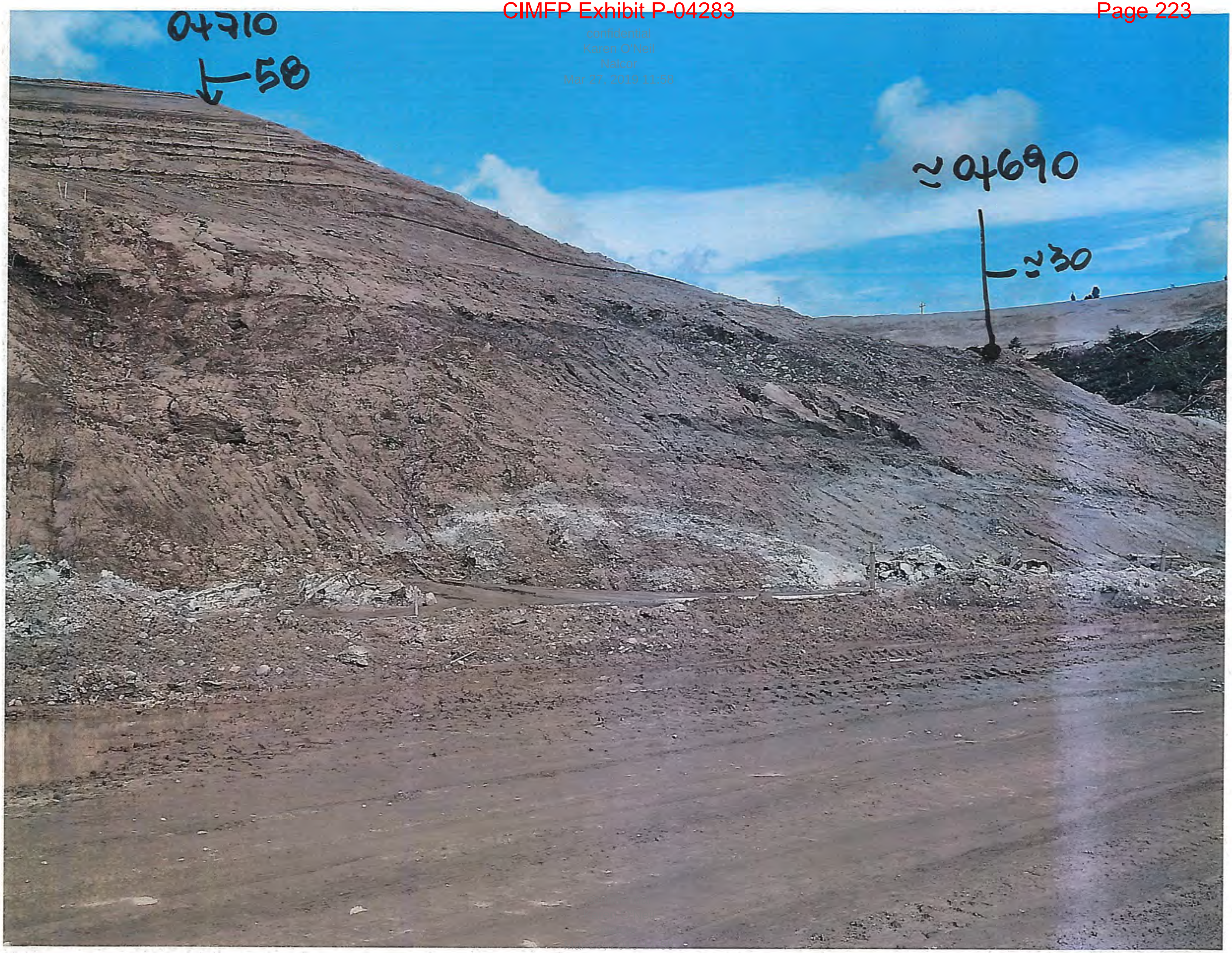
≈30


0+710
58
≈0+690
≈30

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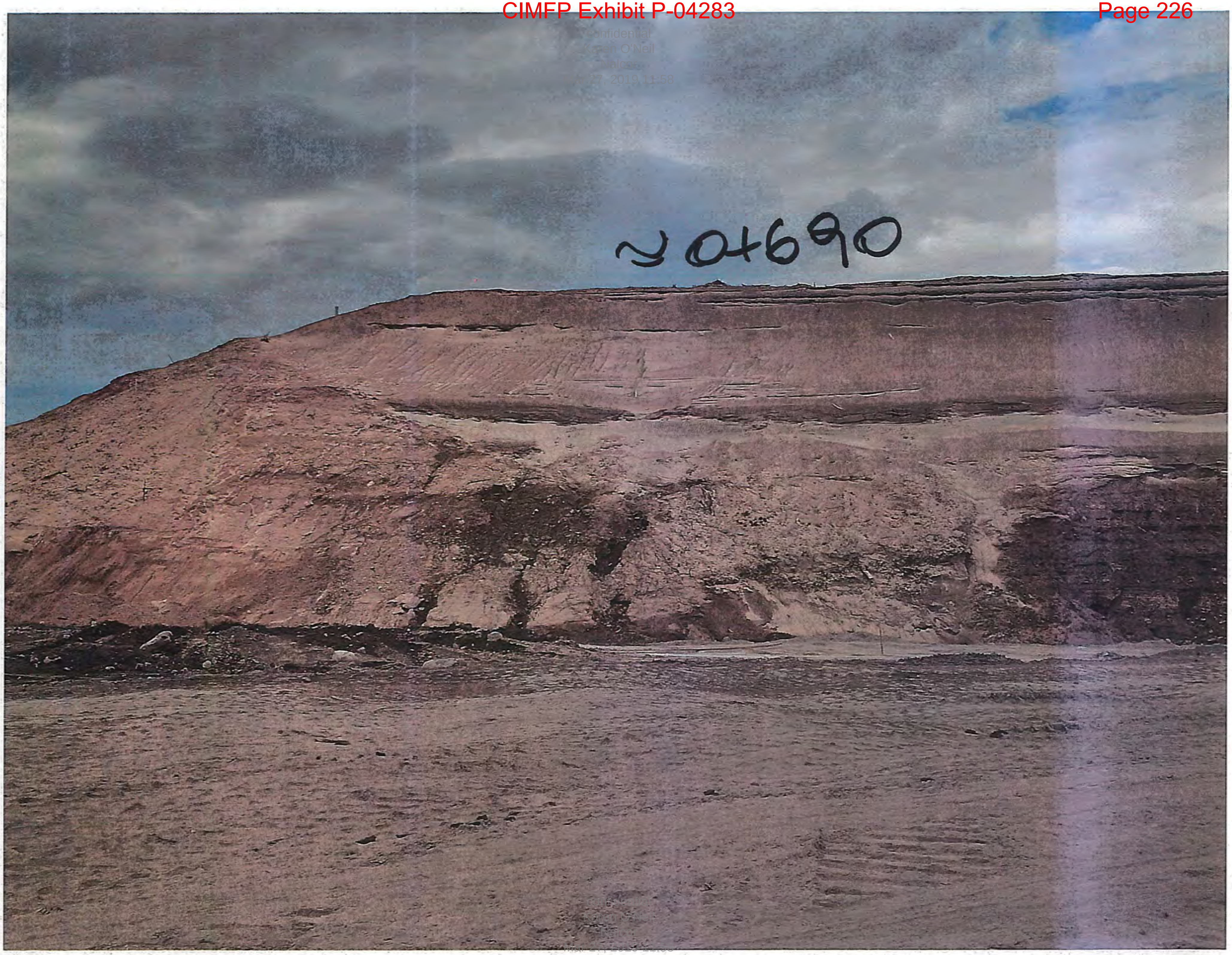
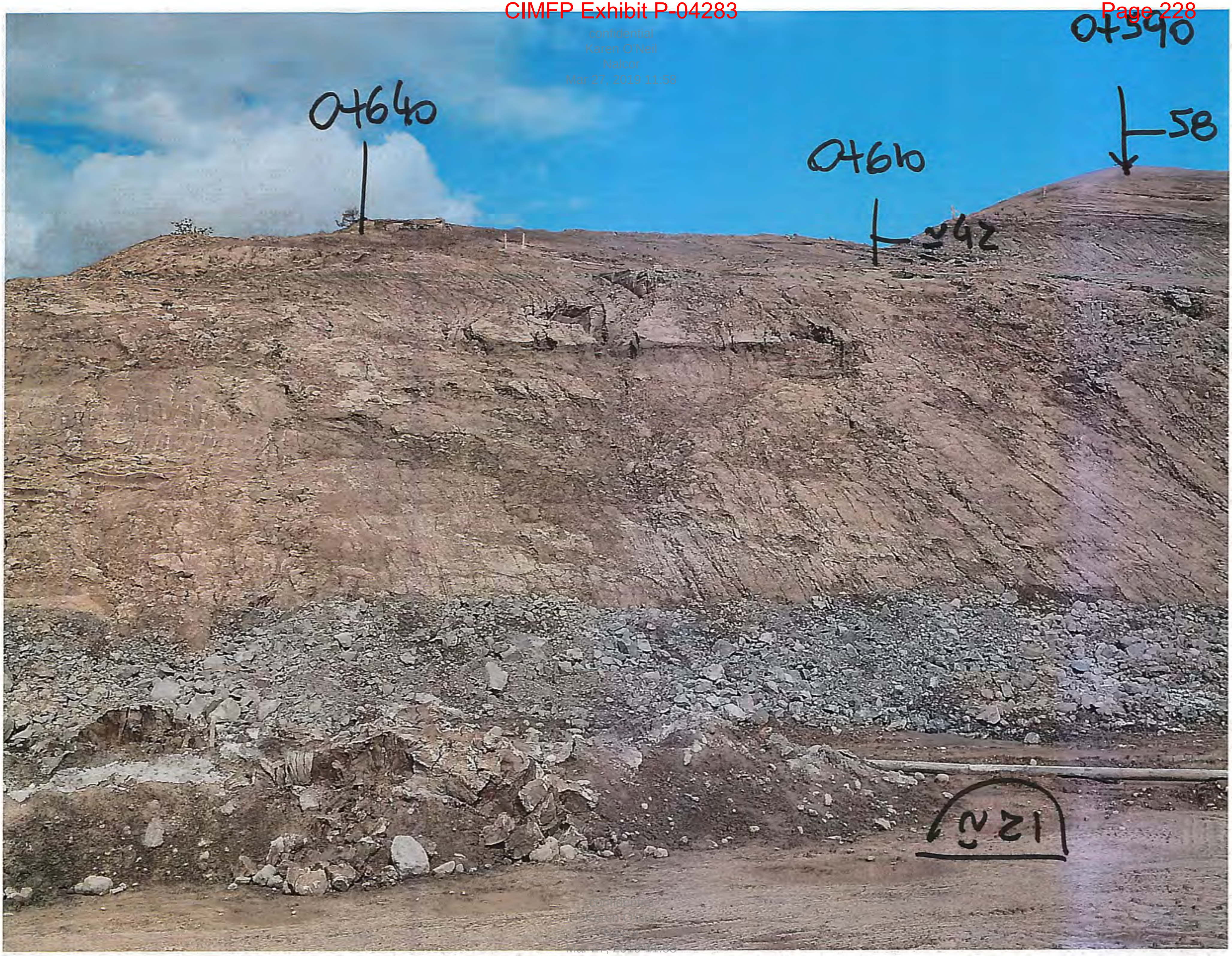
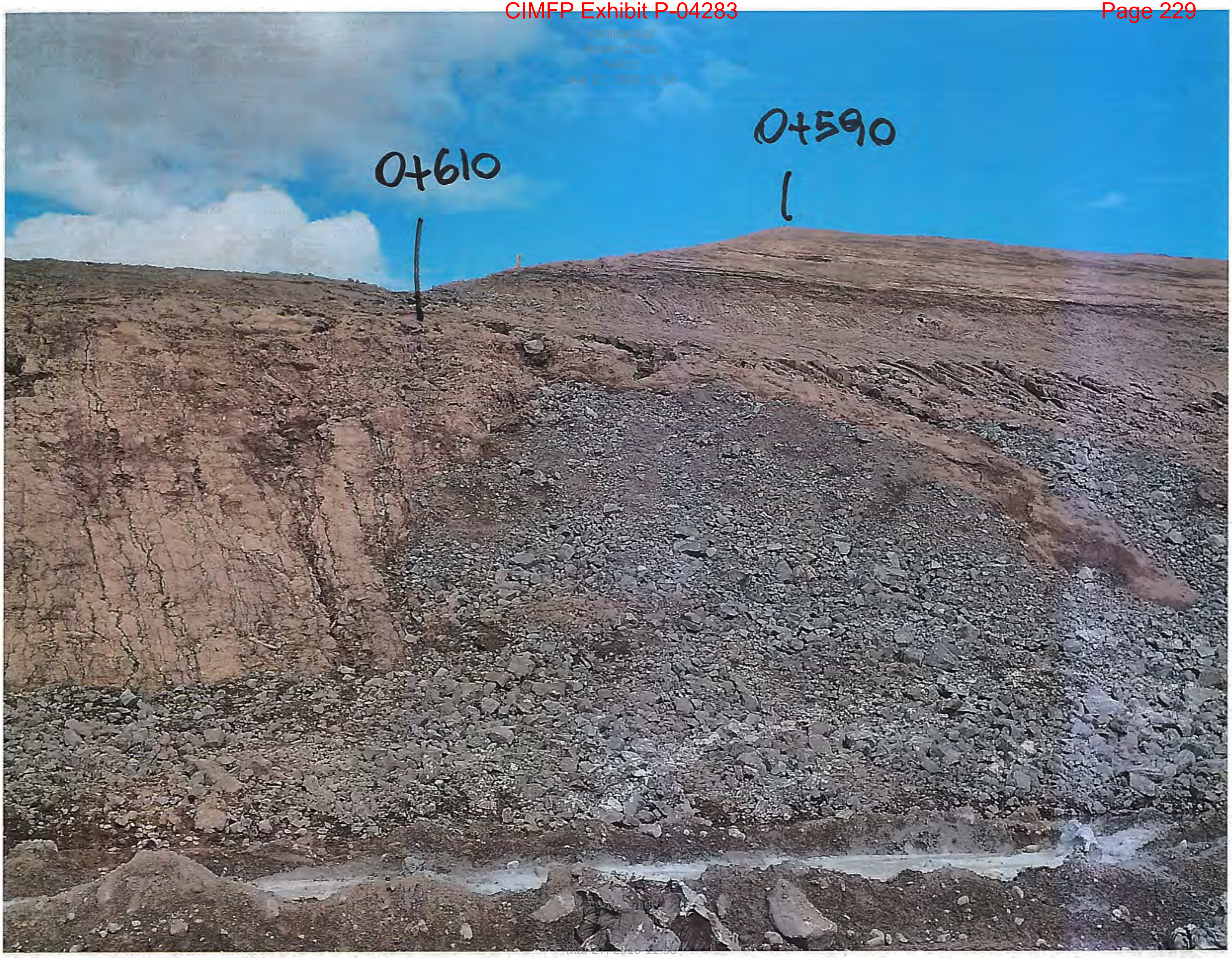
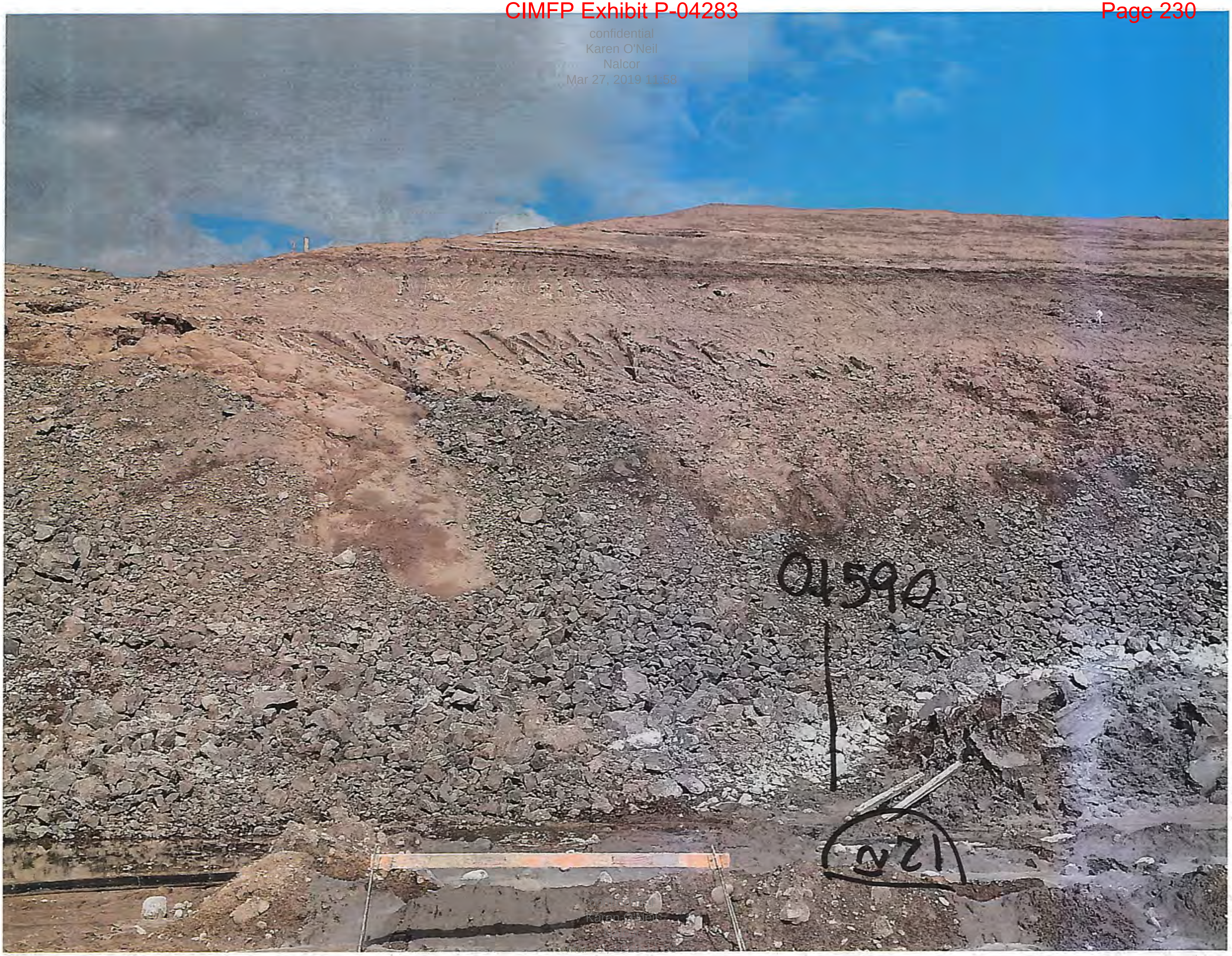
≃690
≃30
≃21


~0+690

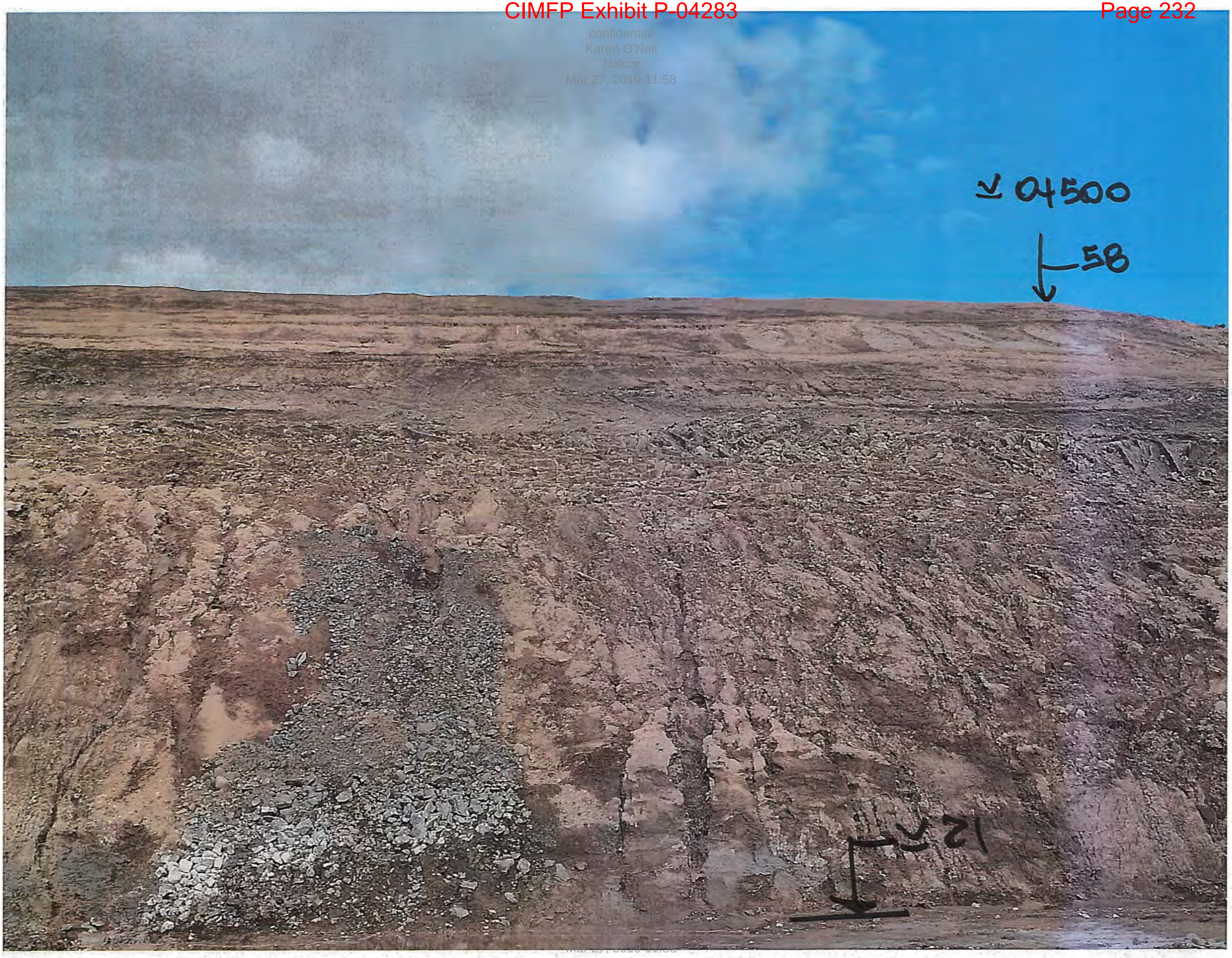

≈ 0+620

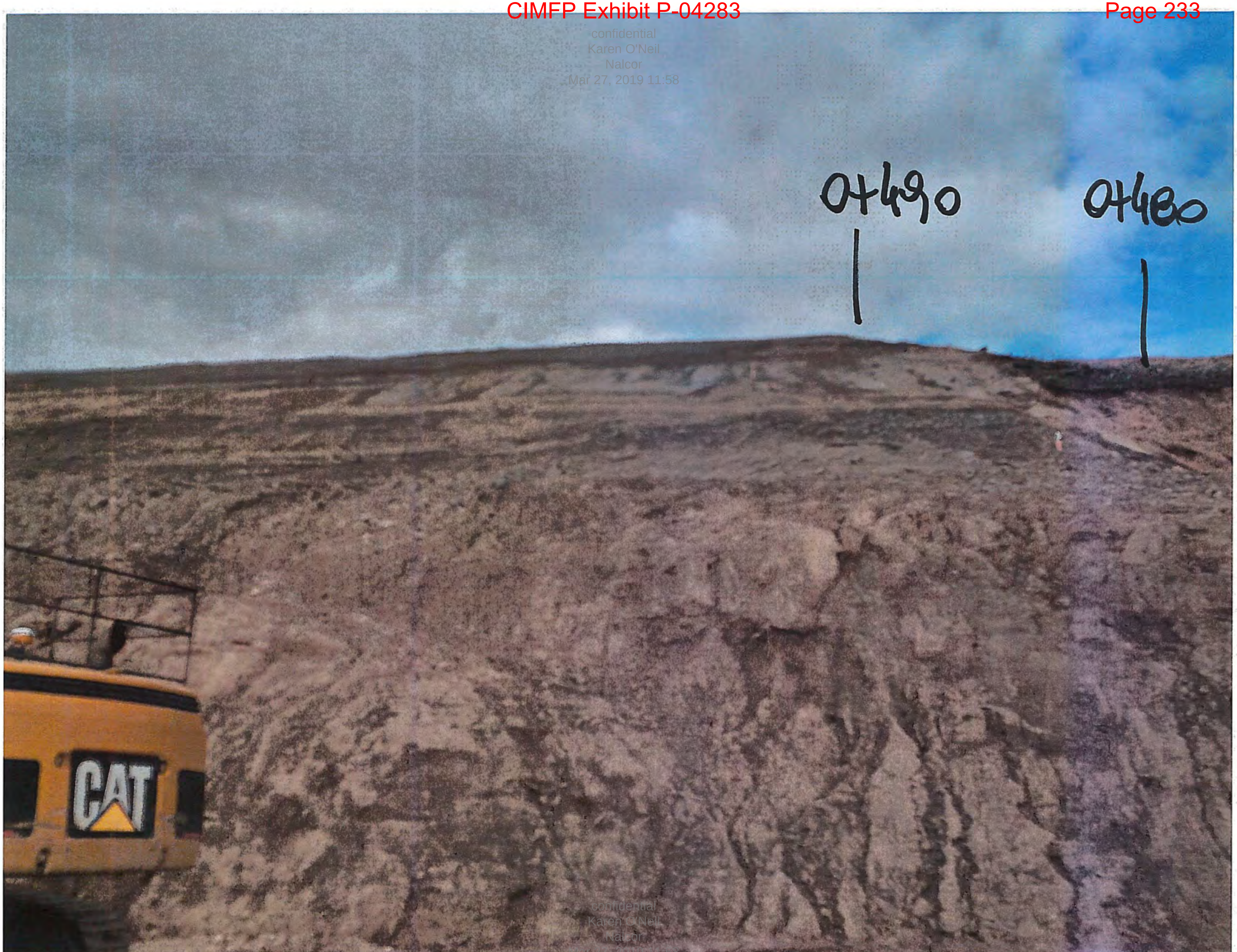

0+640
0+610
42
0+590
58
N21


0+610
0+590


04590
N21


0+590
221


∨ 04500
58
∨ 21


0+490
0+480
CAT


≃0+980
36

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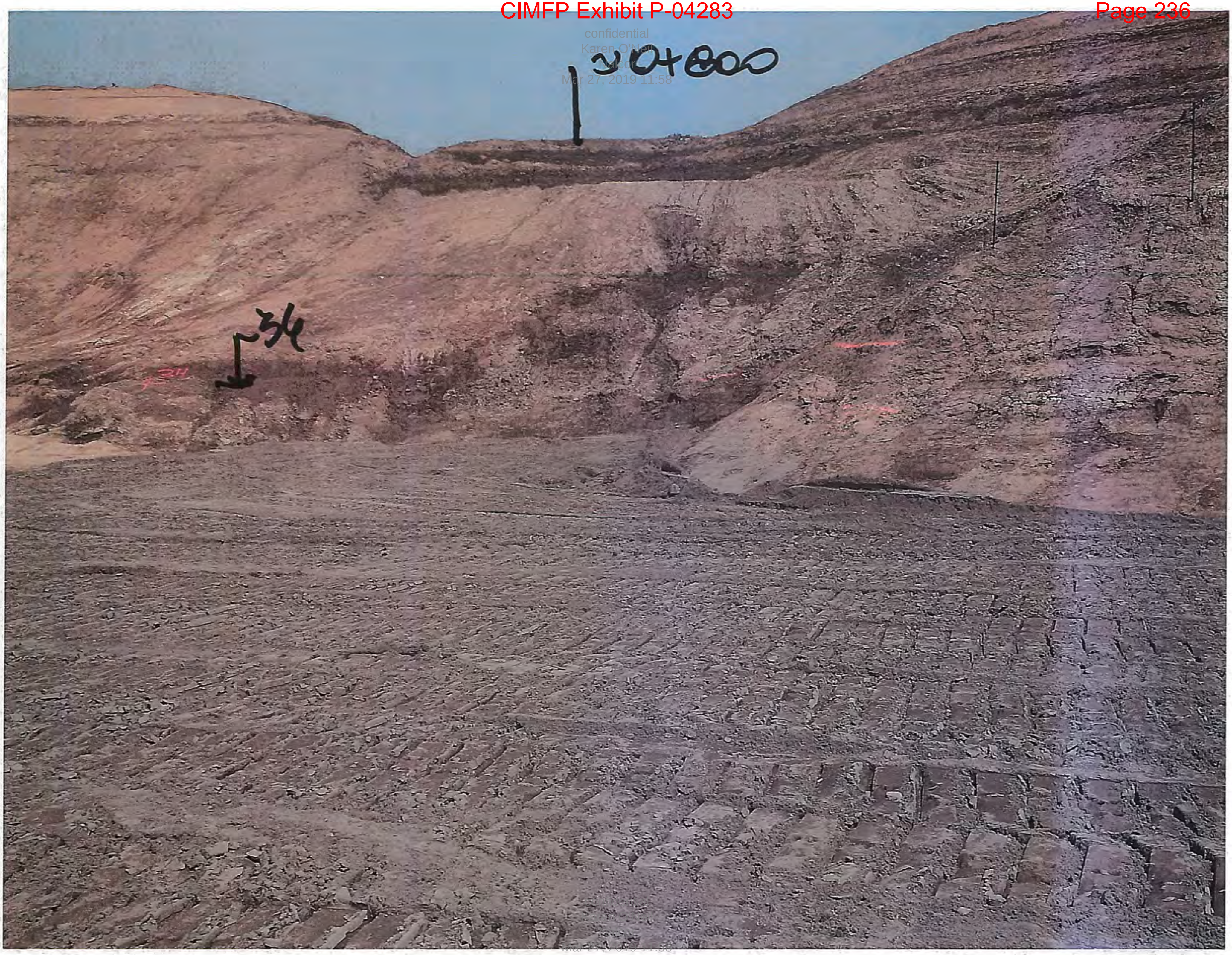
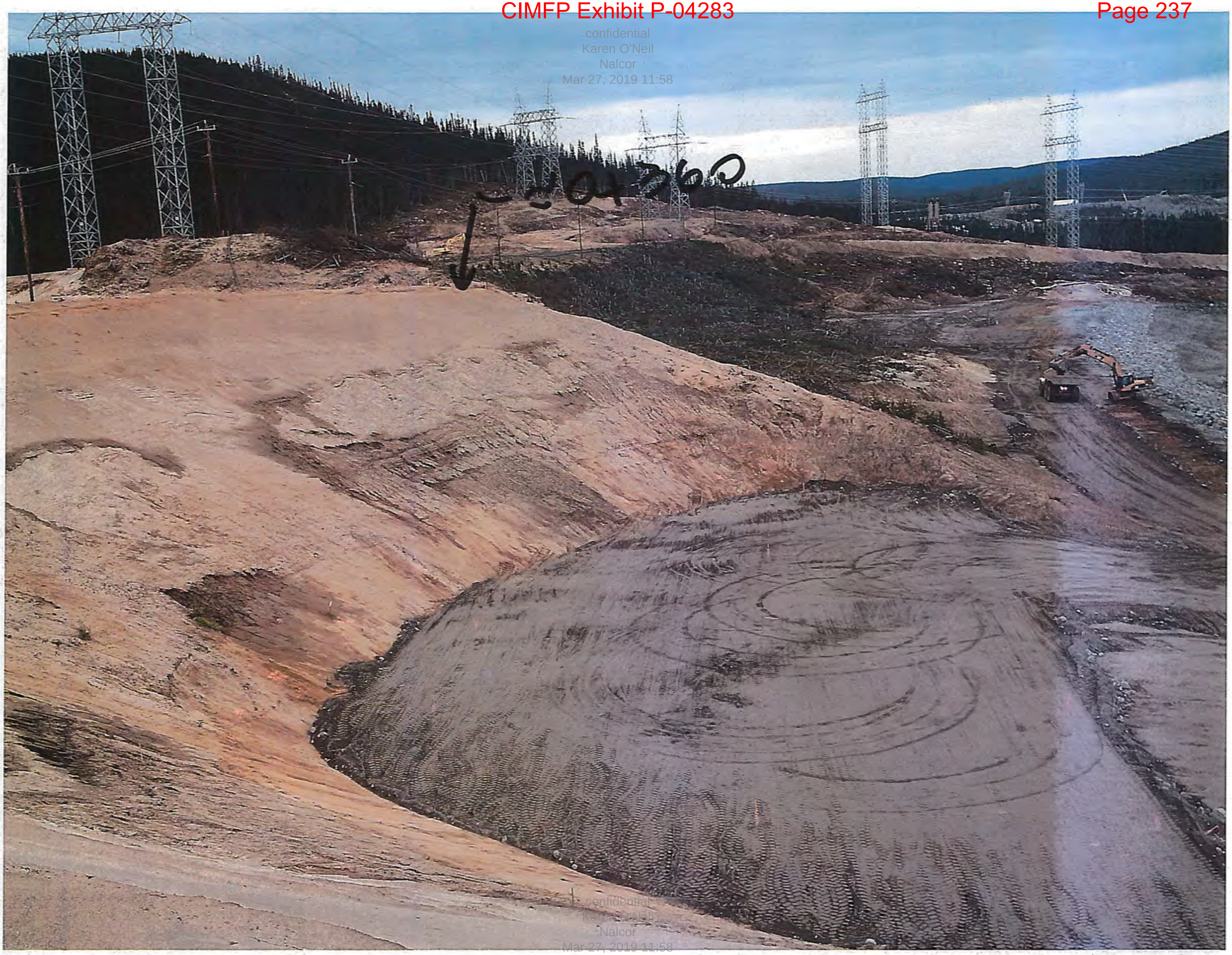
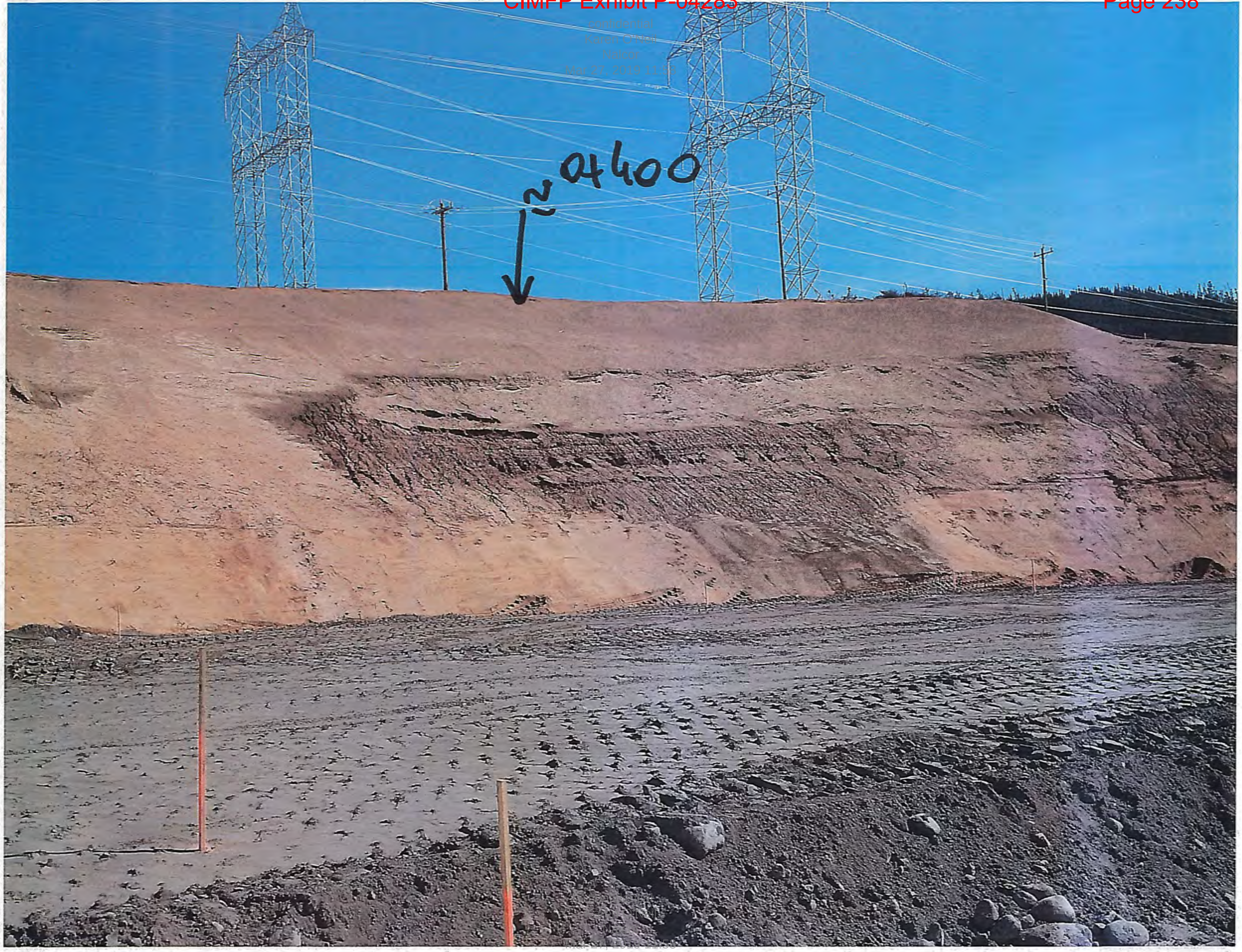
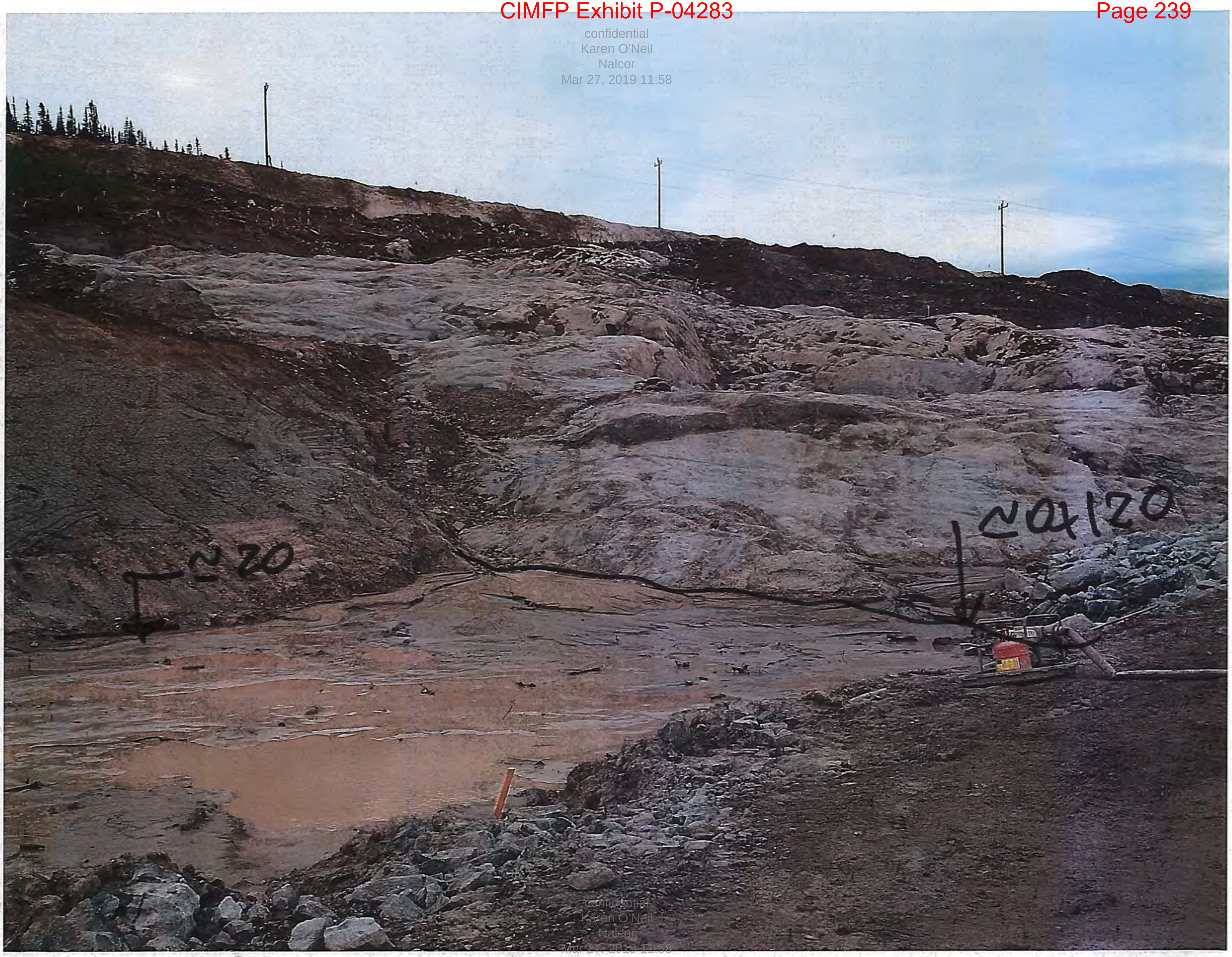
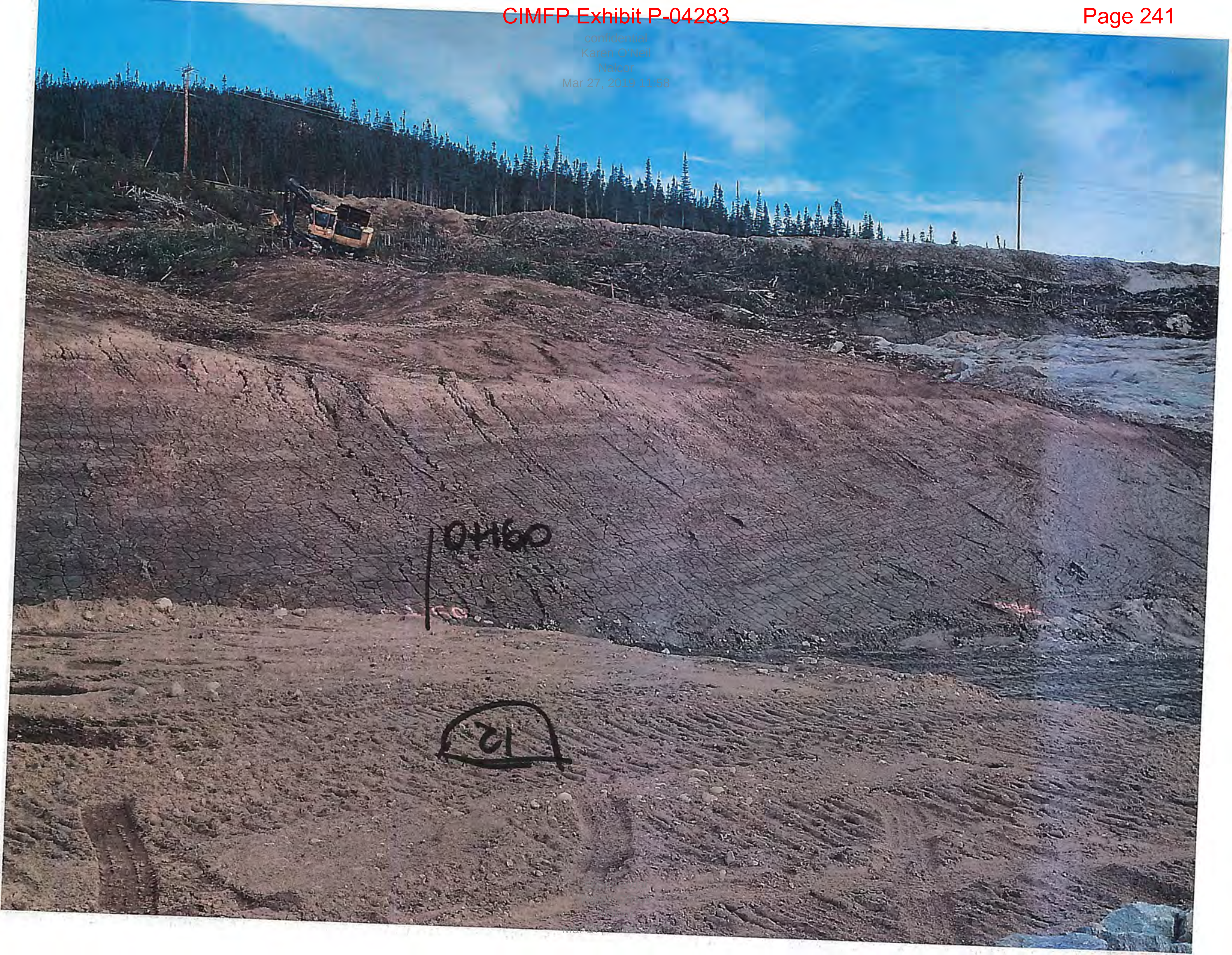

20+800
34


~20+360


≈ 0+400


~20
~0+120

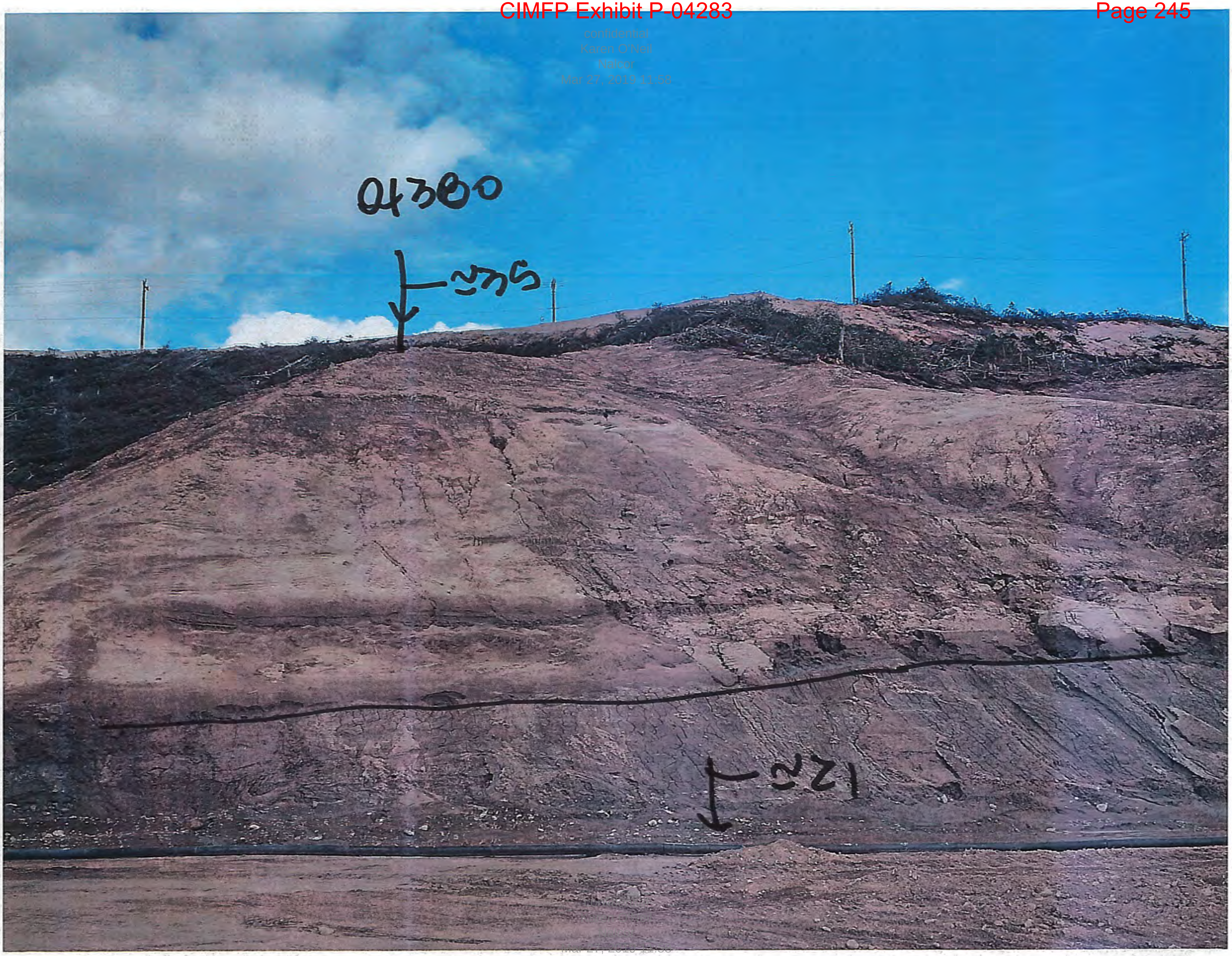

≃04115
21


0+160
12


0440
~34

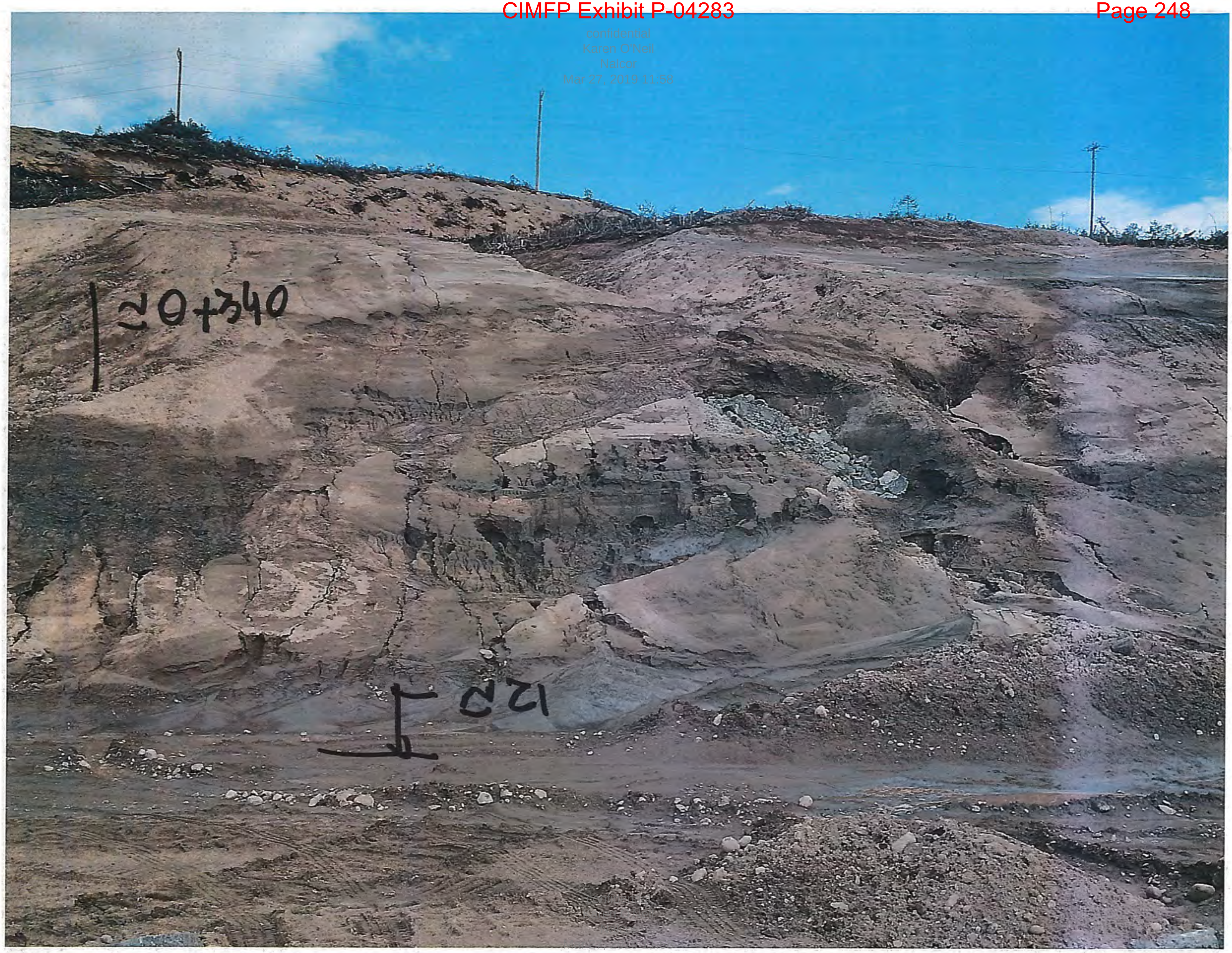

0+480


0+380
~235


04300
~375
~321

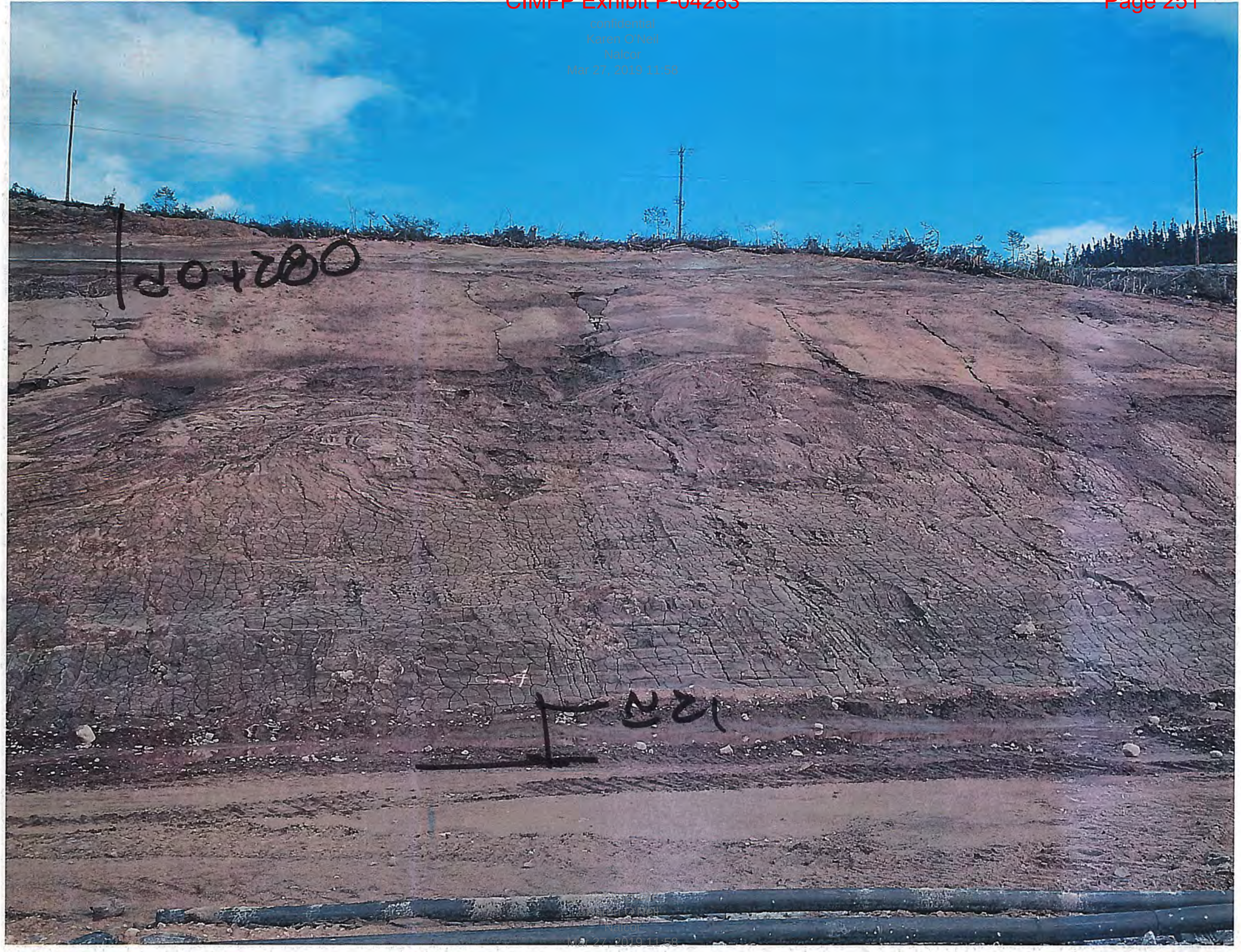

≃ 0+360
≃ .32
≃21


≃0360
≃332

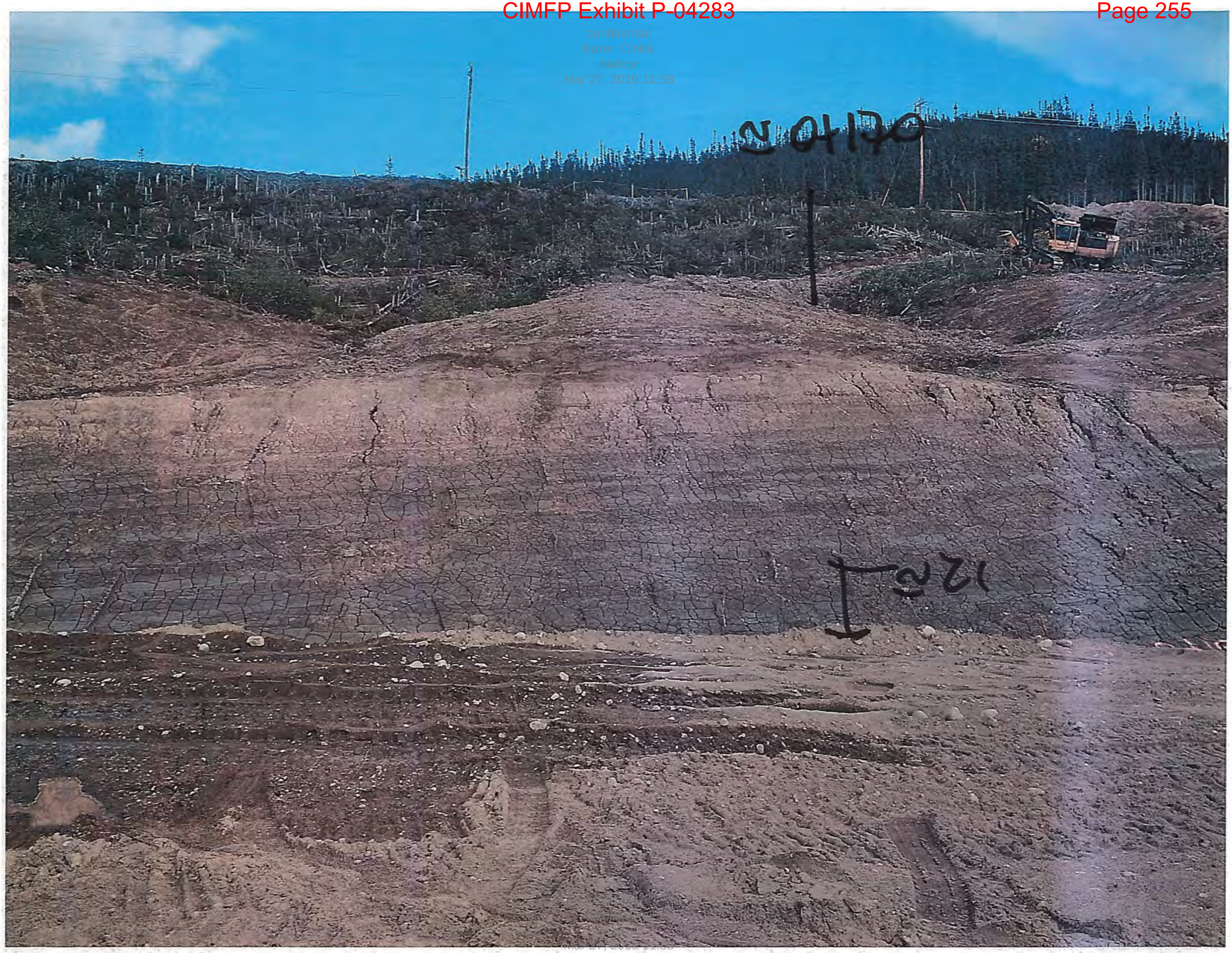


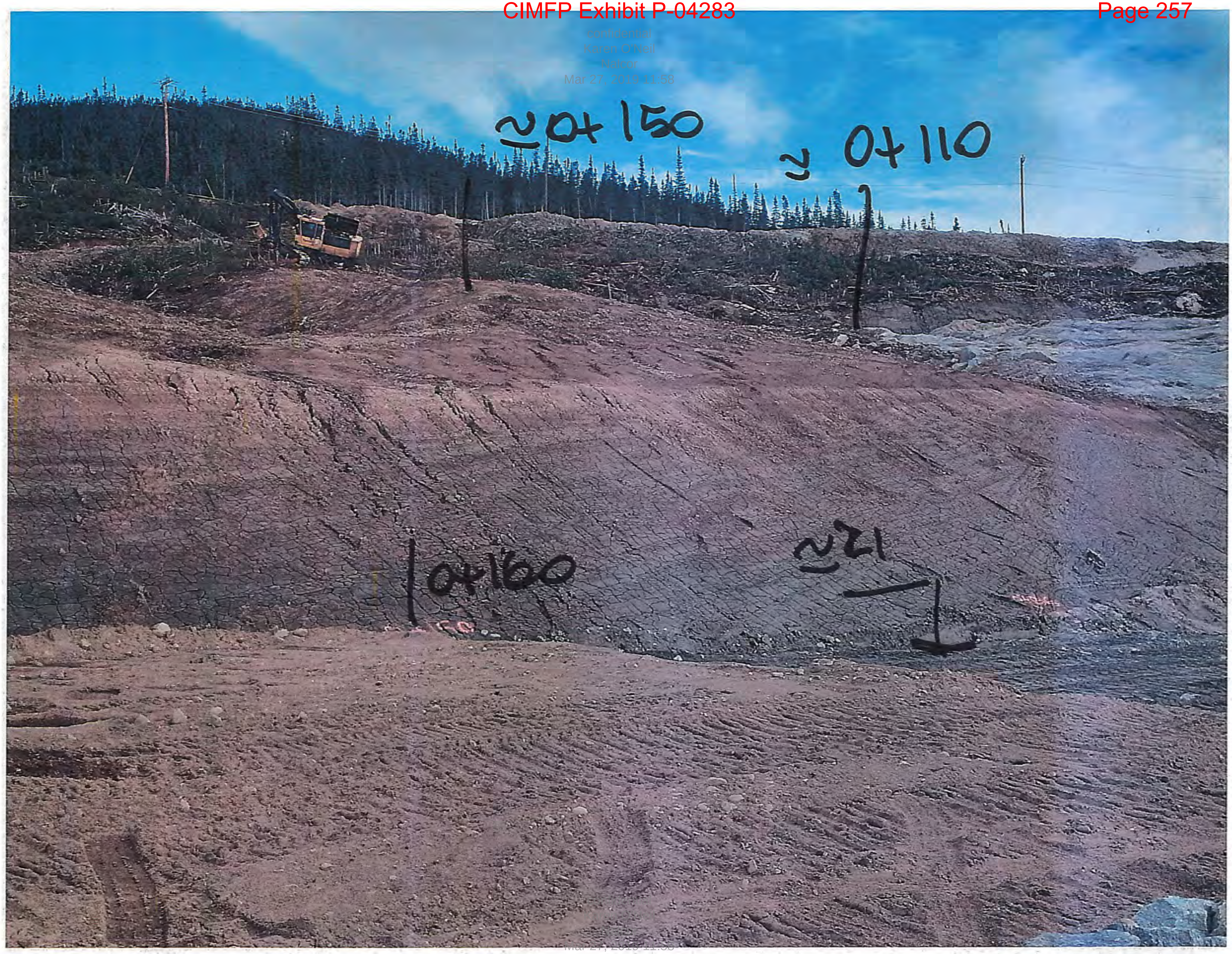

℄ 0+320


~300
~321

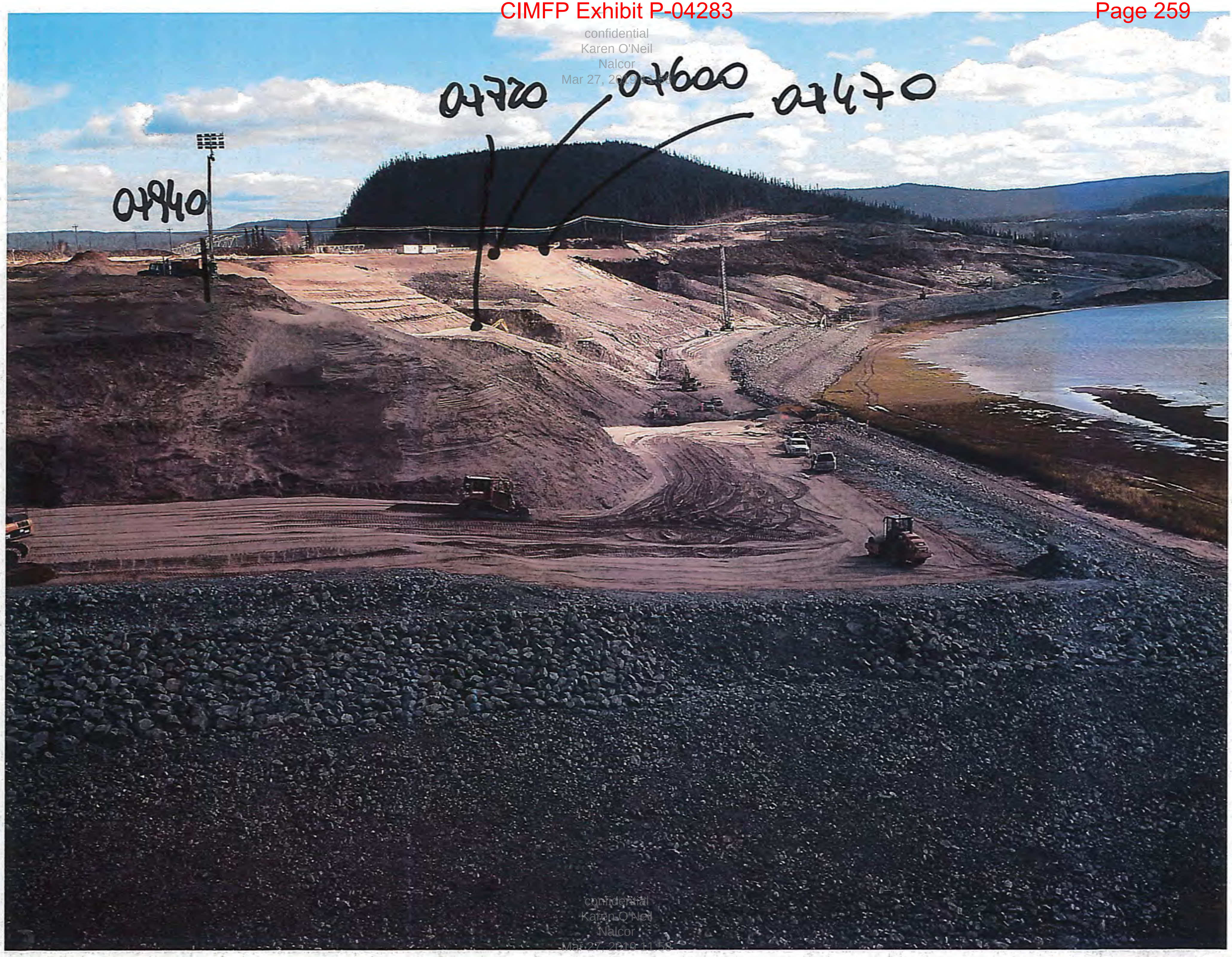


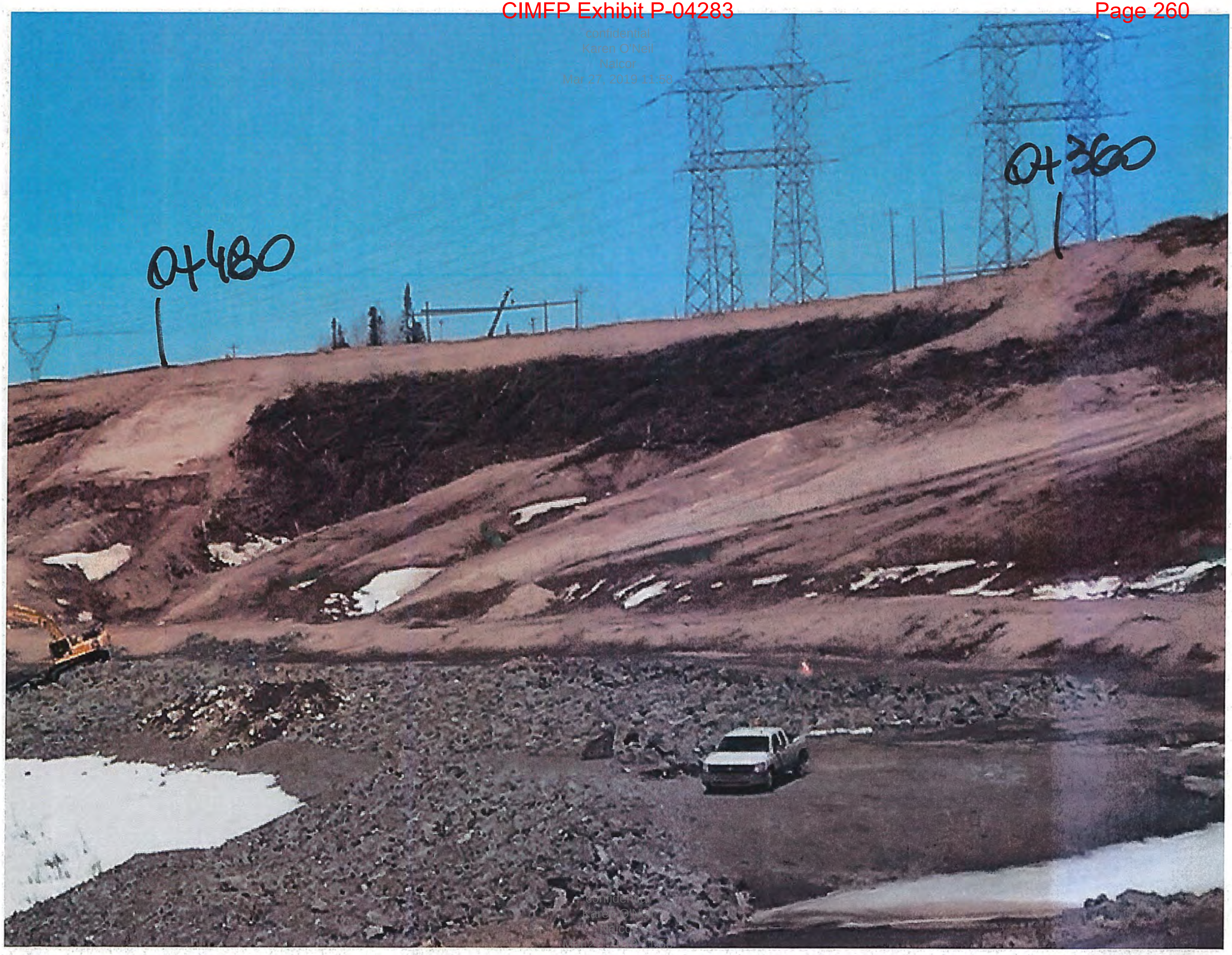

C0+240

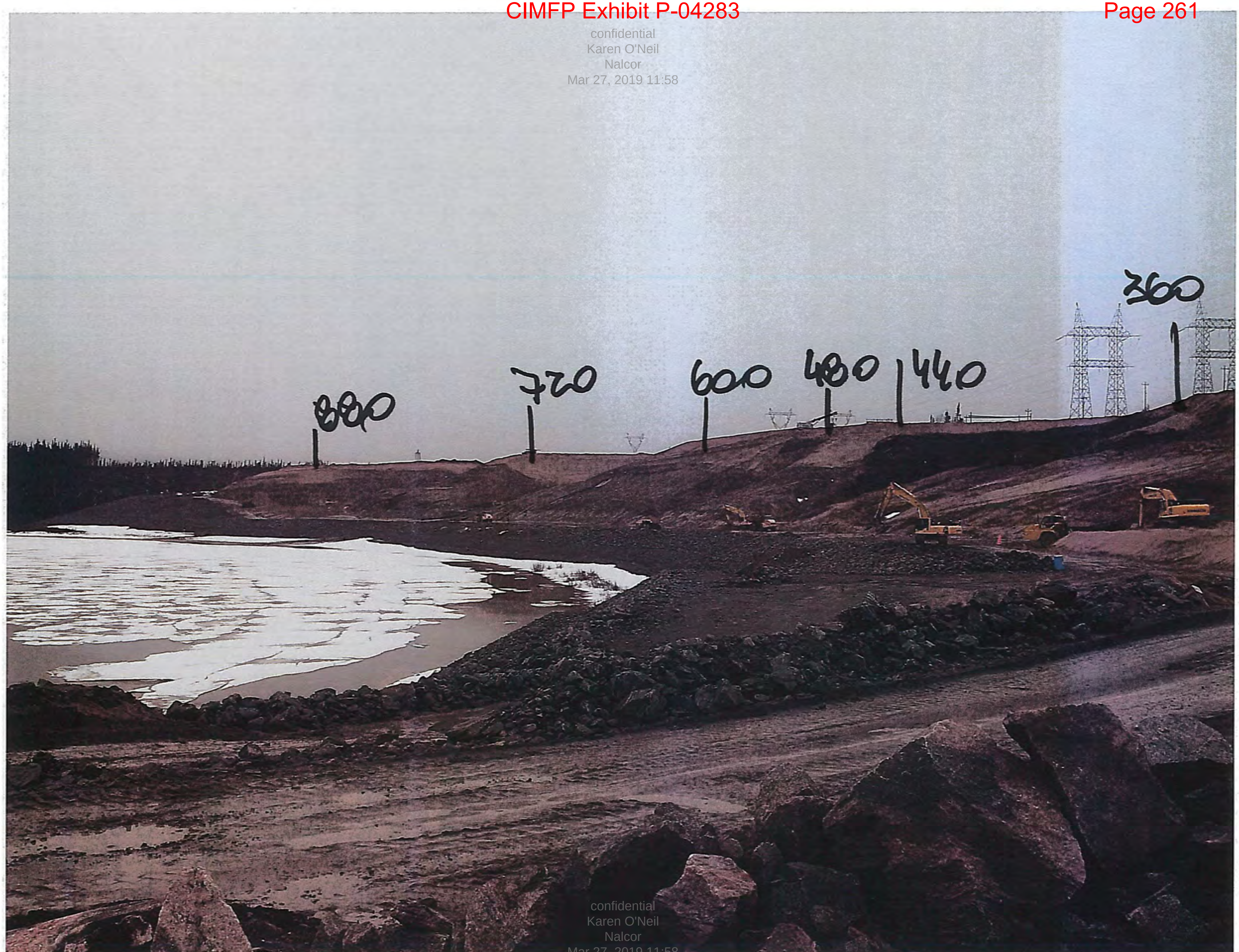



≃0+150
≥ 0+110
0+160
≃21


20+100


0+840
0+720
0+600
0+470


0+480
0+360



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480
360


0+700
0+600
0+480

PICTURES DOWNSTREAM


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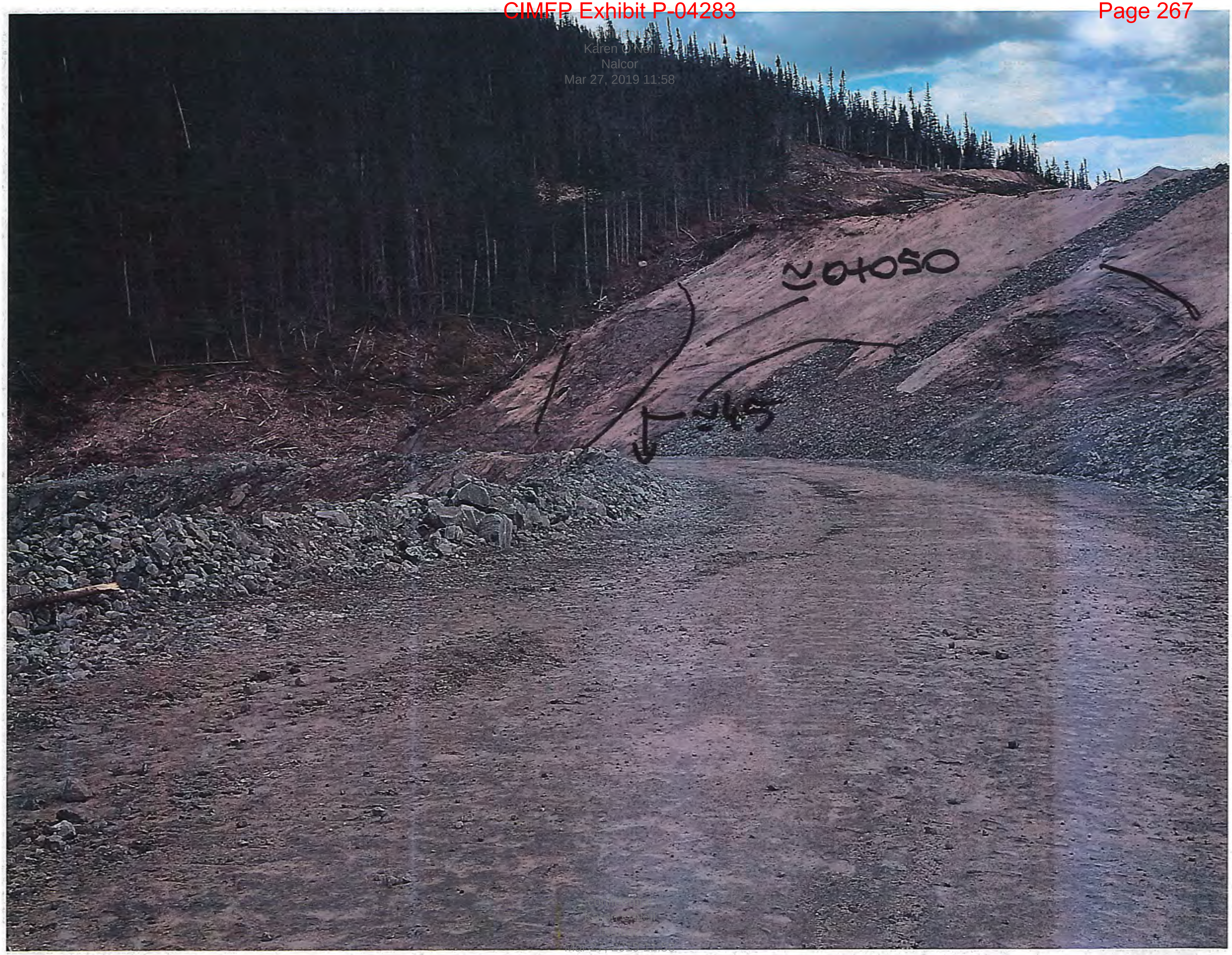
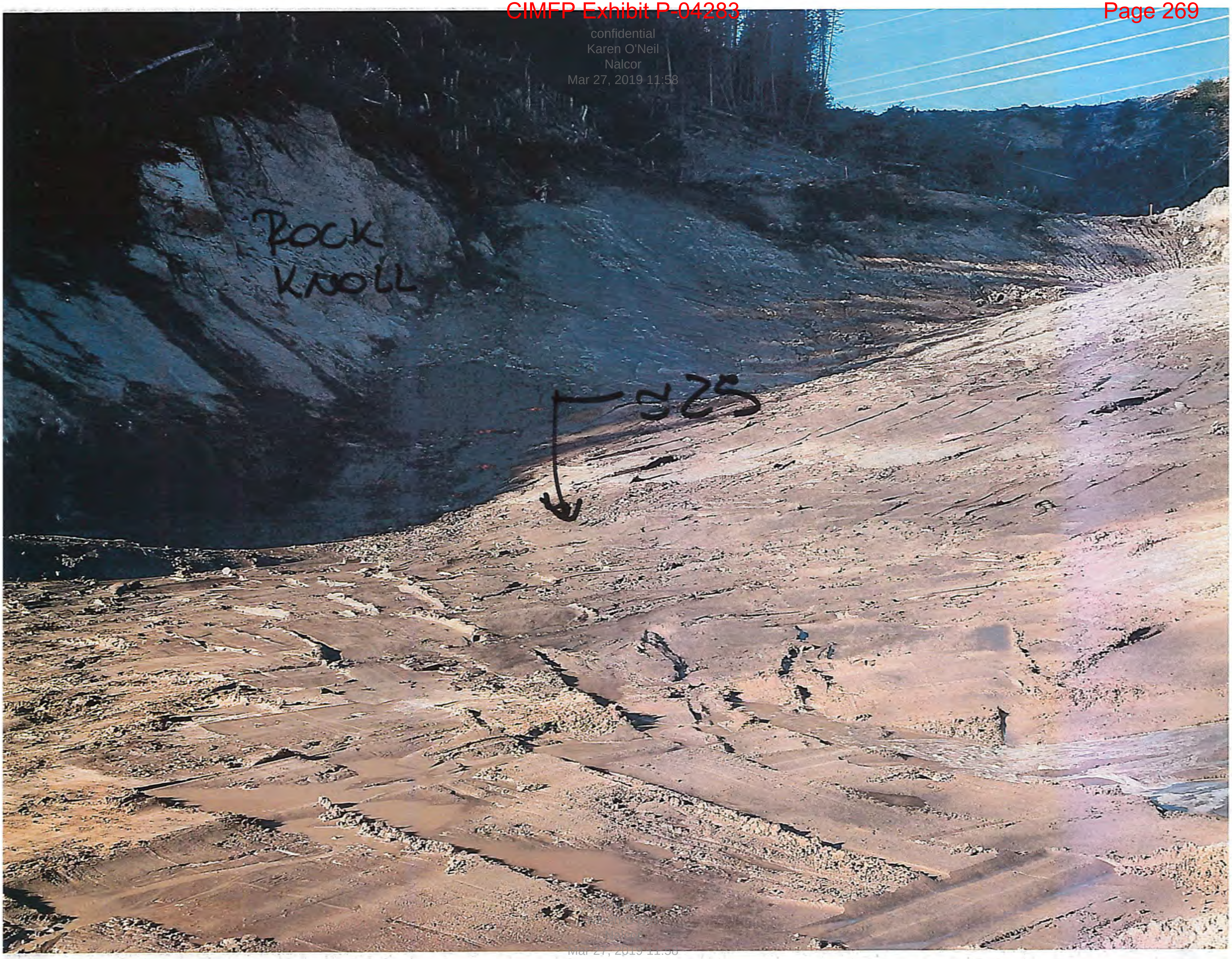

≅0+050
~45


ROCK
KNOLL
~25
KOMATSU
PC 350 LC


ROCK
KNOLL
325


0+090
FINGER
DRAIN
#1
EAST
SOUTH
PC
490
LC


KOMATSU
FINGER DRAIN #1
FINGER DRAIN #1

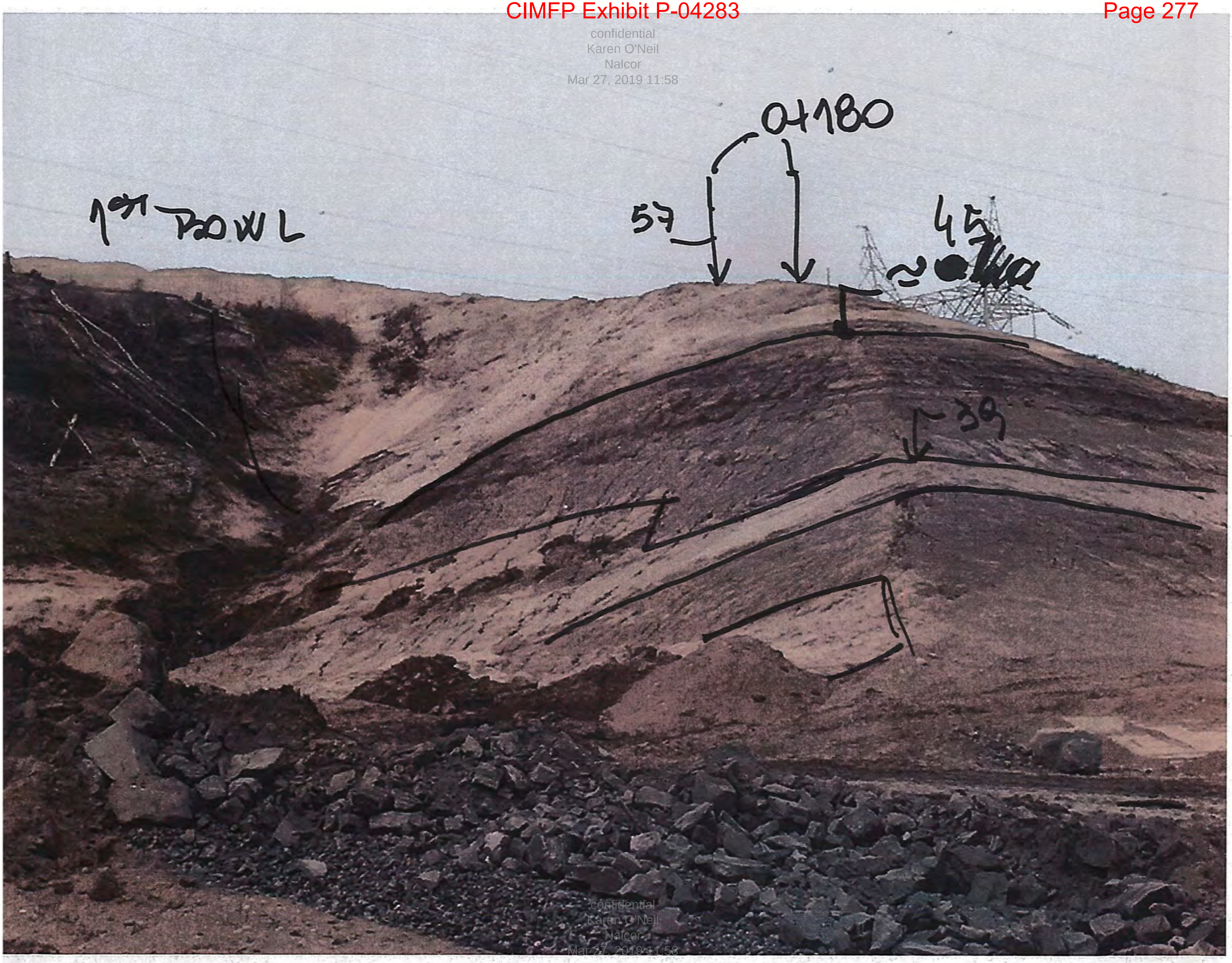

KOMATSU
PC 490
Finger
Drain
#1
20+090


KOMATSU
PC 490 LC
ROCK KNOLL
1ST FINGER DRAIN
0+090


KOMATSU
PC
490
LC


0+090
ALL
FIRST
BOWL
≈27


CAT
~18



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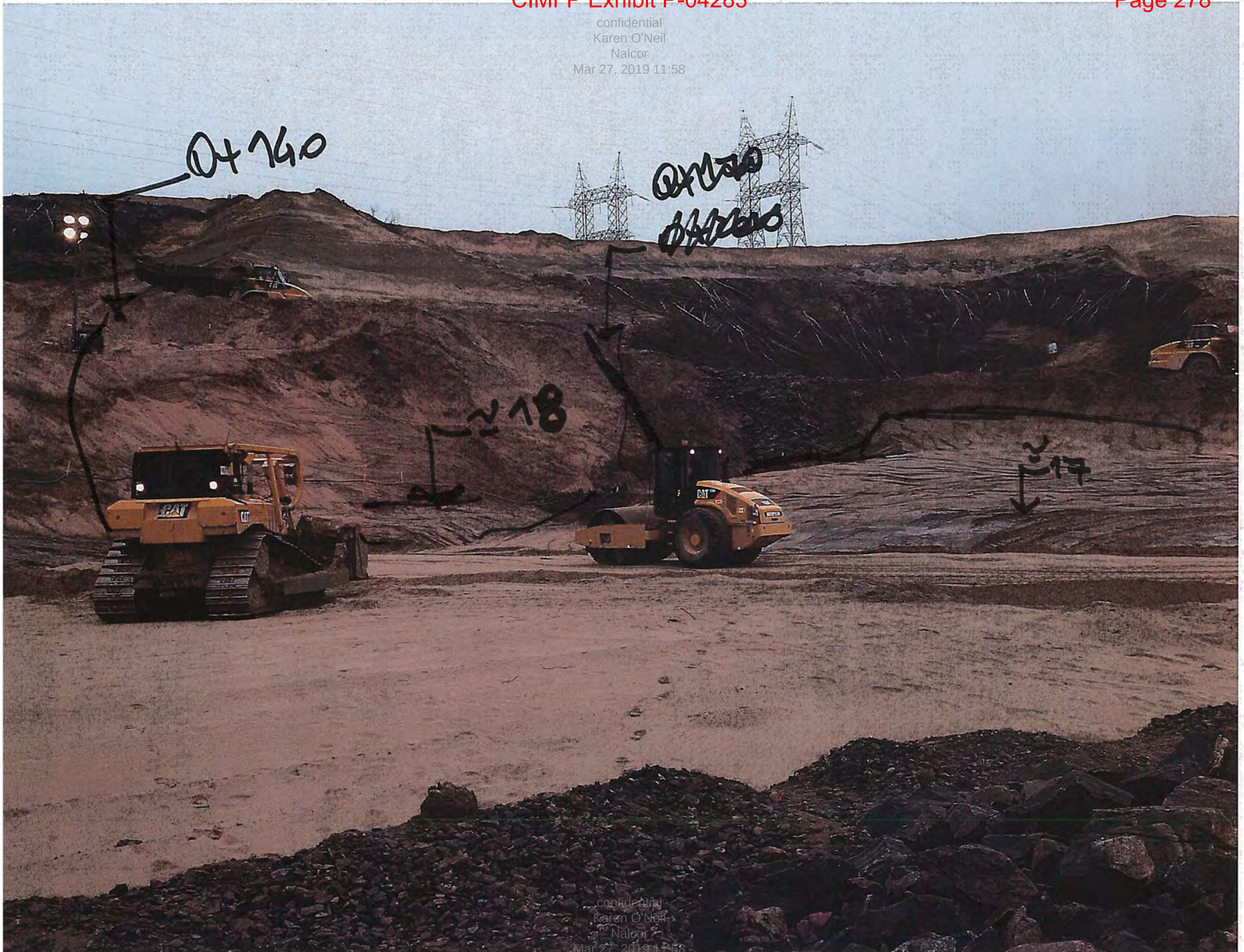

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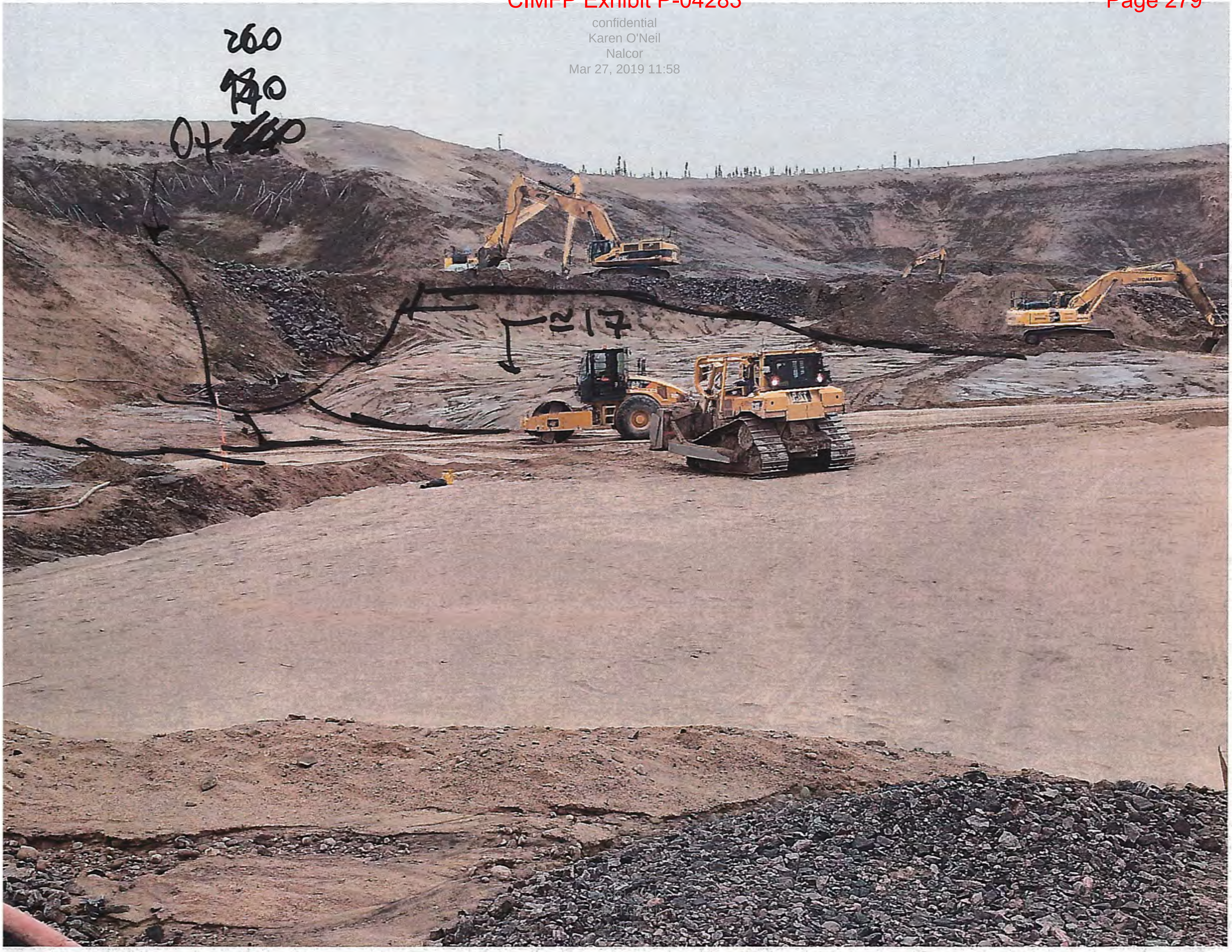
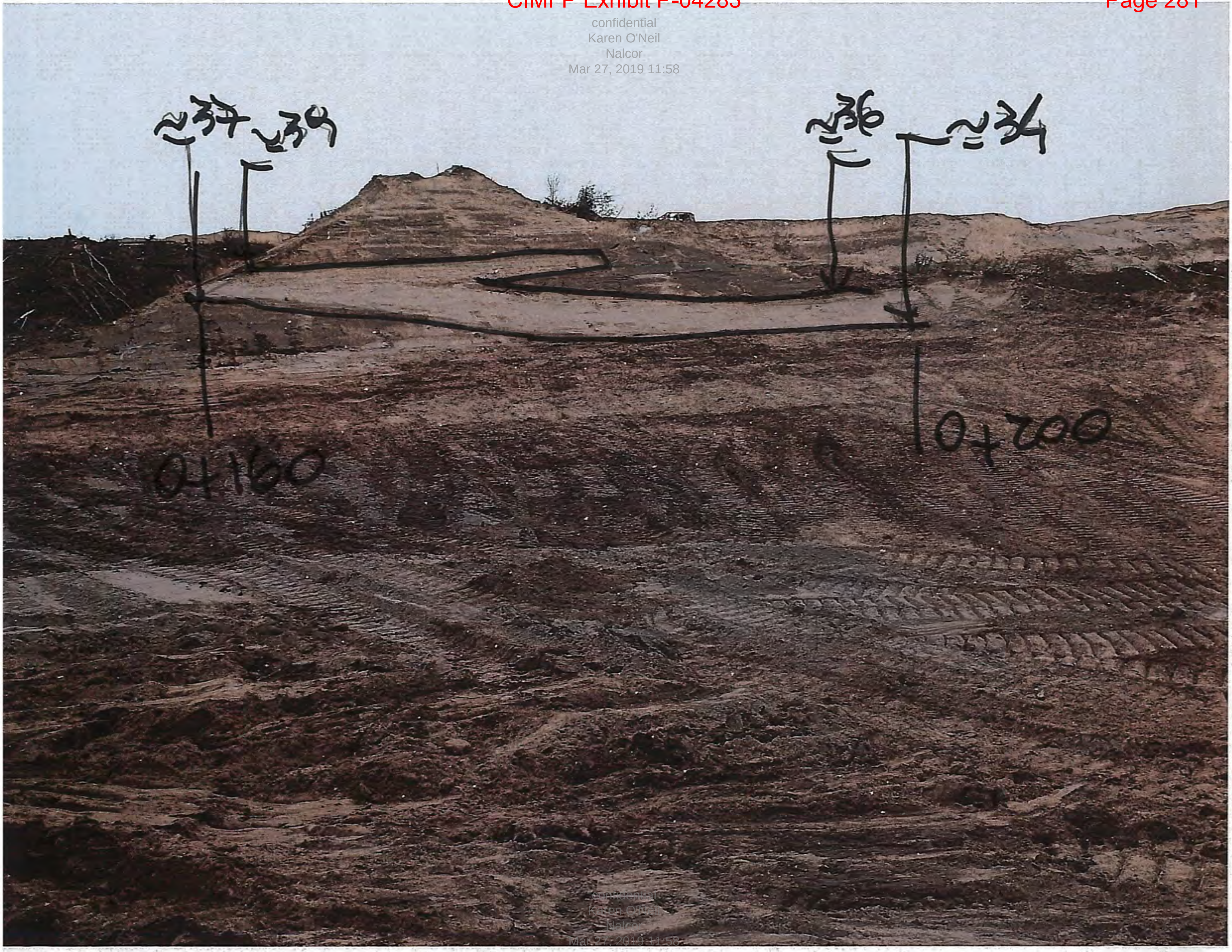

260
~~940~~ 140
0+~~140~~ 00
~17


0+180
≃15
≃ 0+130
0+180


≈37
≈39
≈36
≈34
0+160
0+200

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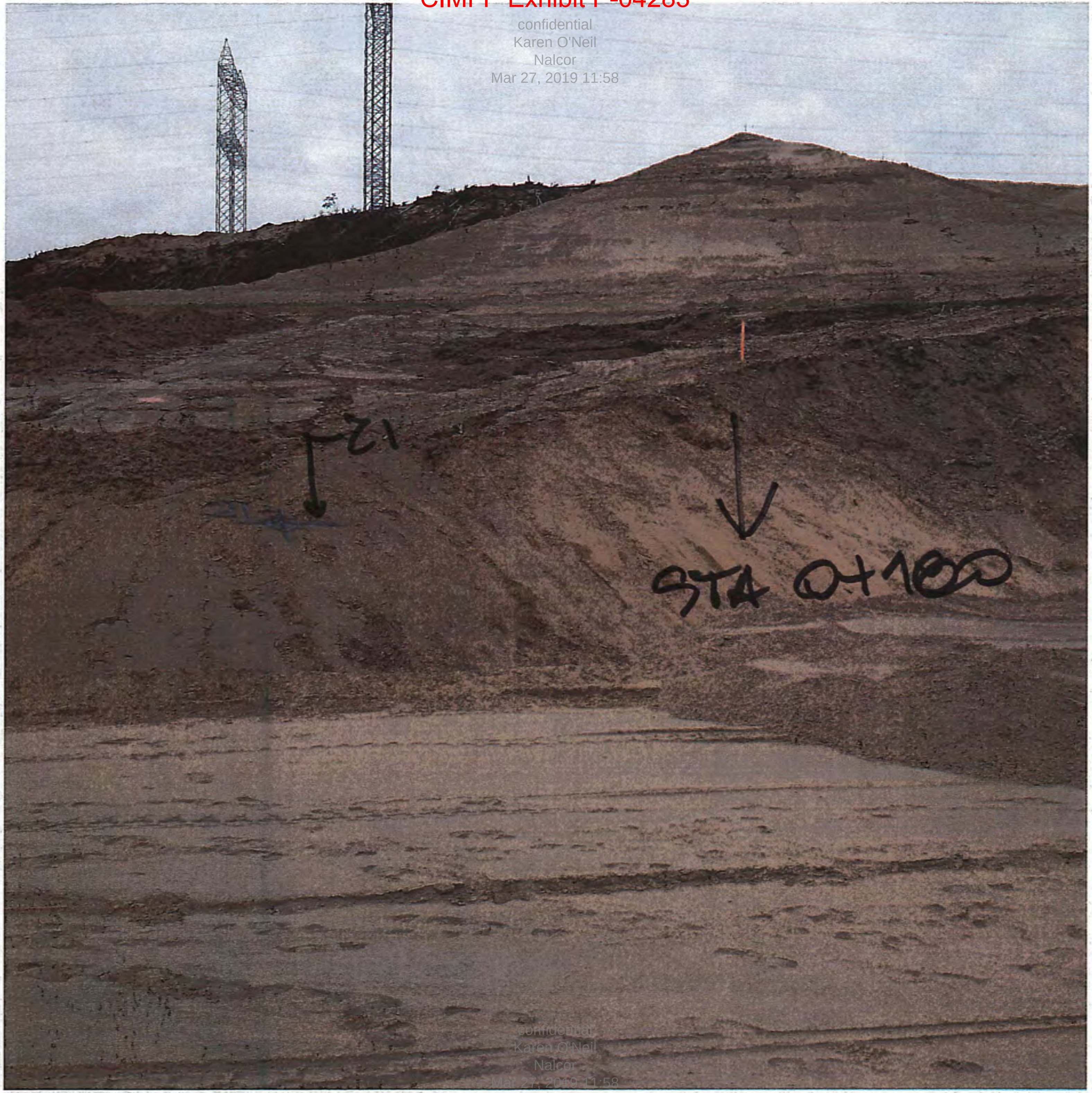
0+180
0+75
STA
0+160



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0+180


0+180
CAT

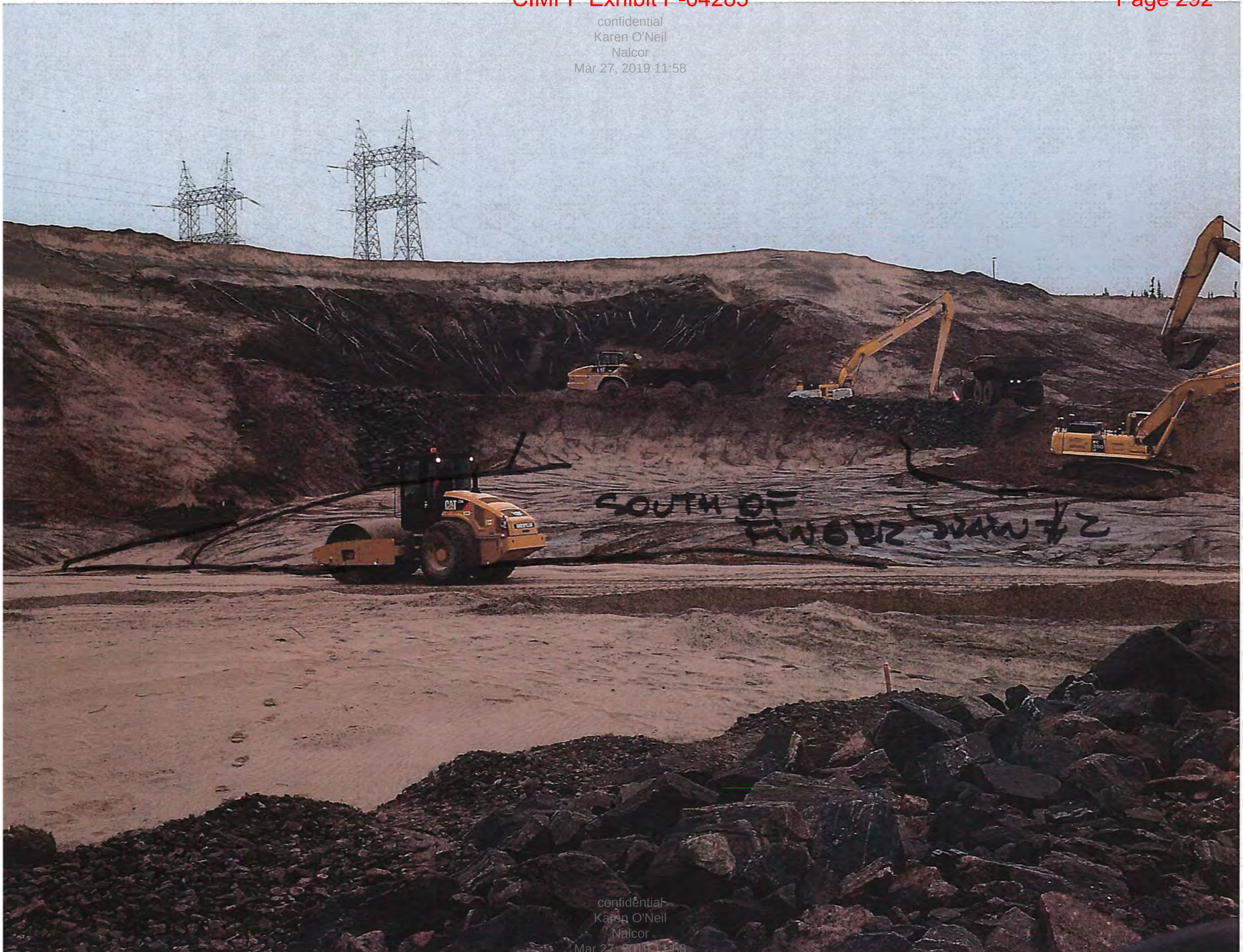

KOMATSU
≈13
0+180


Finger Drain
#7
South


≅ 0+250
Finger Drain #2
≅10


FINGER DRAIN #2
(SOUTH)


Finger Drain #2
(South)



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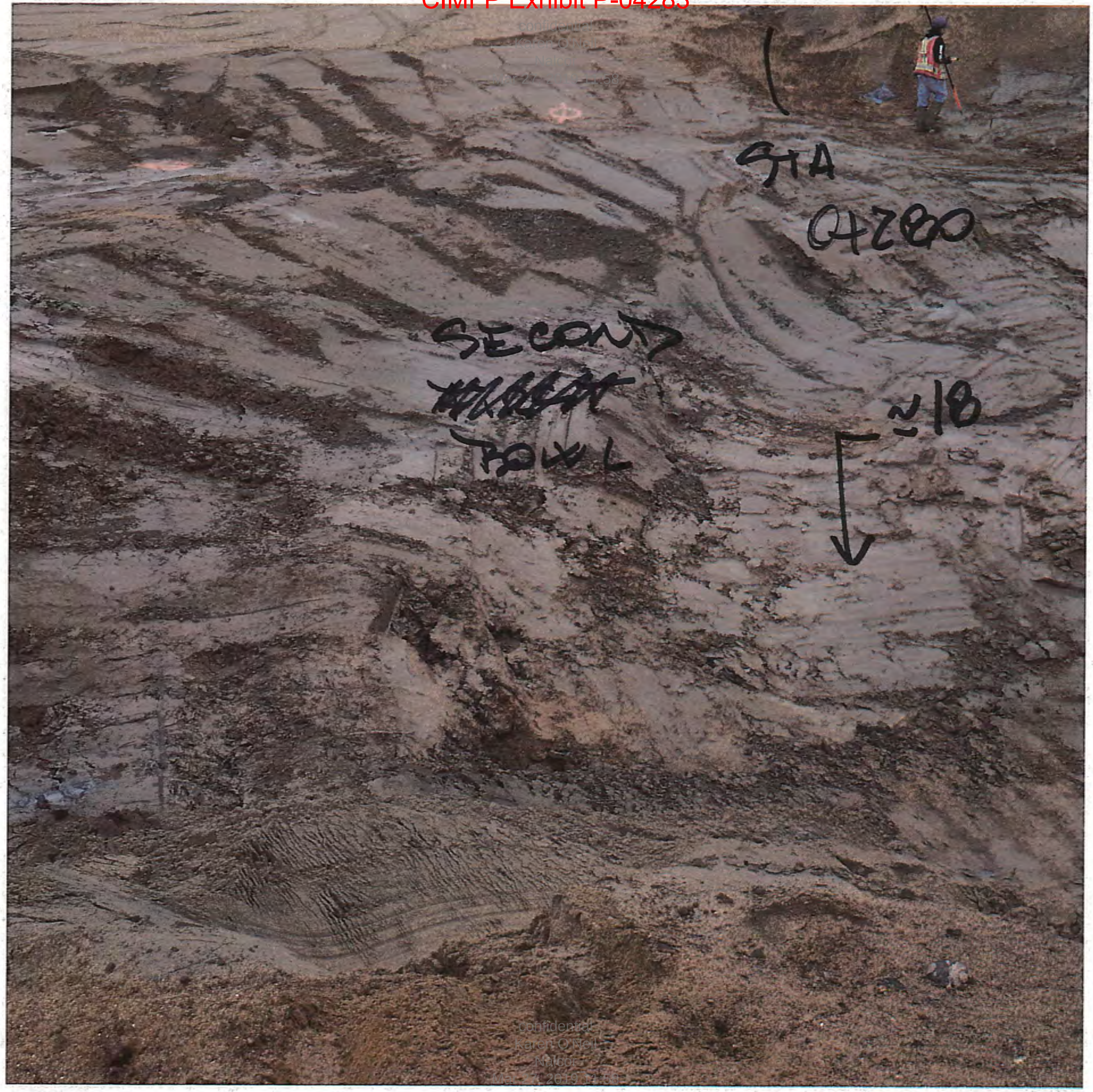
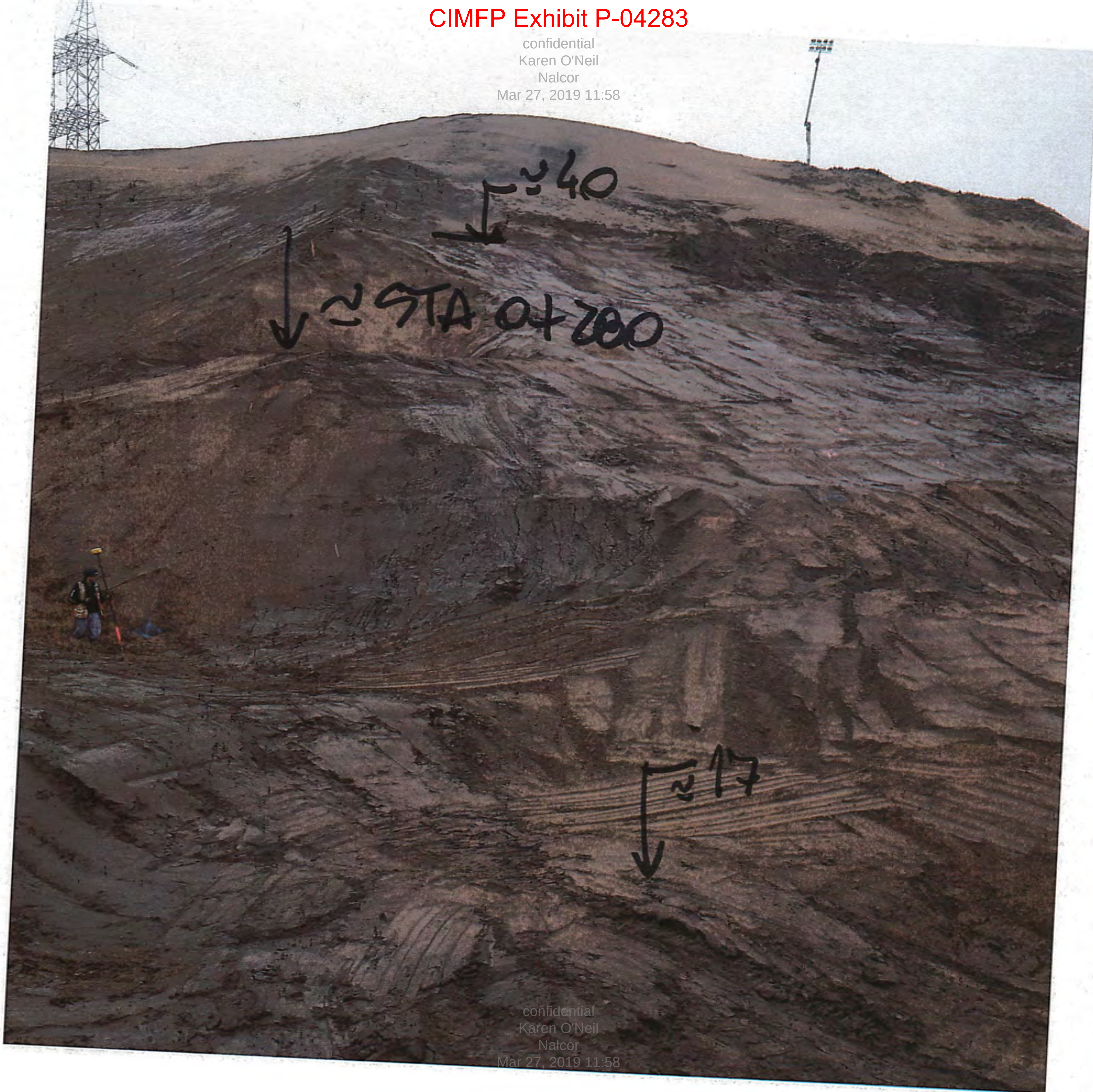
214
Finger Drain #2


KOMATSU
5.5
BETWEEN
FINGERS DRAIN
#2 AND #3


STA
04280
SECOND
BOWL
≈18



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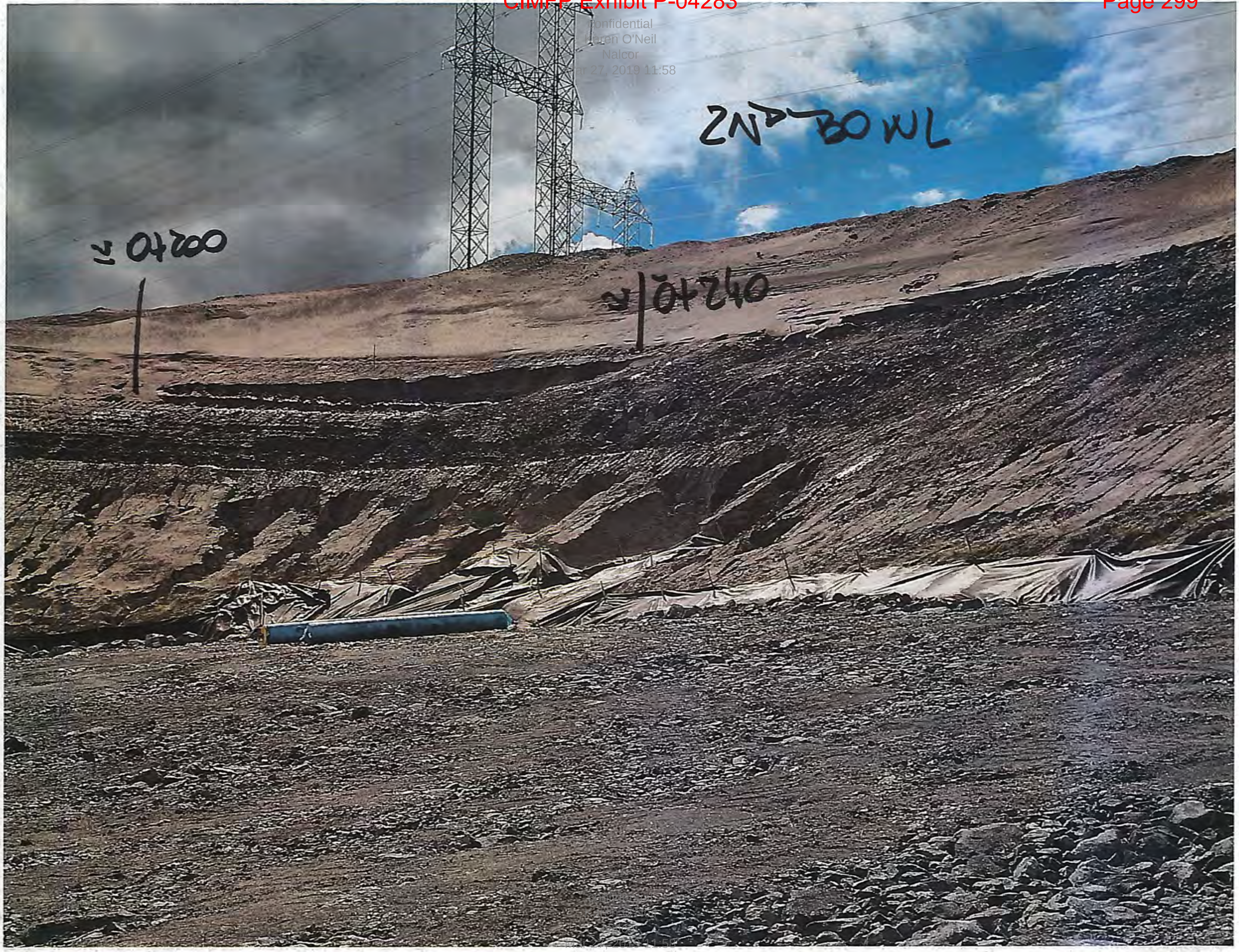
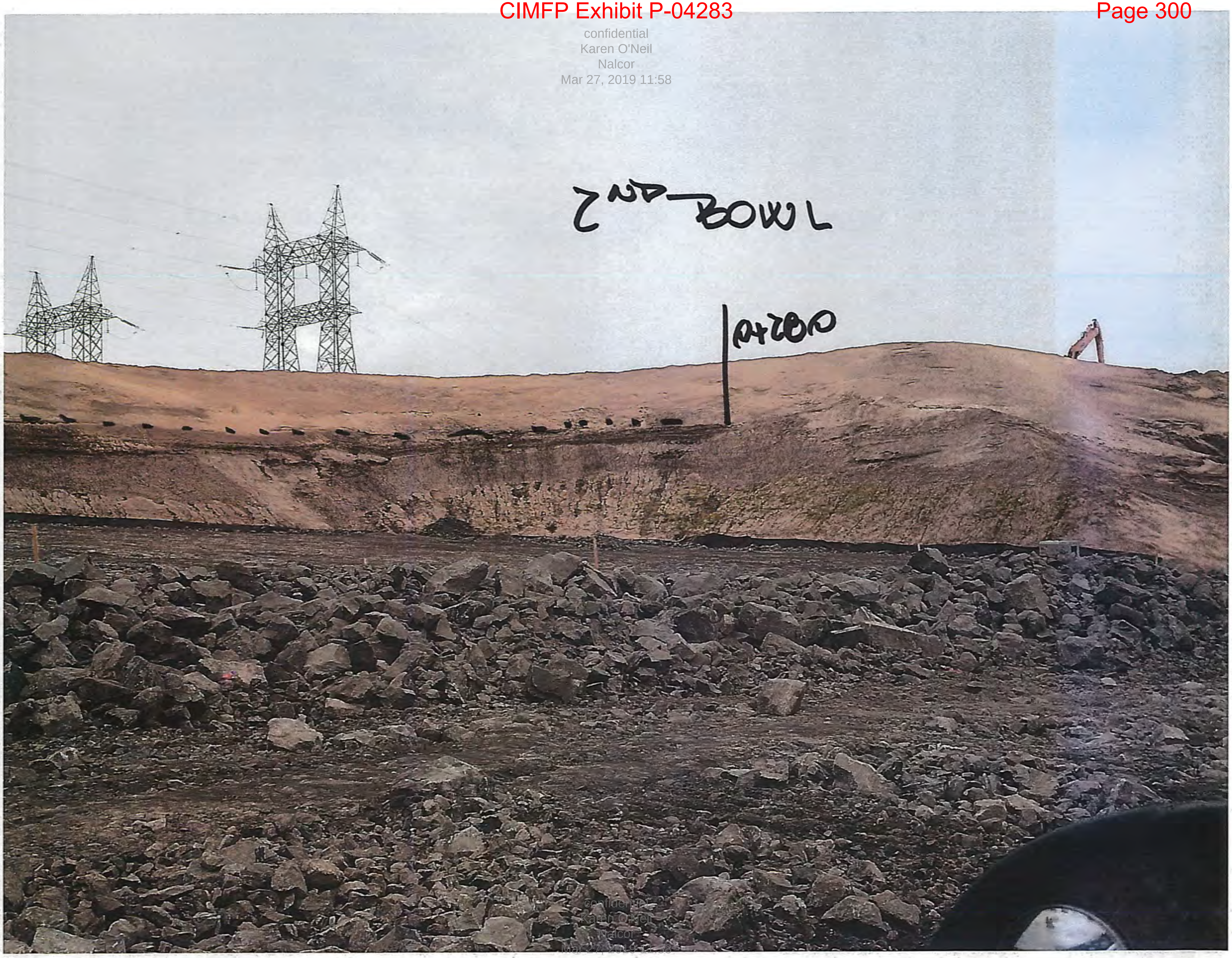
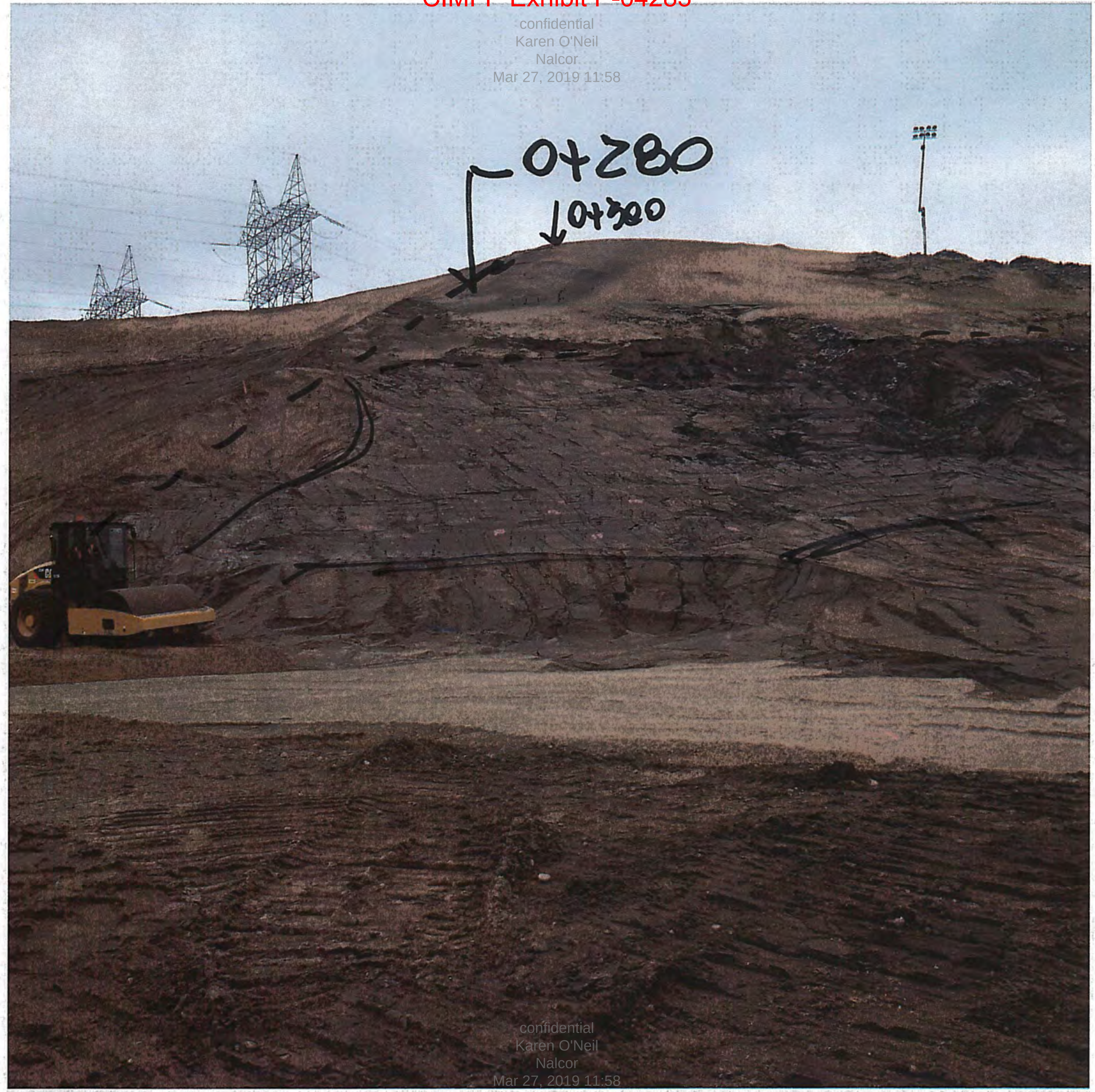
STA 0+200
≈17


2ND BOWL
~50


0+200
0+240
2ND BOWL

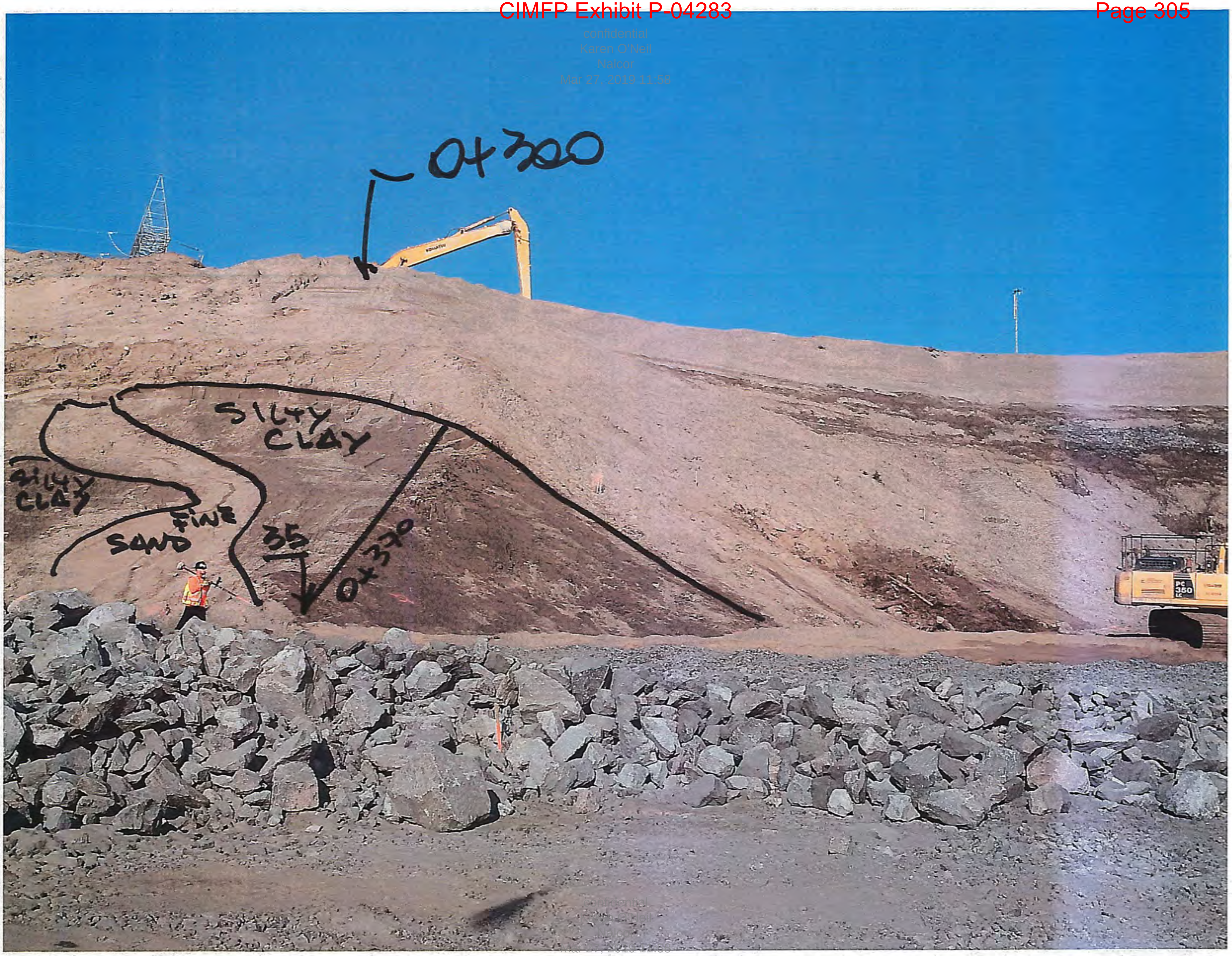

2ND BOWL
0+200


0+250
0+180
≈20
FINGER
DRAW #2
0+240


0+280
0+300


2ND BOWL
~19


BETWEEN DRAIN
FINGERS
#2 AND 3
ELEV ≃ 19 TO 25


0+300
SILTY CLAY
SILTY CLAY
FINE SAND
35
0+370
PC 350

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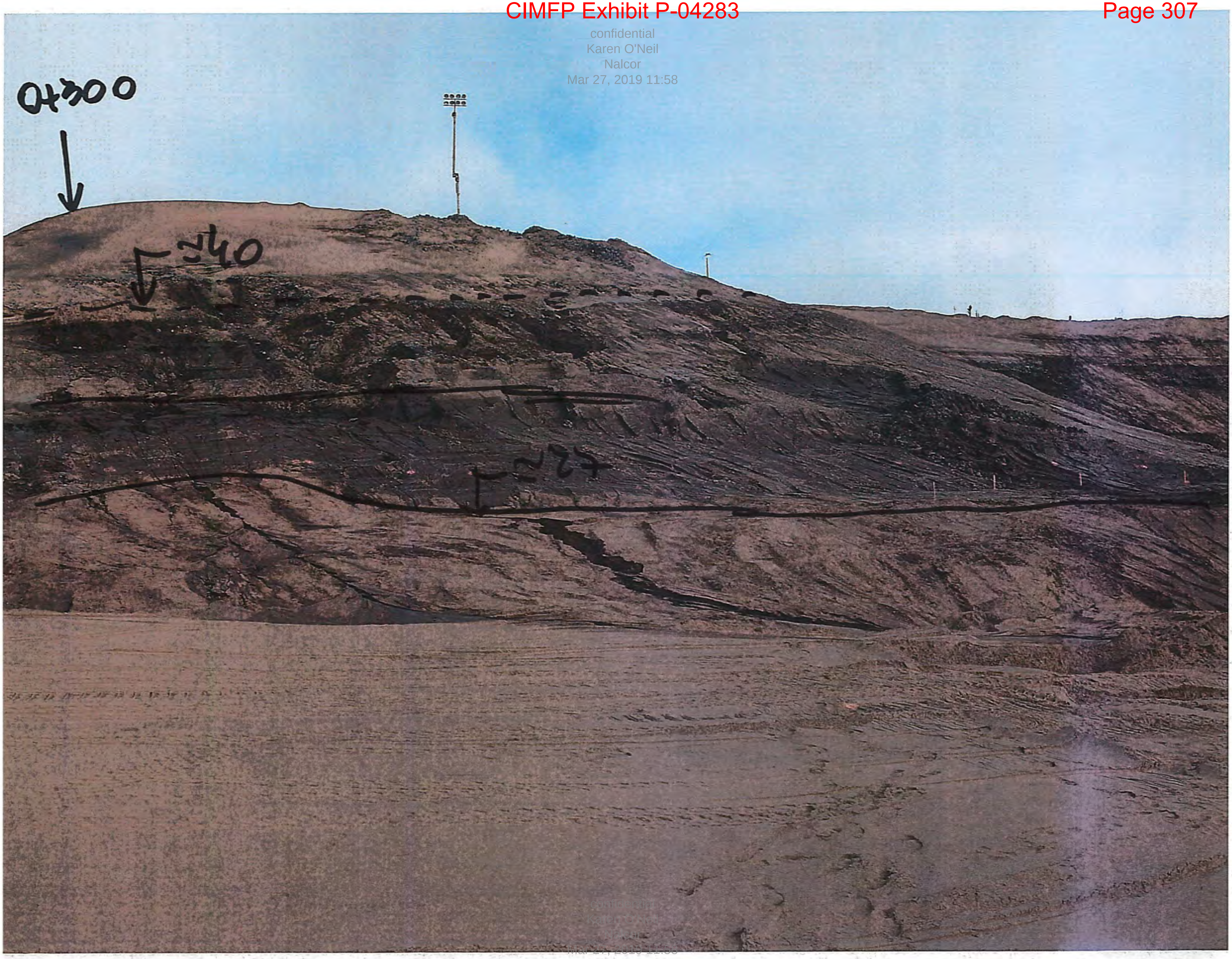
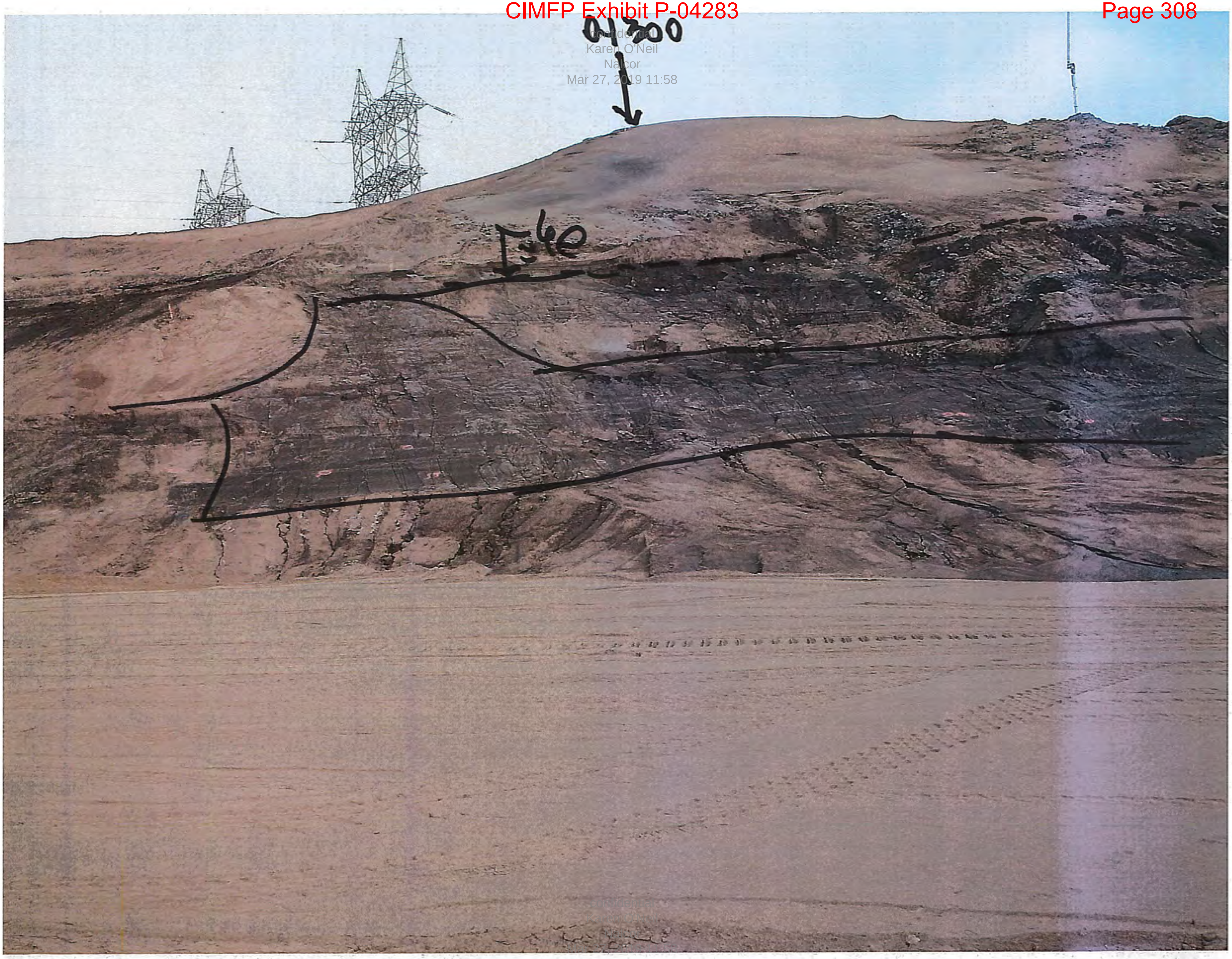
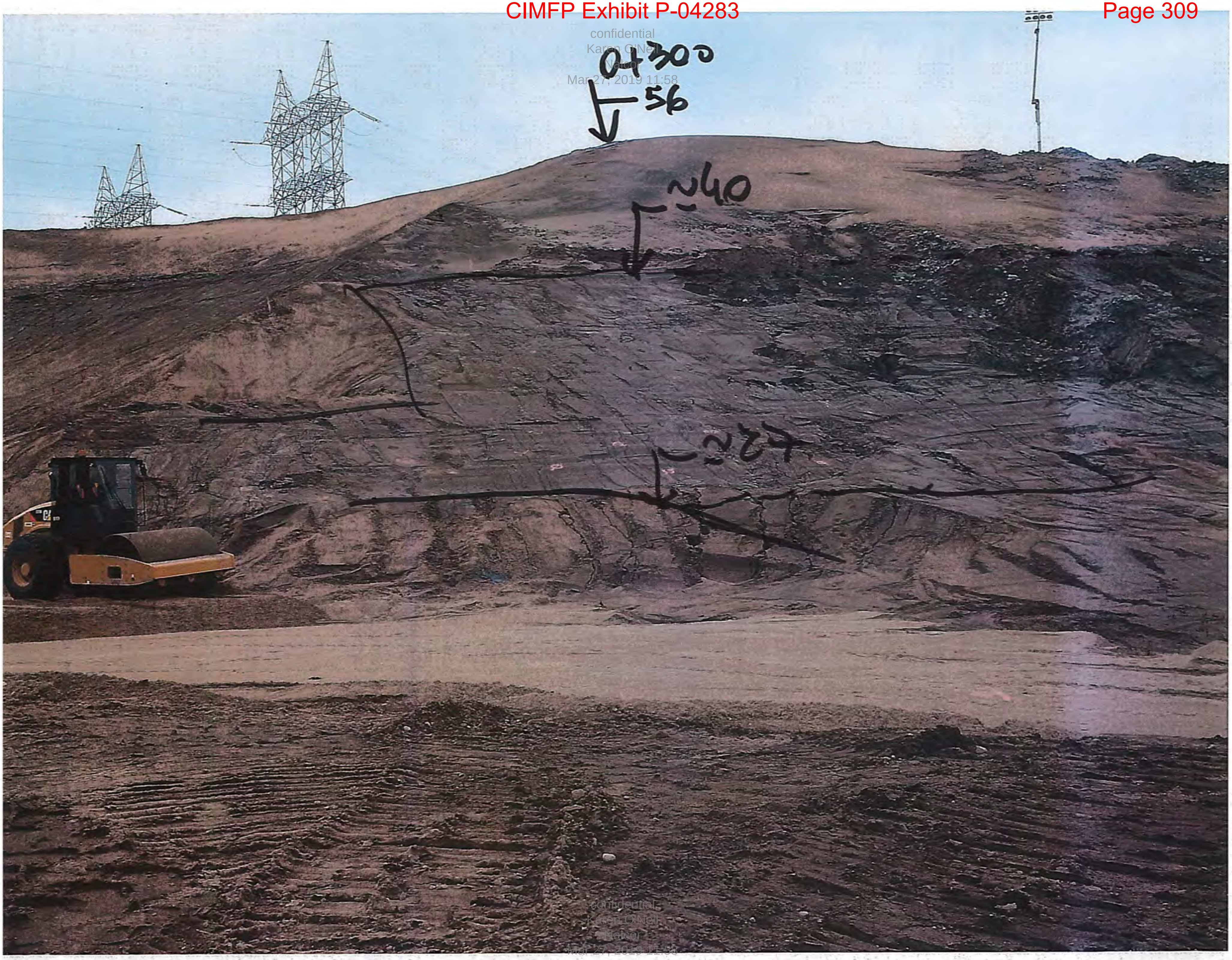
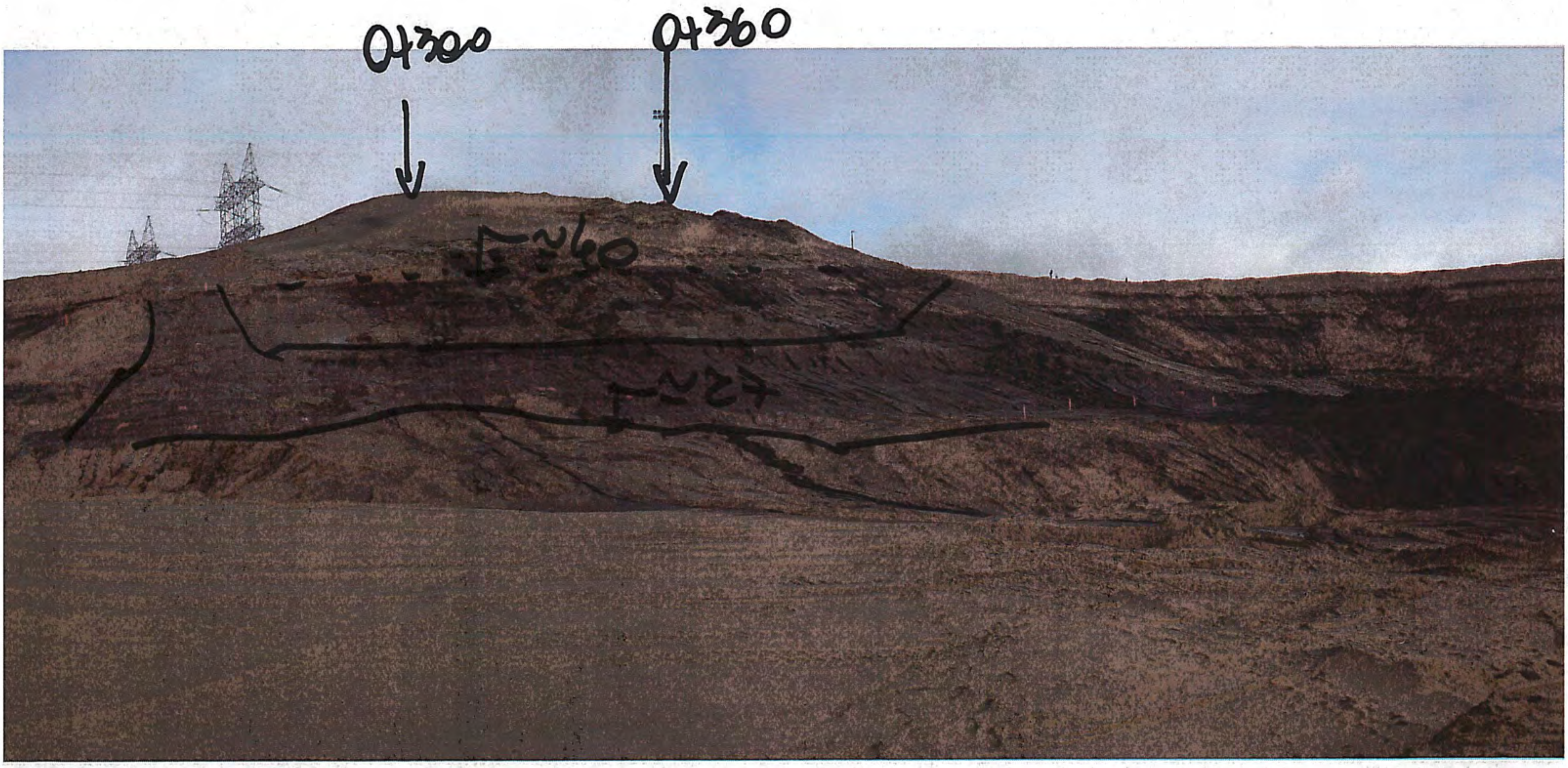

0+300
≈40
≈27


04300
El. 46


0+300
56
~40
~27



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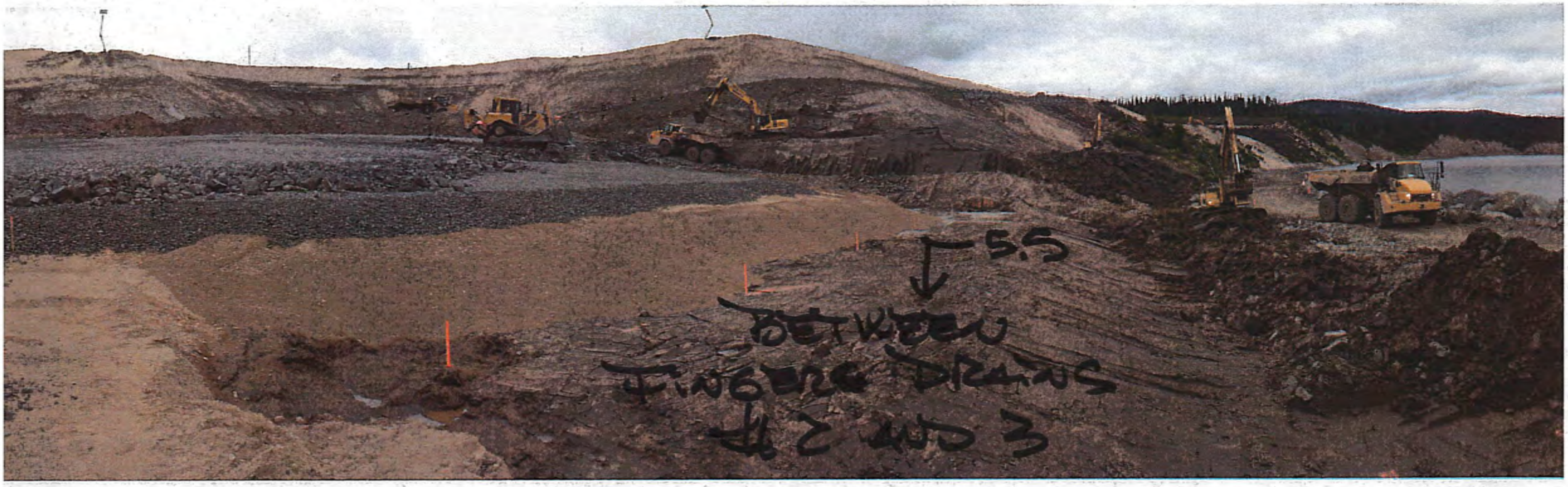
FINGER
DRAIN
#2
#3
C0+340


04360
KOMATSU
740
≈18



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±42
STA 0+350
0+360 ±
±35
0+370 ±
±28

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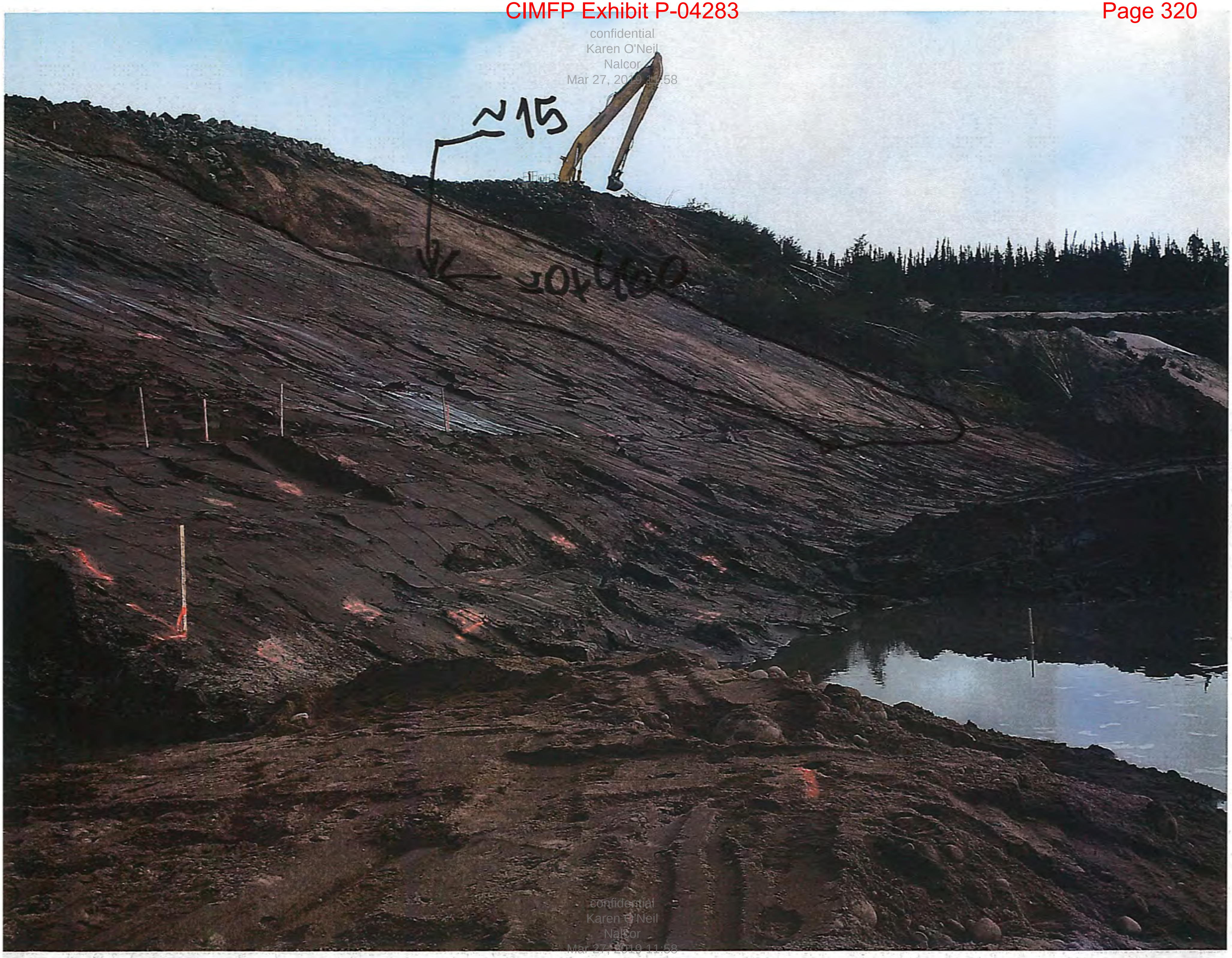
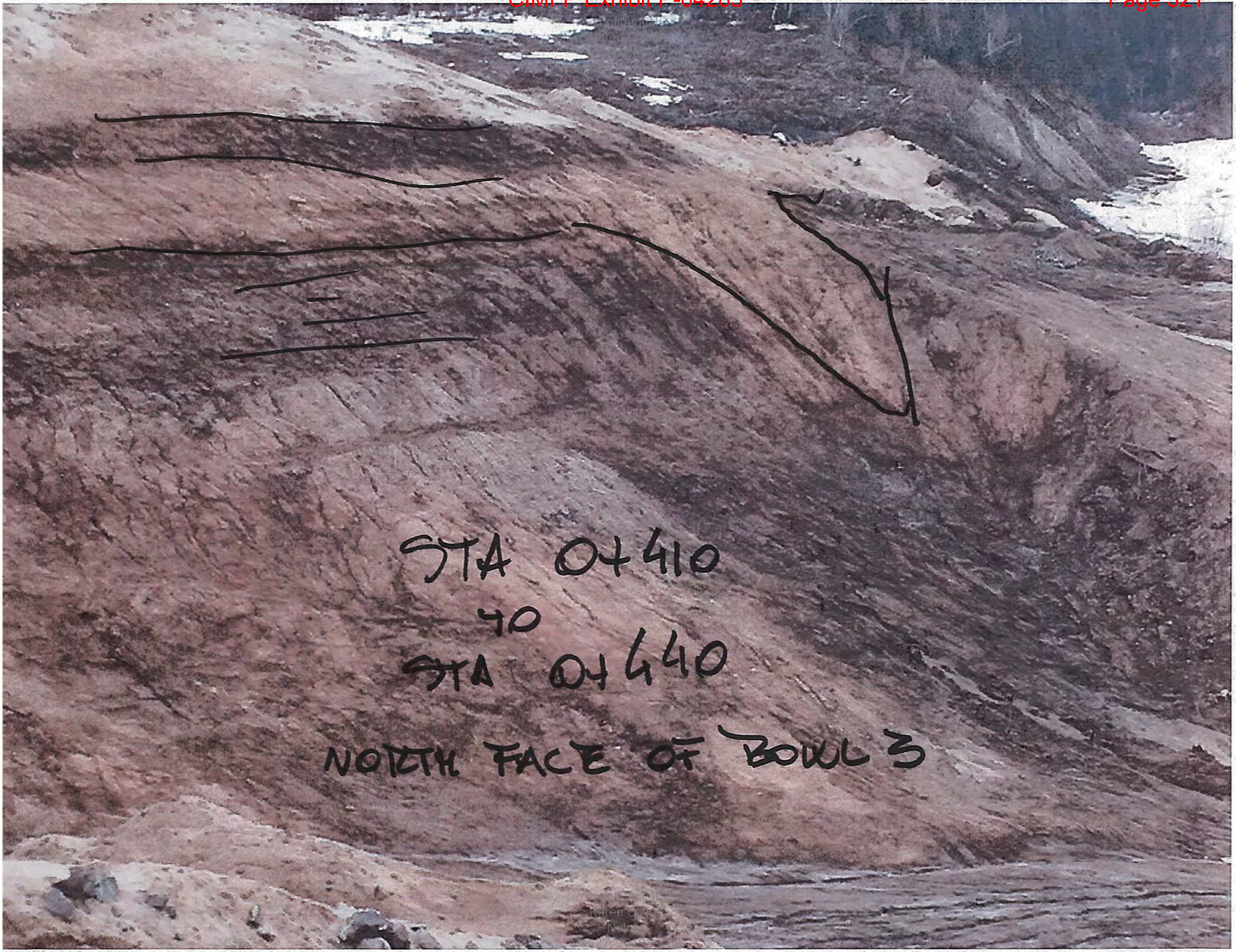
STA 0+380
CLAY
3RD BOWL

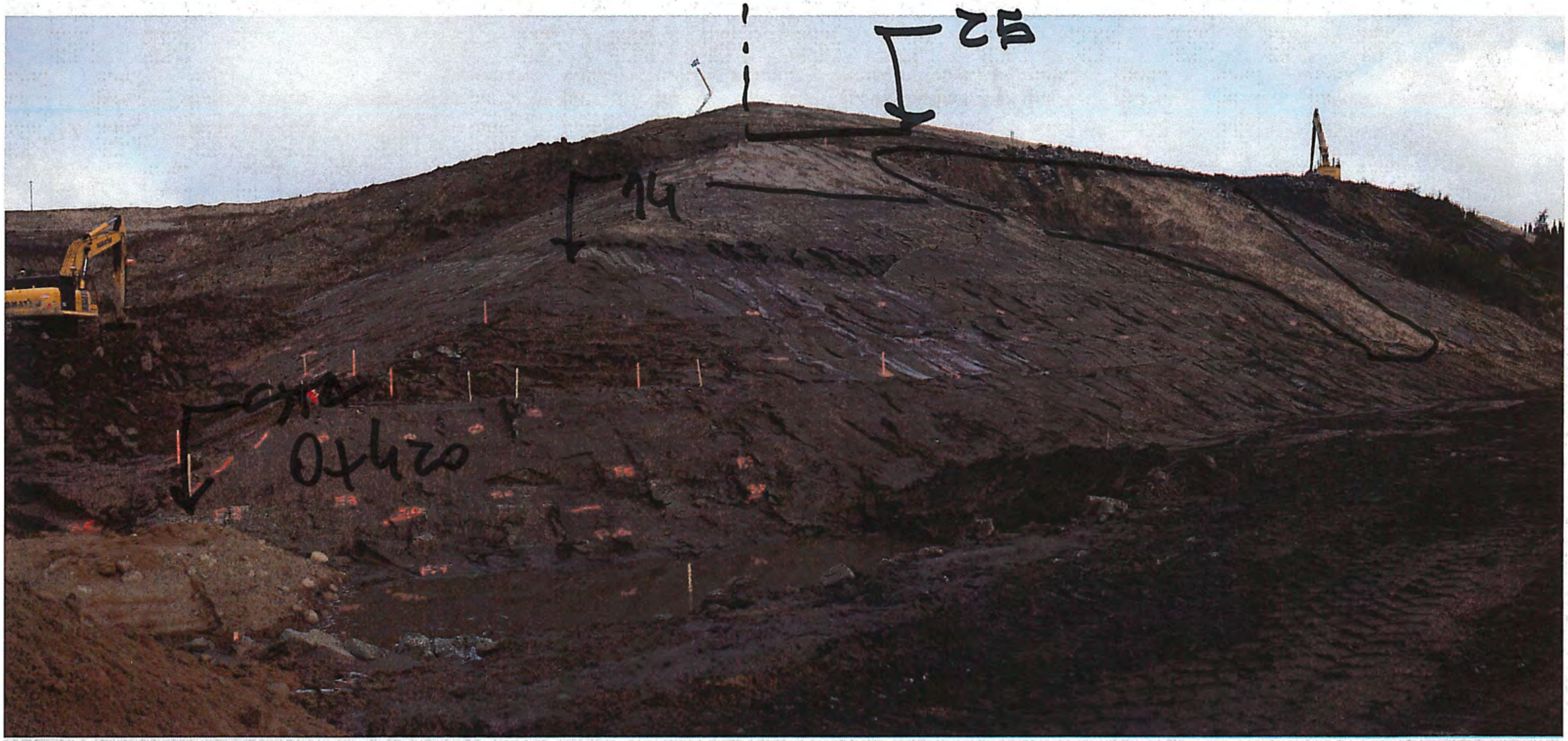

0+380
285


0+440
0+35

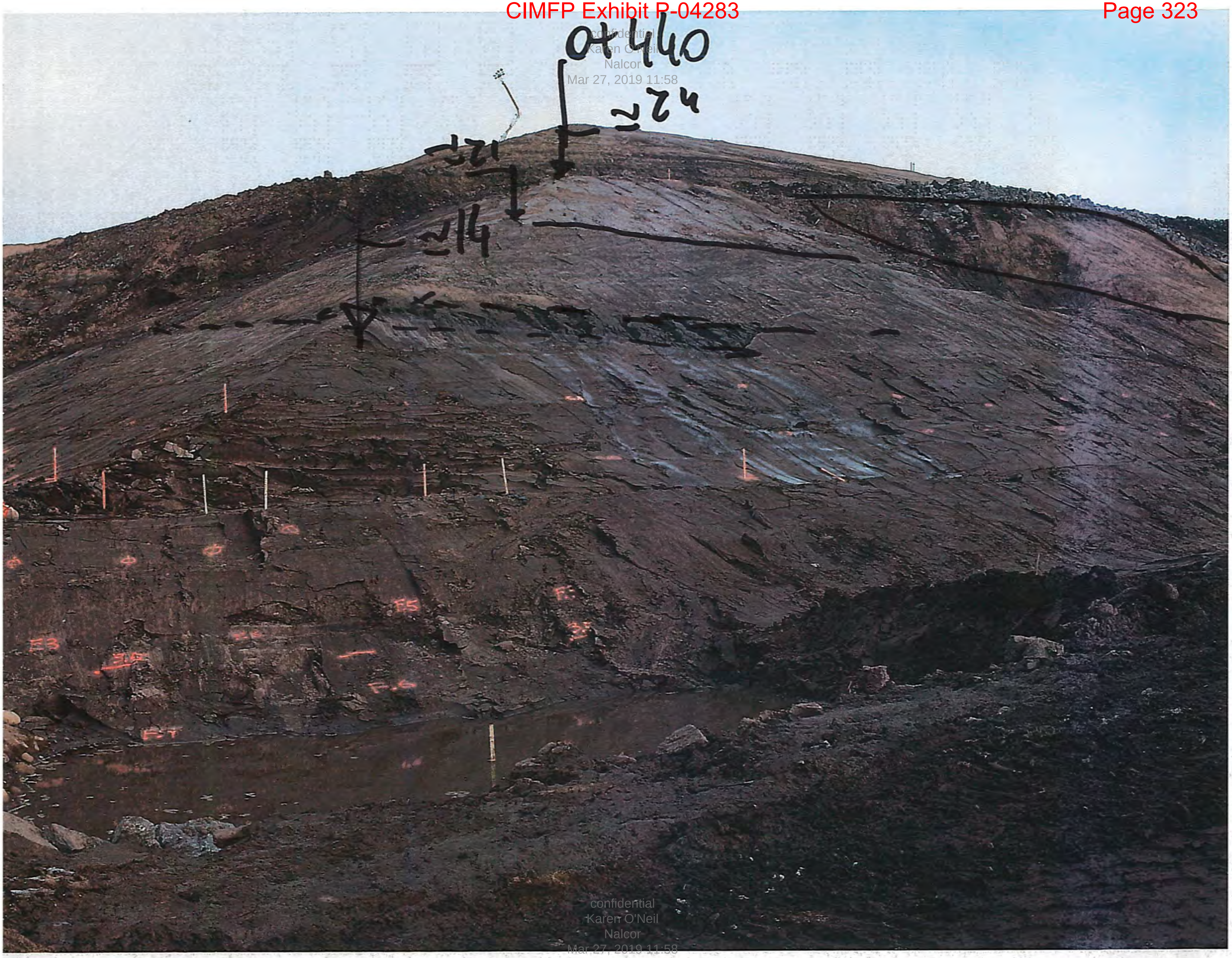

~15
~20x400


STA 0+410
TO
STA 0+440
NORTH FACE OF BOWL 3

~0+440



20160716 08 3248



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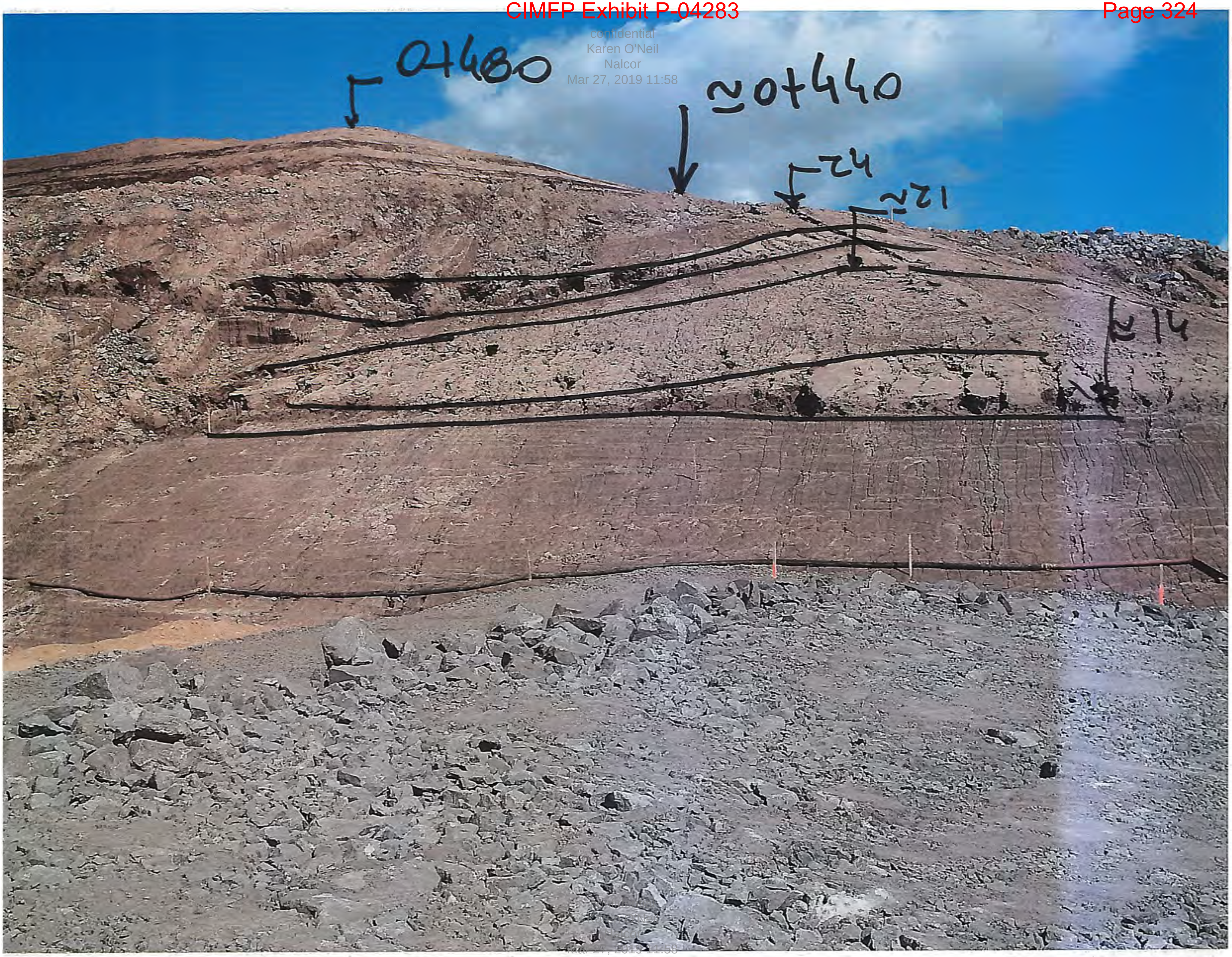
0+480
≃0+440
≃24
≃21
≃14

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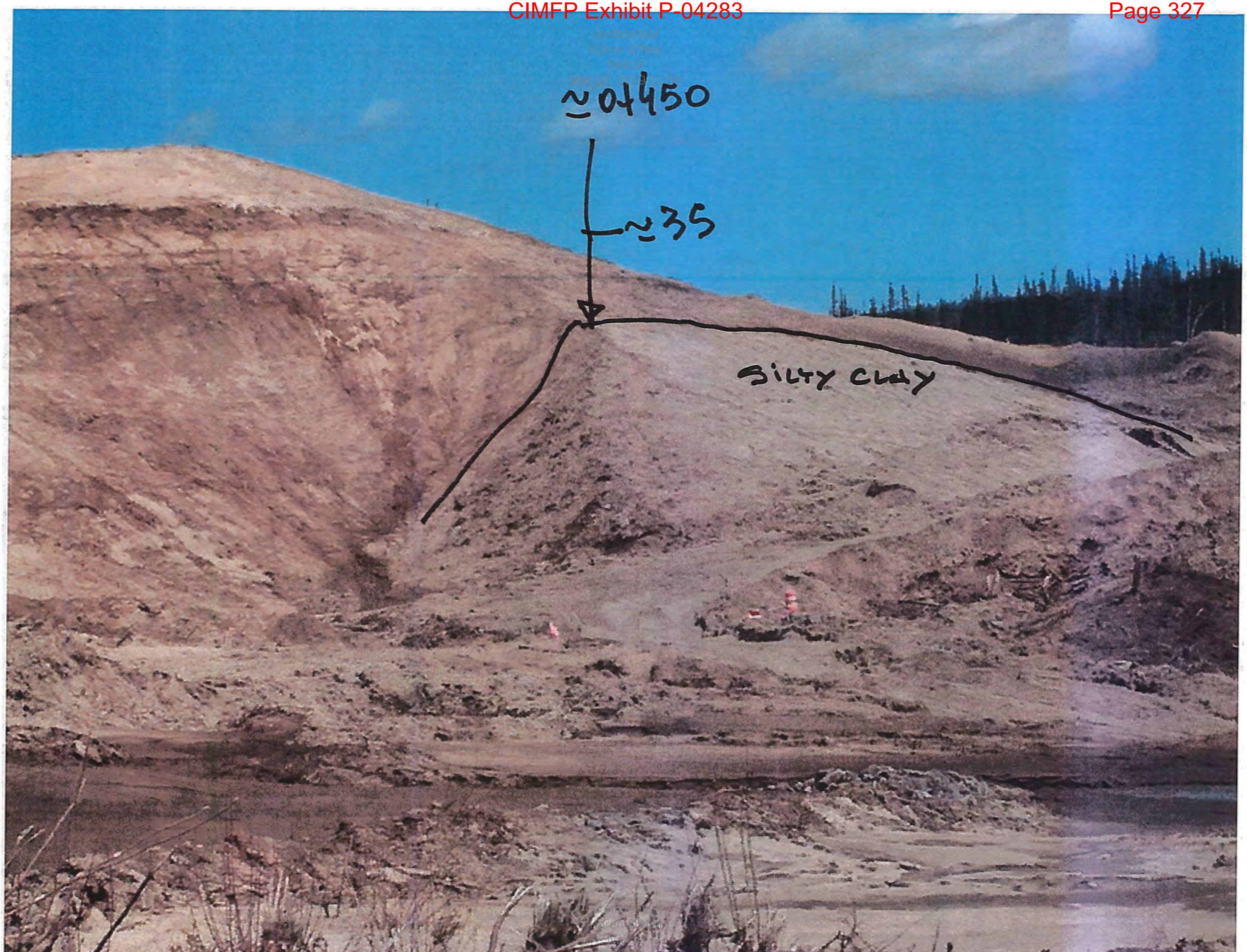
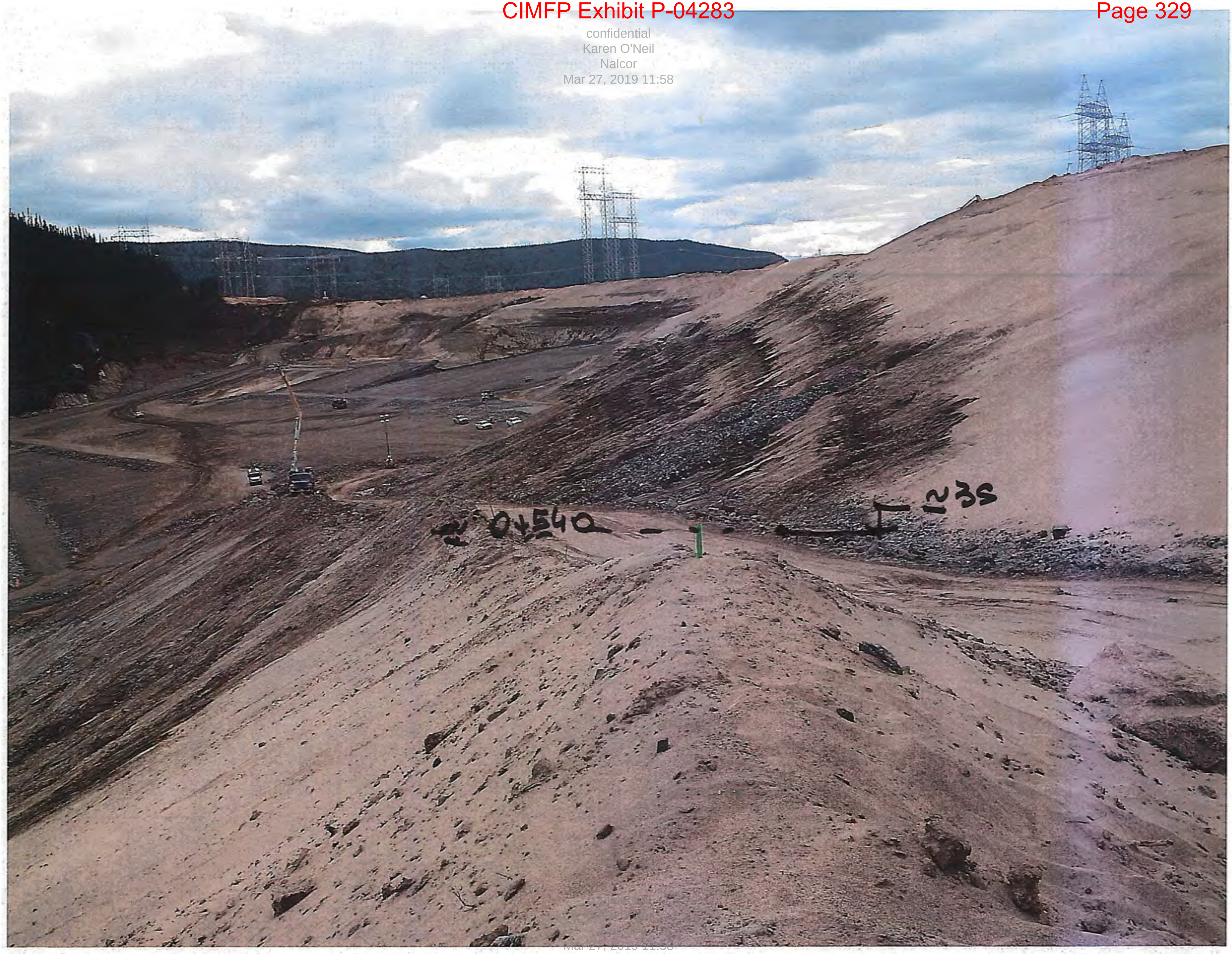
≃24
≃24
≃04480
04480


≃ 0+450
≃ 35
Silty clay


0+490
55



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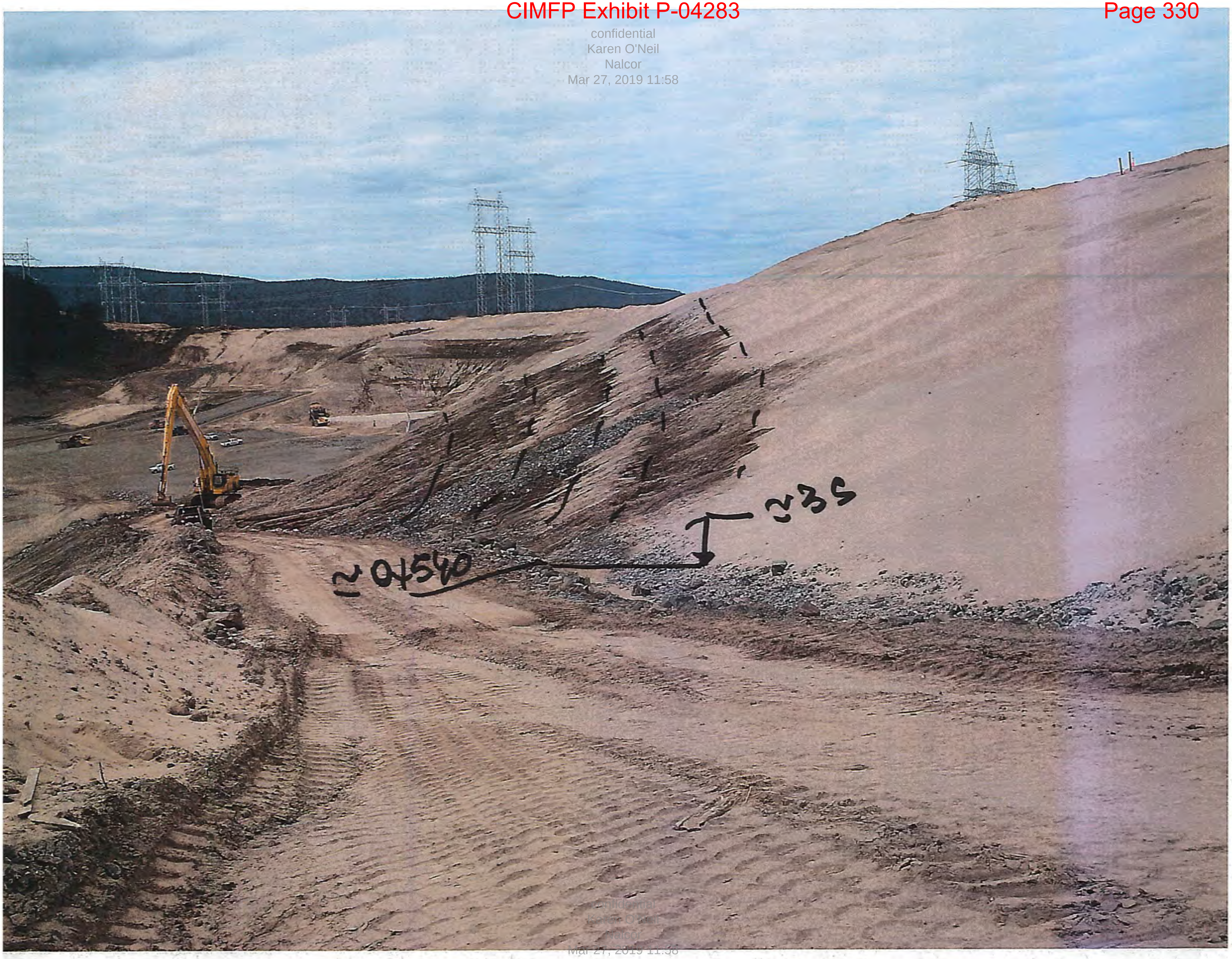

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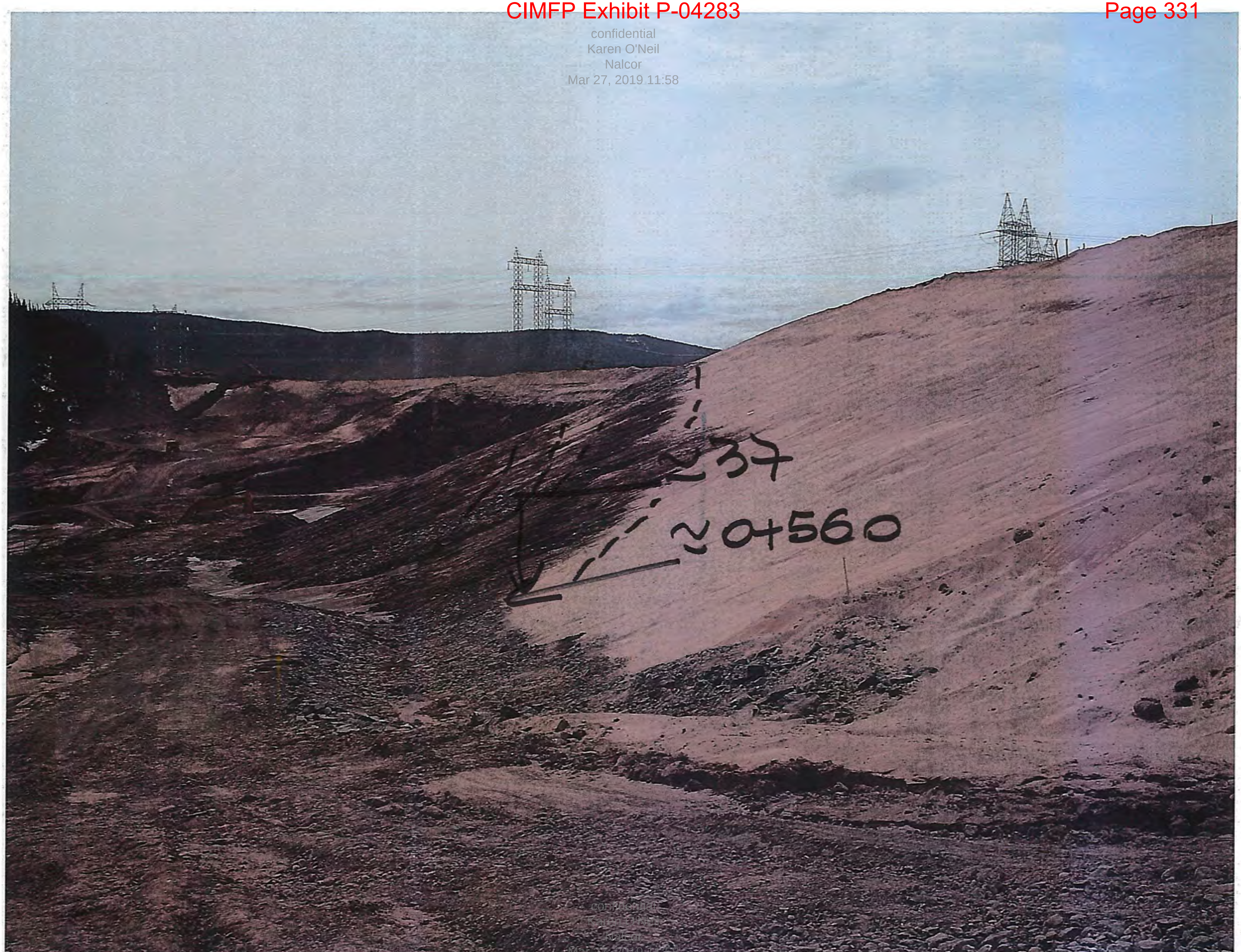
≈237
≈0+560

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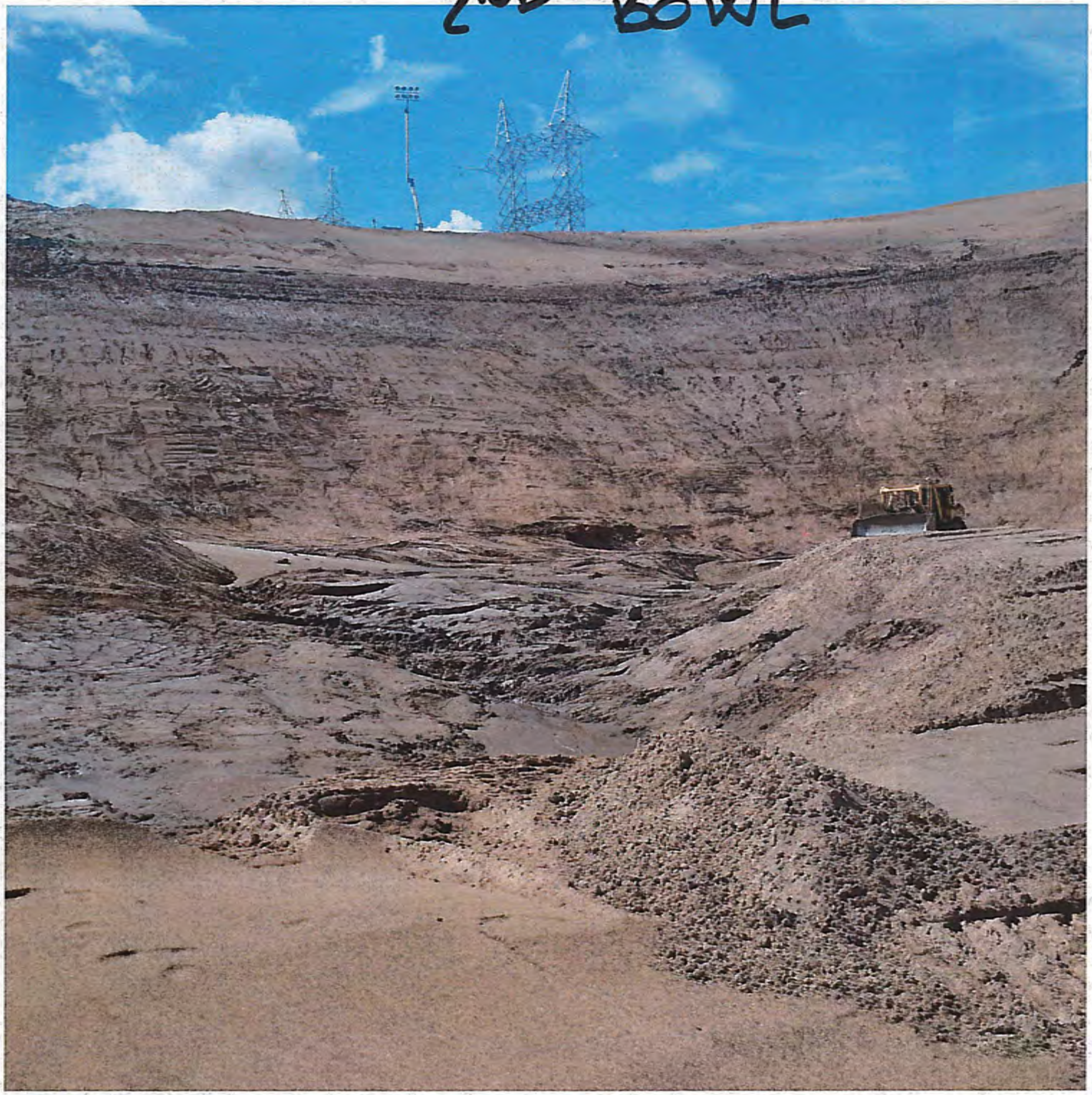
0+200
2ND BOWL


2ND
BOWL


2ND BOWL

2ND BOWL



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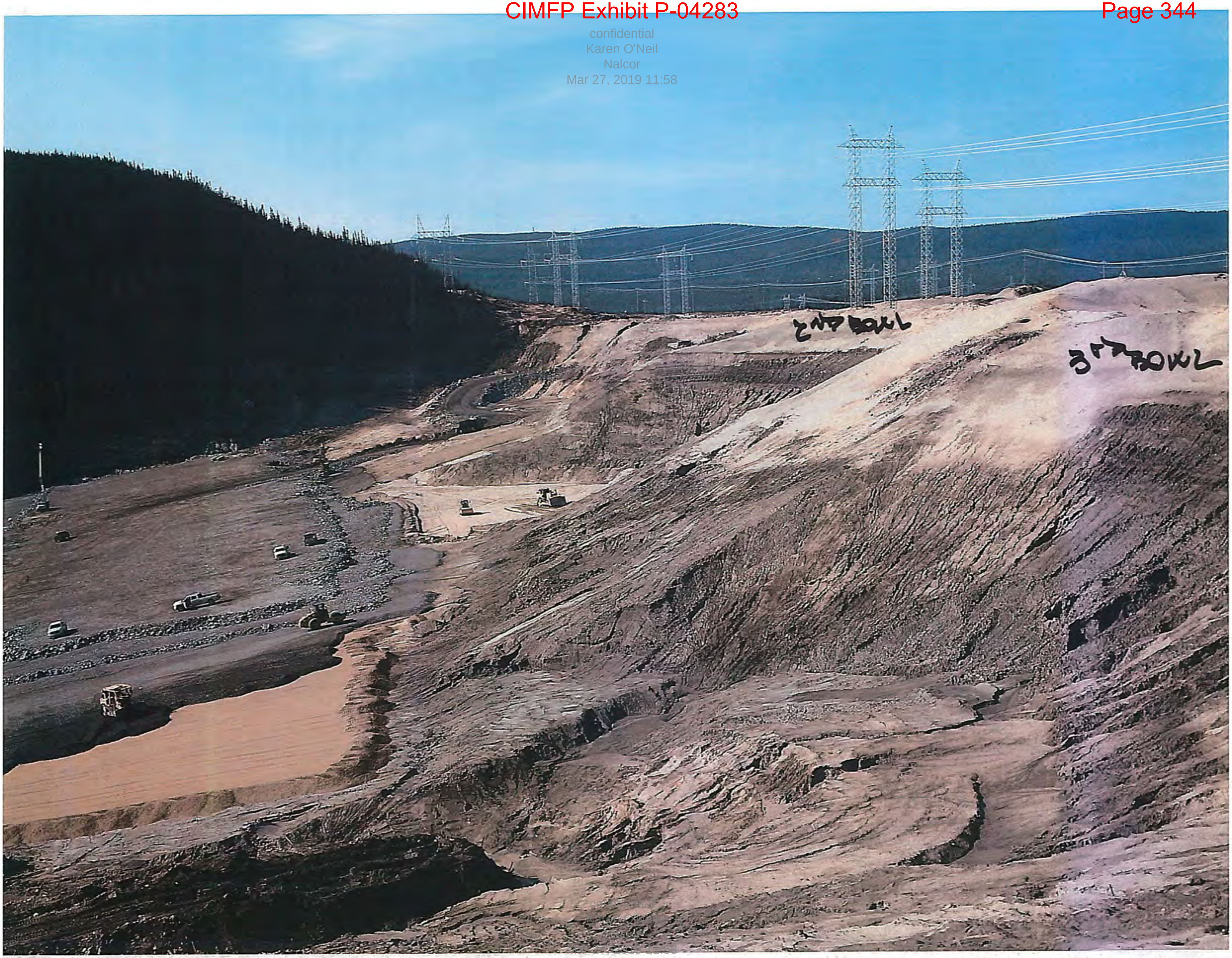
Karen O'Neil
Nalcor
Mar 27, 2019 11:58


3RD BOWL


3RD BOWL


3RD BOWL
KOMATSU


3RD BOWL


2ND BOWL
3RD BOWL


3RD BOWL

3rd BOWL



3rd BOWL

PICTURES KETTLE LAKES OUTLET

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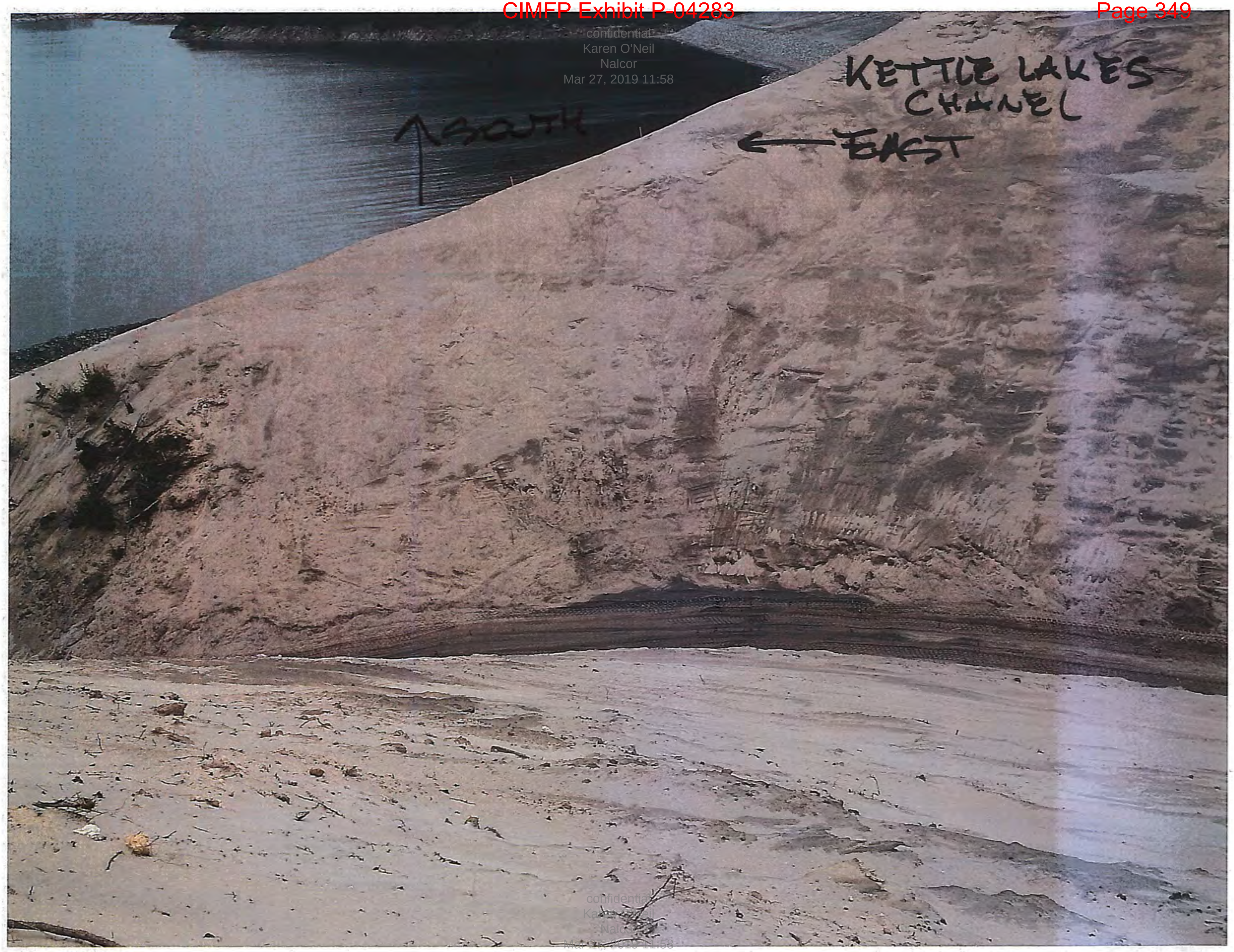

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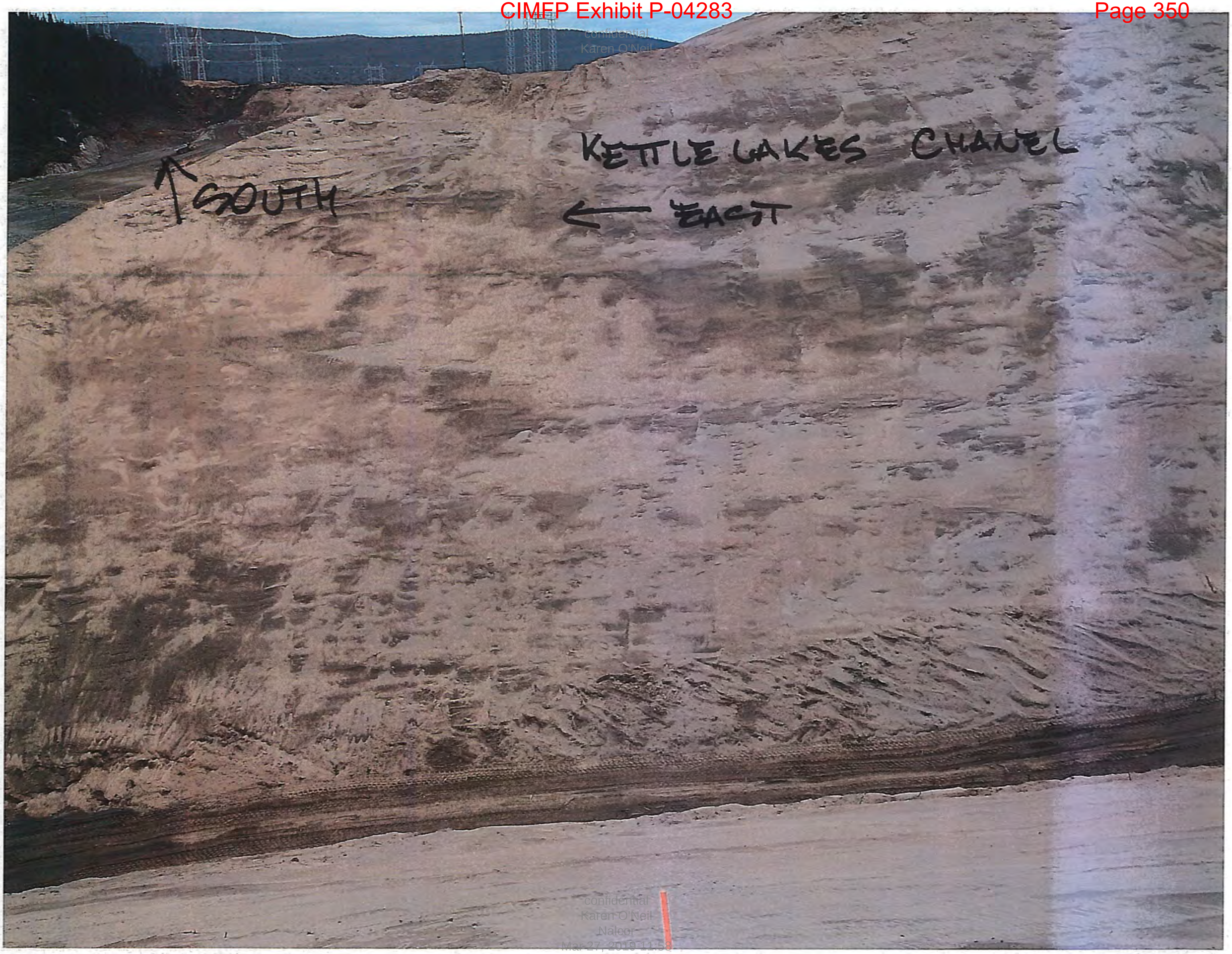
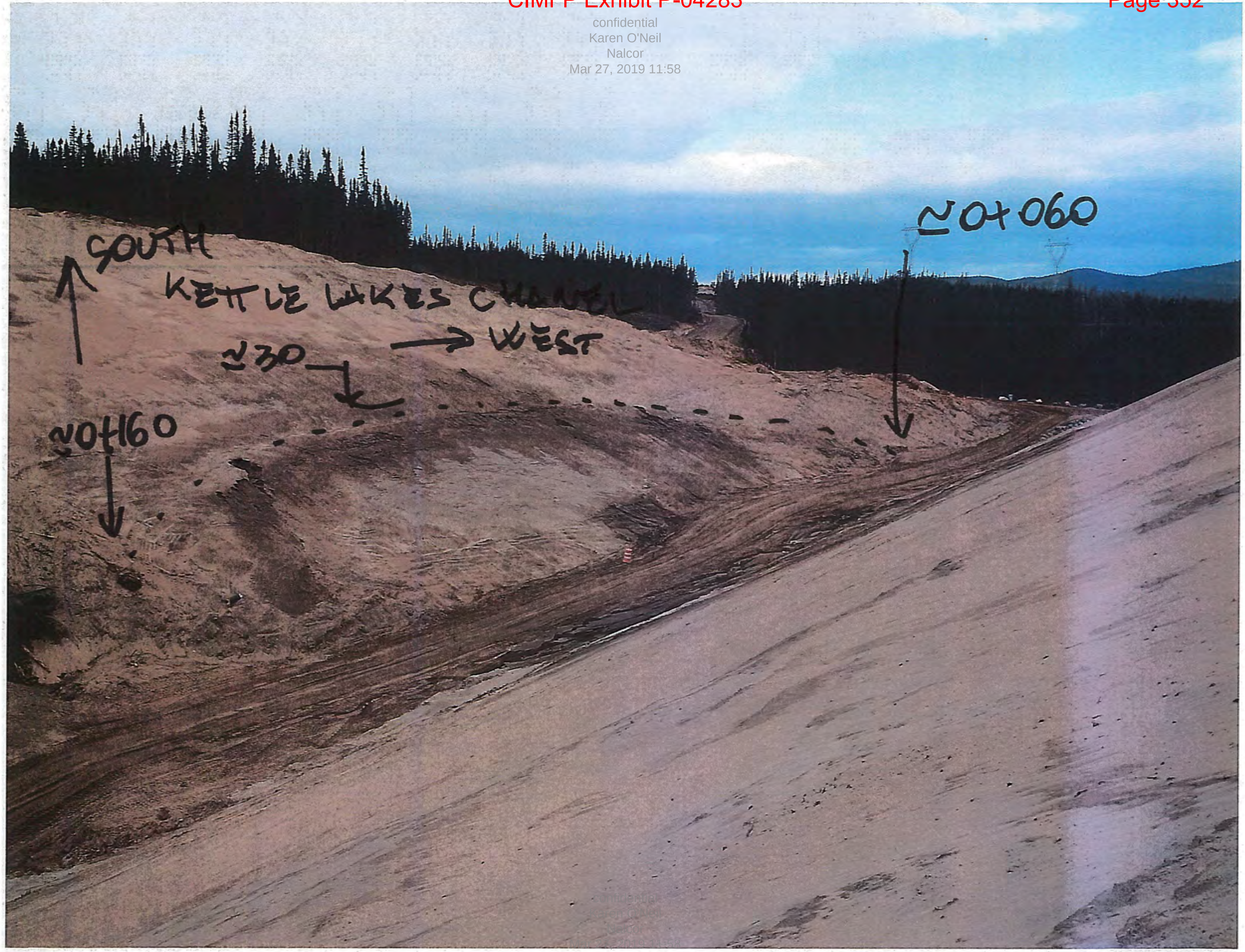
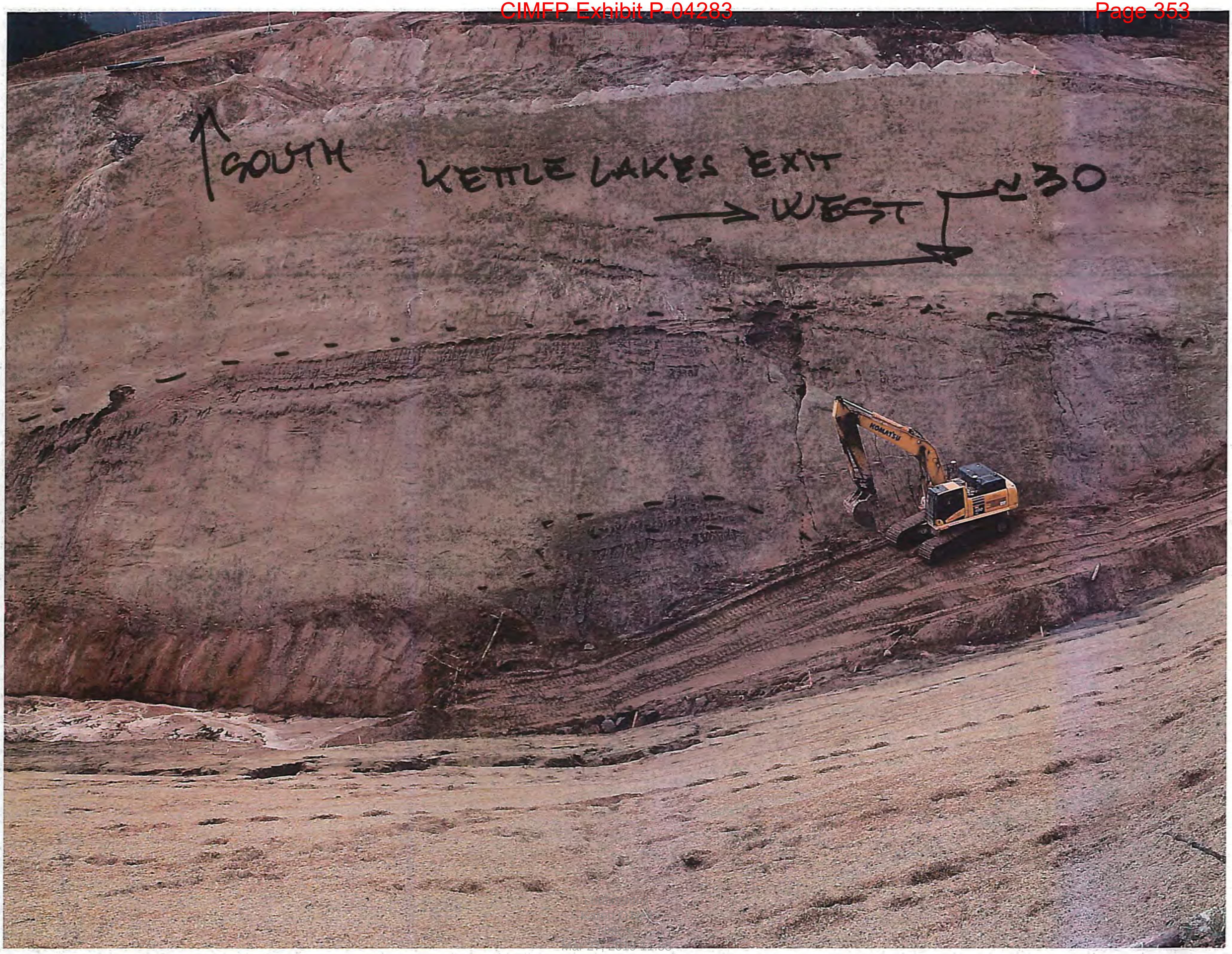
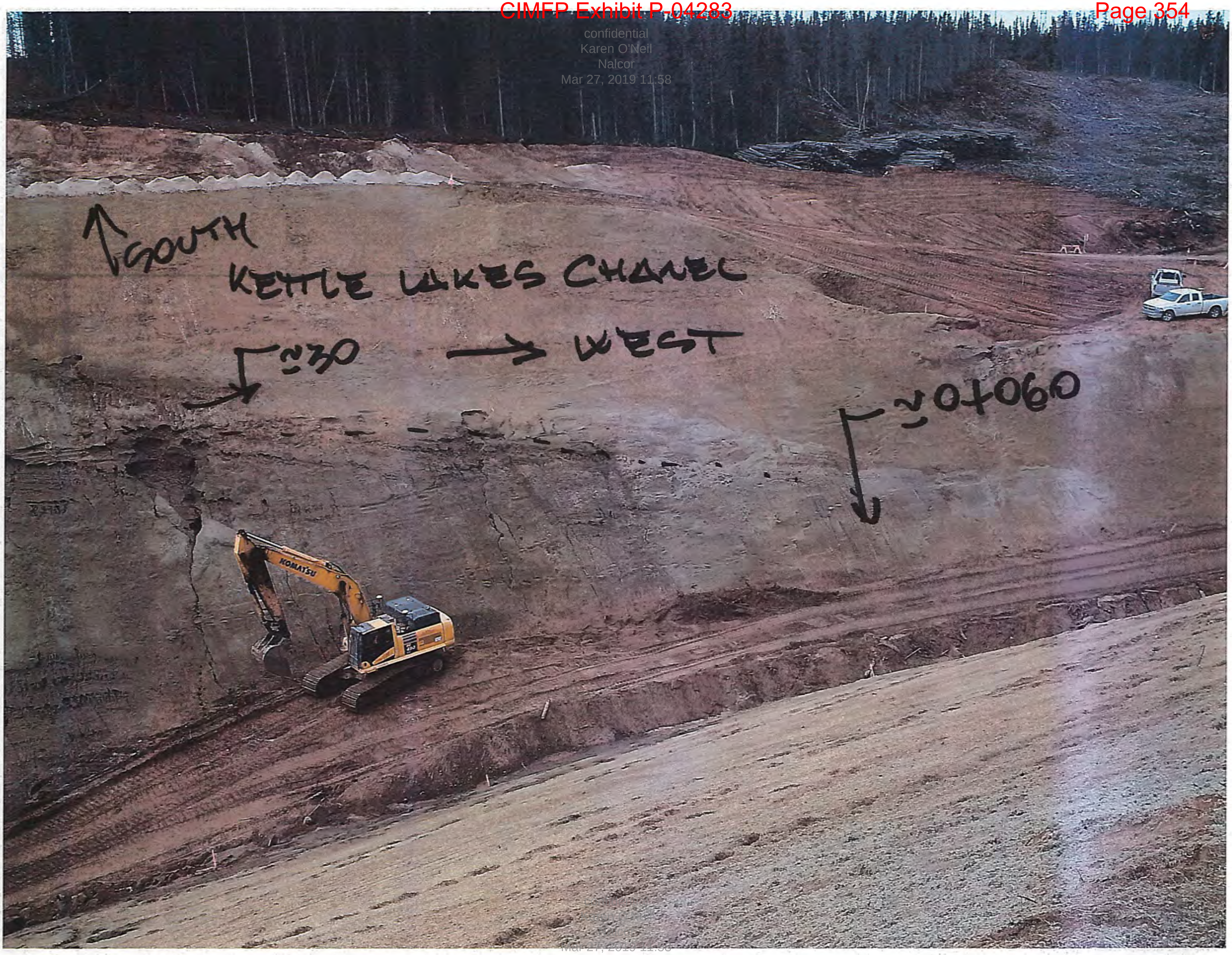

KETTLE LAKES CHANEL
SOUTH
EAST


EXIT PUMPWELL
KETTLE LAKES CHANEL
SOUTH
EAST
≃ 0+160


SOUTH
KETTLE LAKES CHANEL
WEST
≃30
≃0+160
≃0+060


SOUTH
KETTLE LAKES EXIT
WEST
≃30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KETTLE LAKES CHANEL
≈30
WEST
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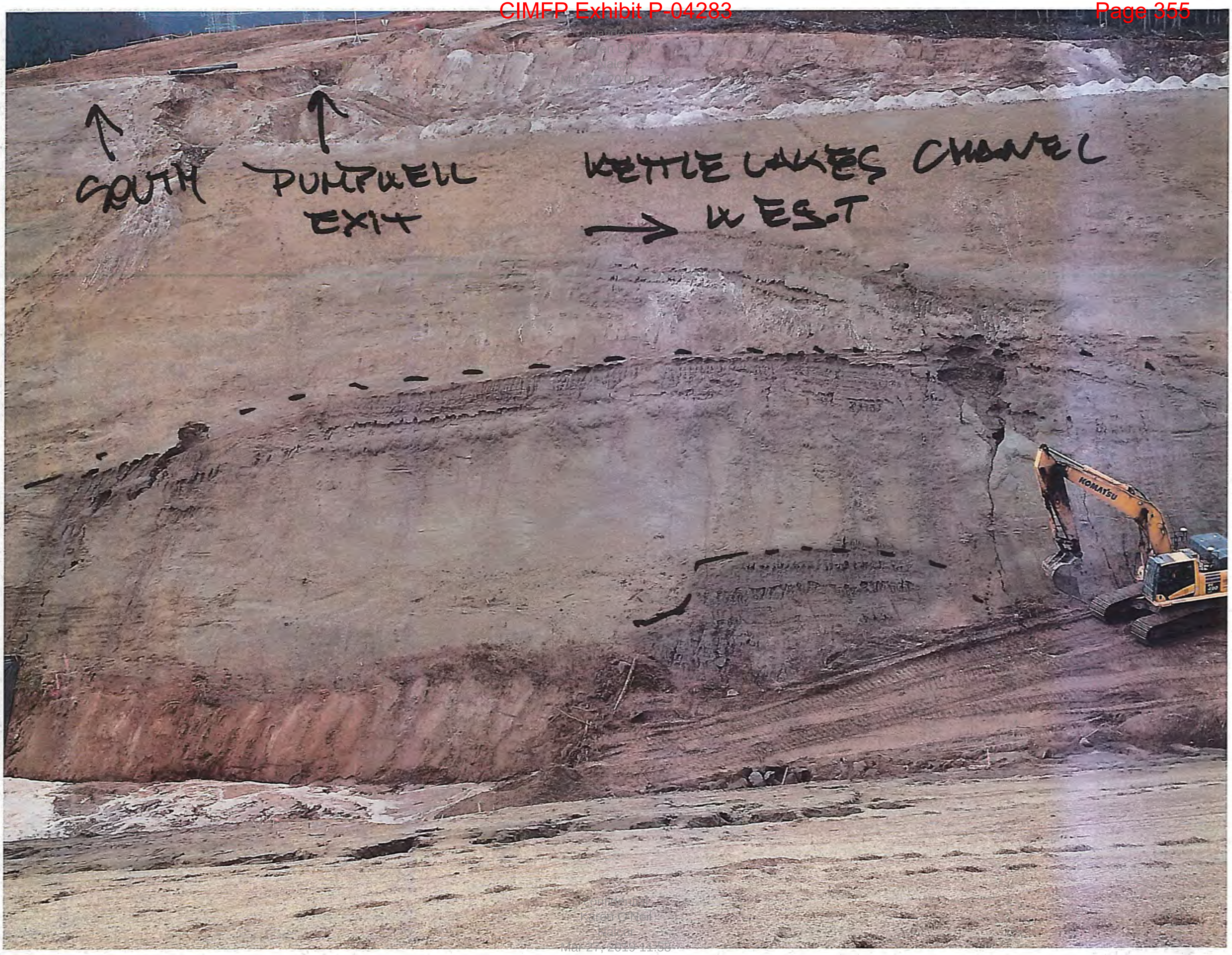
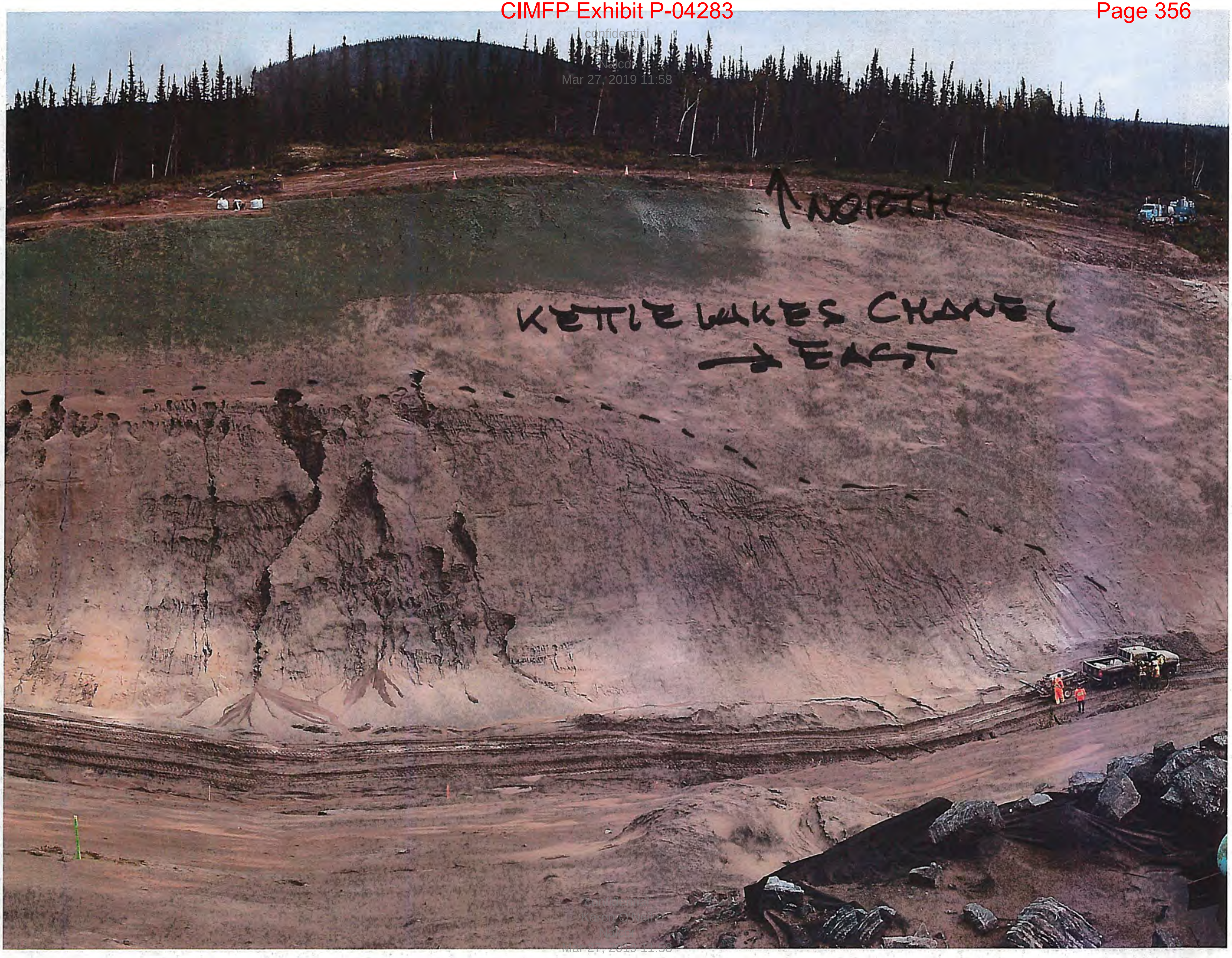
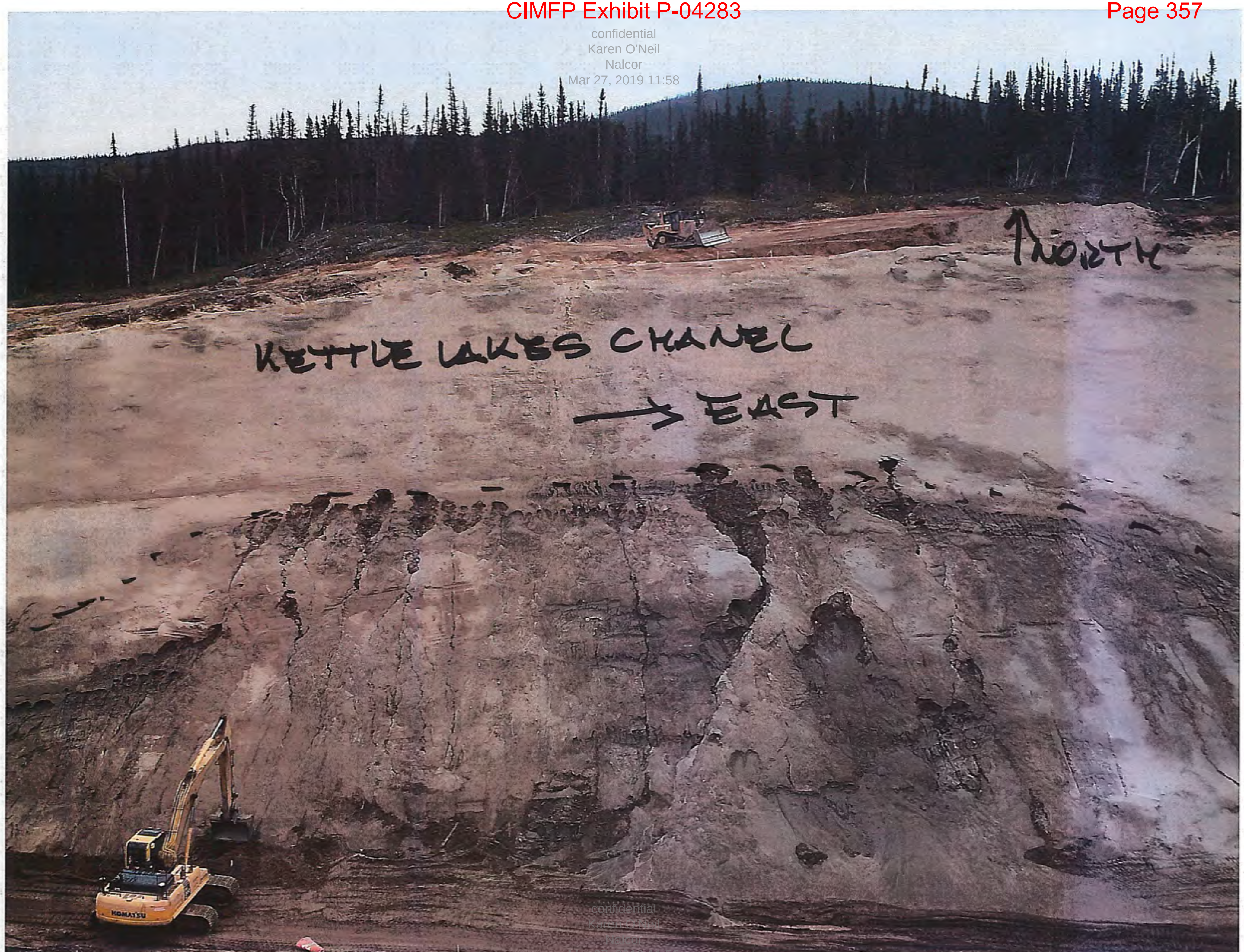
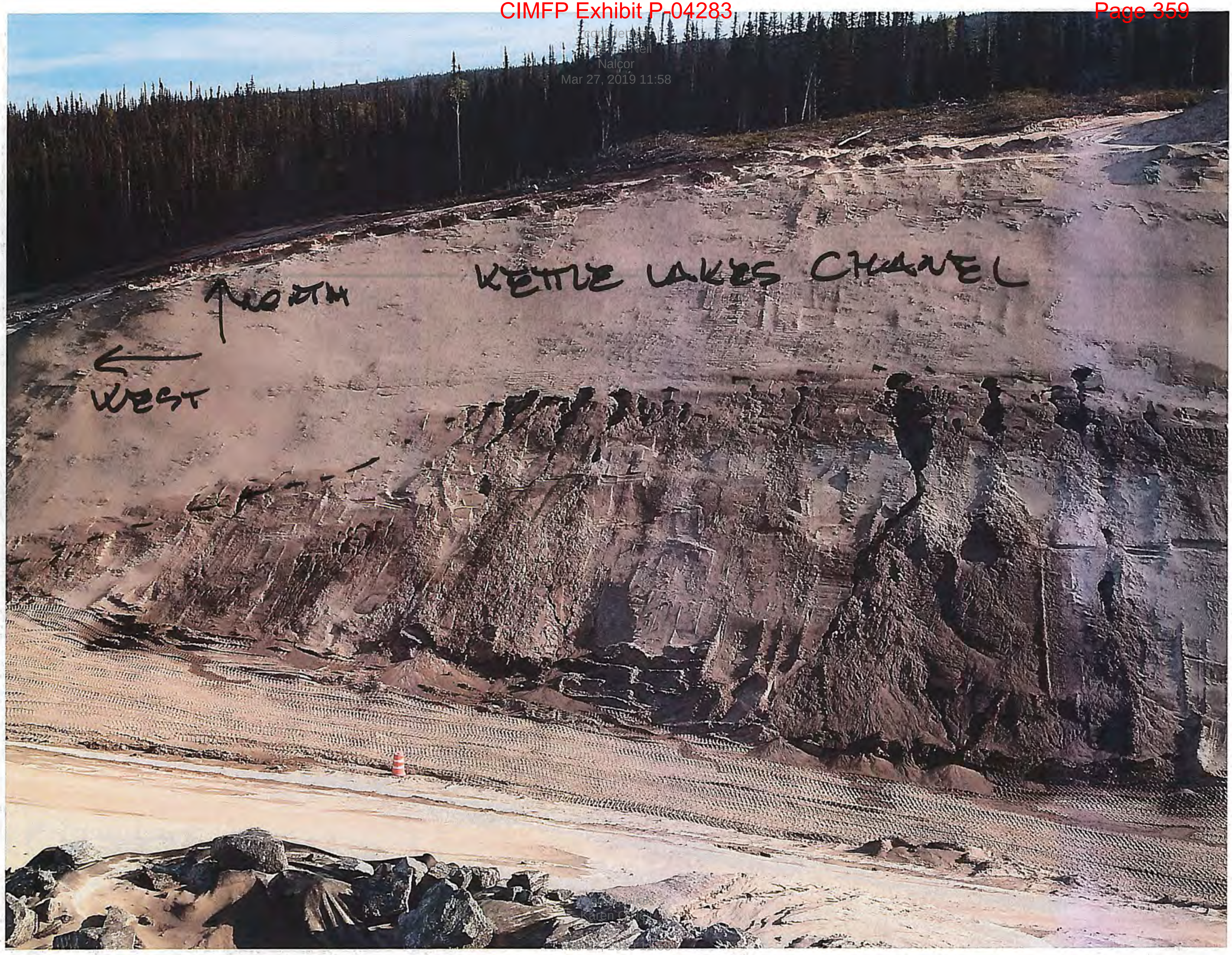
KOMATSU


SOUTH
PUMPWELL EXIT
KETTLE LAKES CHANNEL WEST
KOMATSU

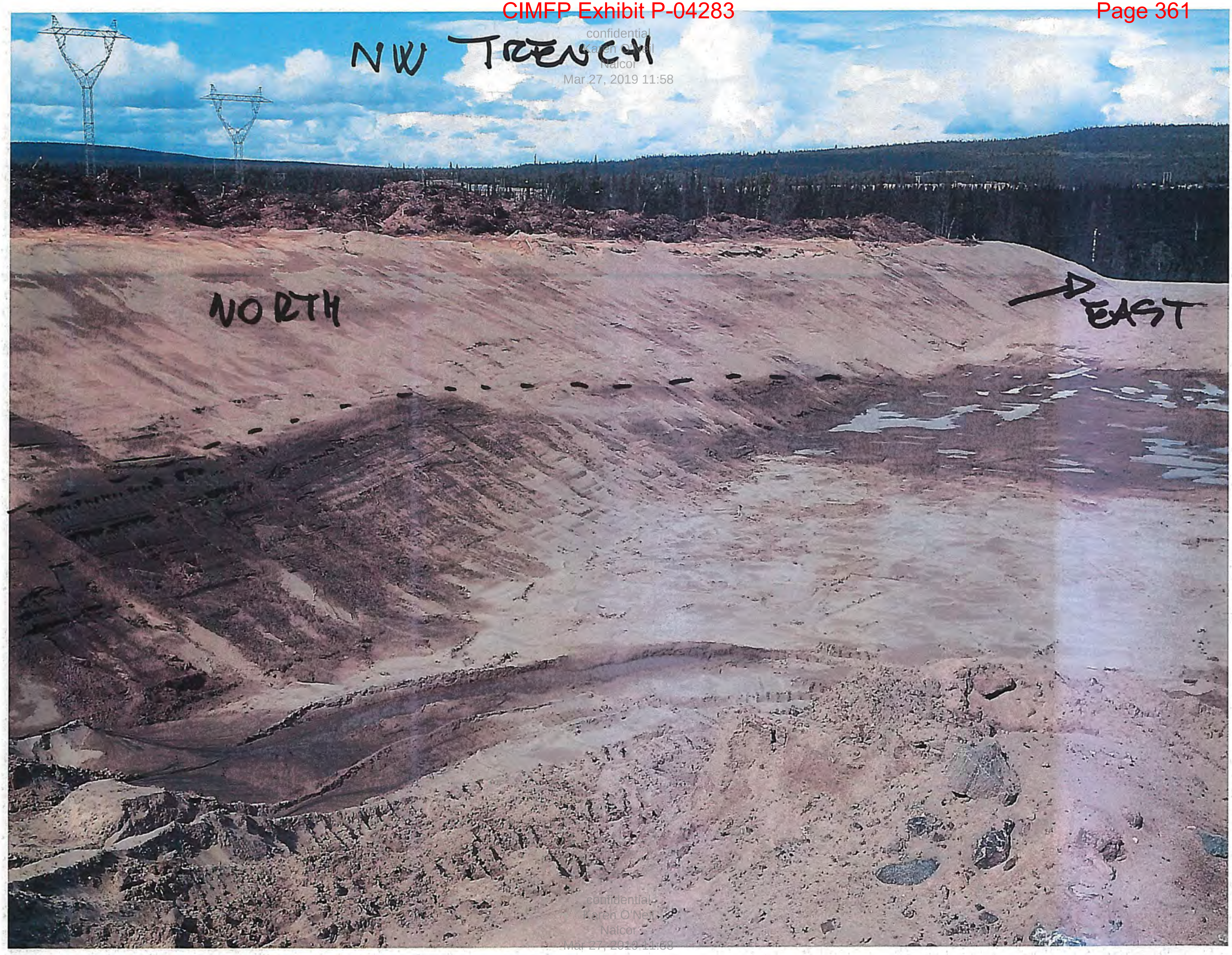

NORTH
KETTLE LAKES CHANEL
EAST


NORTH
KETTLE LAKES CHANEL
EAST

confidential
Karen O'Neil
Nalcor
Mar 27, 2019 11:58

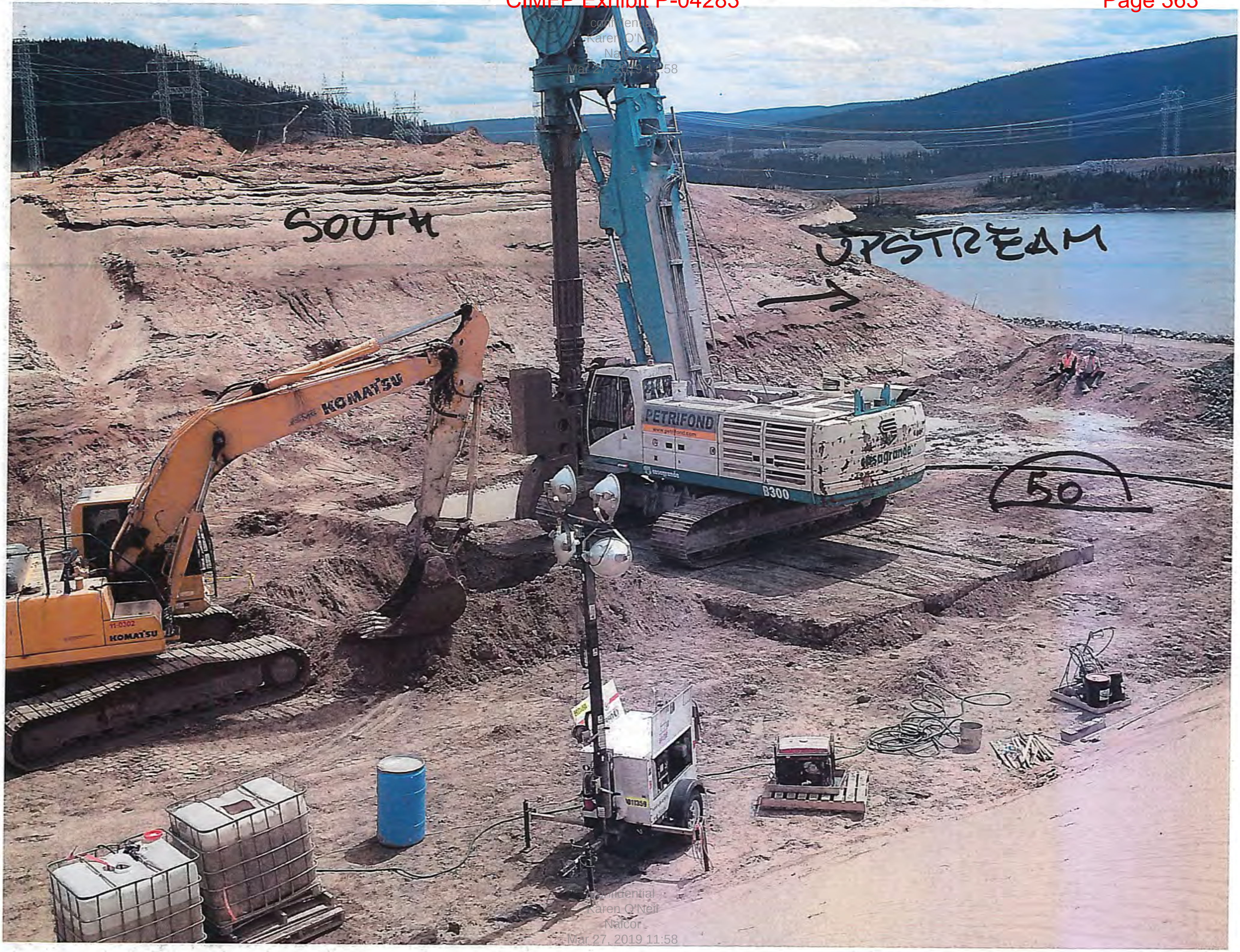

KETTLE LAKES CHANEL
NORTH
WEST

PICTURES NORTHWEST TRENCH



confidential
Karen O'Neill
Nalcor
Mar 27, 2019 11:58


NW TRENCH
KETTLE LAKE
50


SOUTH
UPSTREAM
50
KOMATSU
PETRIFOND
B300
KOMATSU


UPSTREAM
NORTH
50


UPSTREAM
50