Dover Underground Test Facility (UTF) Project Overview

- Project located ~65 km northwest of Fort McMurray
- Adjacent to Suncor MacKay River Project
- Dover Commercial Project consists of underground SAGD (UTF) and Surface SAGD portions
- UTF permanently abandoned by Suncor in 2013
- UTF consists of Phase A, Phase B, and Chevron Heated Annulus Steam Drive (HASDrive) tests
- Surface SAGD project consists of Phase D, Phase E, Phase F, Phase G, and DOVAP (Dover VAPEX) experimental scheme
- Information presented herein will focus on the UTF portion of the Dover Commercial Project only
UTF Overview

- UTF was constructed between 1985 and 1987
- Facility consists of two vertical shafts and a 1.5 km underground tunnel system
- Tunnels were driven into Devonian limestone below the McMurray Formation
- Wells drilled upwards from the tunnels starting at angles of 15 to 20 degrees above the horizontal and then dropped to horizontal in the oil sand
- Consisted of 3 tests to investigate different variations of the SAGD process:
  - Phase A
  - Chevron HASDrive
  - Phase B
- Wellhead abandonment occurred in 2008
- Underground Mine abandonment and associated surface facilities decommissioning was completed in 2013
Project Area and Project Site
Project Area and Project Site

- UTF located in Sections 7 and 18, Township 93, Range 12, west of the 4th Meridian
- Mineral Surface Lease (MSL) 830941
Project Area and Project Site
Project History

- Dover Project was originally known as the Alberta Oil Sands Technology and Research Authority (AOSTRA) UTF
- Facility was built in 1984 and operated by AOSTRA, now the Alberta Energy Research Institute (AERI)
- Gibson Petroleum Co. Ltd. Operated the UTF from 1995 to 1997
- Northstar Energy Corporation (Northstar) acquired the majority of working interest and assumed operatorship of the UTF in January 1998 – project renamed Dover
- Northstar became Devon Canada Corporation (Devon) in 2001
- Petro-Canada acquired the Dover Project from Devon in February 2005 – acquisition included the bitumen resources
- Suncor acquired the UTF through a merger with Petro-Canada in August 2009
- Resources immediately adjacent to the UTF area are depleted; consequently Suncor has no further use for the underground facility
- Complete abandonment of the UTF and associated infrastructure occurred in 2013
Historical Project Approvals – ERCB/EUB

- AOSTRA UTF originally approved under Energy Resources Conservation Board (ERCB) Approval No. 4198 in 1984
- Approval No. 4198 amended in 1986 to include Phase A test (Approval No. 4198A)
- Approval No. 4198A amended in 1987 to include Chevron HASDrive test (Approval No. 4198B)
- Approval No. 4198B was rescinded in 1990 and new Approval No. 6809 was issued to include the Phase B test
- Approval No. 6809 became commercial scheme Approval No. 9044 in 2002 when Devon applied to extend the operating term to June 2007
- Experimental Scheme Approval No. 9046 was issued in 2002 for the DOVAP experimental scheme
- In 2009 Approval No. 9046 and Approval No. 6809 were combined into the existing Approval No. 9044
- In December 2010 Approval No. 9044H was issued to Suncor for the abandonment of the UTF
Historical Project Approvals – Alberta Environment

- Alberta Environment originally issued Environmental Protection and Enhancement Act (EPEA) Approval No. 705-00-00 in 1992 for the AOSTRA Oil Production Site

- In August 1999, the EPEA approval was renewed and issued as Approval No. 705-01-00 to Northstar Energy Corporation for the Construction, Operation and Reclamation of the Dover Enhanced Recovery In-Situ Heavy Oil Processing Plant

- In June 2010, EPEA Approval No. 705-01-00 was again renewed, and issued as Approval No. 705-02-00 to Suncor Energy Inc.

- The Suncor Dover Commercial Project (UTF and Surface SAGD/Pilot Projects) currently operates under EPEA Approval No. 705-02-00 (as amended)
  - ESEIEH and BEST Pilot Projects included in current EPEA Approval
North-South estuarine channel sand deposit

- Channel width is about 500 to 800m
- Main target reservoir is the McMurray Formation
- Best quality at the base of reservoir
  - (high porosity and So)
- Lower quality near the top of reservoir
  - (bioturbated interbedded shales)
- No extensive bottom water and top gas/water
West-east cross section through the post-Devonian strata in the UTF Area
North-south cross section through the post-Devonian strata in the UTF Area
Geology and Geoscience

Year: 2008
Geology and Geoscience

Year: 2008
### Hydrostratigraphy of UTF Site

<table>
<thead>
<tr>
<th>Stratigraphy</th>
<th>Composition</th>
<th>Hydrostratigraphy</th>
<th>Water Quality</th>
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<td>Glacial</td>
<td>Till, clay, sand, silt</td>
<td>Variable K</td>
<td>Variable/Fresh Water</td>
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<td>Upper Clearwater</td>
<td>Lithic sand and sandstone, Shale and siltstone</td>
<td>K ~ 1x10^-7 m/s</td>
<td>Fresh Water</td>
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<td>Clearwater</td>
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<td>McMurray</td>
<td>Quartzose sand with heavy oil</td>
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<td>Devonian Limestone</td>
<td>Aquitard K~1x10^-16 m/s</td>
<td>Saline TDS ~ 22,000 mg/l</td>
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Source: 2010 Approved Dover UTF Mine Abandonment Plan
Dover Shafts, Tunnels, and Well Layout

**UTF Wells:**
- Phase A – 3 well pairs (A1, A2, and A3)
- HASDrive – 1 well pair (CH and CP)
- Phase B – 3 well pairs (B1, B2, and B3)

**Surface Wells:**
- Phase D, E, F, G and DOVAP

Source: 2010 Approved Dover UTF Mine Abandonment Plan
UTF Construction

Underground Facility:
- Two vertical shafts provided access to tunnels in the limestone that host the well chambers
- Well-pairs were drilled horizontally upwards into the reservoir
- Surface facilities and infrastructure were required to support UTF
  - Access, ventilation, and production services
UTF Shafts

• Two 4 m diameter shafts drilled in 1985 to a depth of 223 m and finished with 3 m diameter steel hydrostatic lining installed to depth of 213 m
• No. 1 Shaft provided the main access
  – equipped with a single rope hoist with cage and counterweight
  – emergency ladder-way
  – services for power and communications
• No. 2 Shaft was the main bitumen production shaft
  – equipped with rise chamber
  – various pipelines, electrical power and communication cables
  – return air shaft with exhausting ventilation by two axial-flow fans
UTF Shafts Continued

No. 1 Shaft General Arrangement Cross Section

No. 2 Shaft General Arrangement Cross Section

Source: 2010 Approved Dover UTF Mine Abandonment Plan
UTF Tunnels

• Total of ~ 1.5 km of rectangular tunnels (5 m wide by 4 m high) developed using the drill and blast method of mining
• Tunnels were constructed in competent limestone about 15 m below the McMurray Formation
  – Limestone roof with rock bolts were installed for stability
• Layer of shotcrete was applied to the sides in sections of the tunnels for durability
  – Painted white to improve reflectivity
• Tunnels remained stable for over 24 years without additional support required
UTF SAGD Wells

Phase A:
• Consisted of 3 well-pairs (A1, A2, and A3) - operated from 1987 to 1990
• Pilot test of the SAGD Process
• Produced 20,600 m³ (~130,000 barrels) of bitumen

HASDrive:
• Chevron patented HASDrive (Heated Annulus Steam Drive) process tested at UTF from 1987 to 1989
• Two underground horizontal wells (CH and CP) and one surface injection well (CI)
• Production unpublished

Phase B:
• Consisted of 3 well-pairs (B1, B2, and B3) – operated from 1990 to 2004
• Test to prove SADG process on commercial scale
• Produced 696,000 m³ (~4.4 Mbbl) of bitumen
Phase A – Drilling and Completions

- Three horizontal well-pairs (A1, A2, and A3) were drilled in 1987 and shut-in in 1990
- The six wells were 160 m long with a 60 m horizontal section completed in the oil sands
- Wells were drilled in pairs with steam injection well 5 m above the production well
- Three pairs spaced 25 m apart
- Achieved recovery of ~ 53% of original bitumen in place (OBIP)

Source: UTF Phase A Summary Report (AOSTRA, 1991)
A1 Well Pair

244.5 mm N-80 BT&C casing, 59.53 kg/m. LD = 37.63 m

222 mm Hole
Top of TCRL Filter @ 89.69 m

42.16 mm Schedule 40 pipe, LD = 140.1 m

Casing LD = 142.0 m
Bottom of TCRL Filter at 138.95 m

TD = 145.85 m

2.0 t of Class G cement + 40% Silica to surface

311 mm Hole

244.5 mm x 177.8 mm Drag Block Assembly LD = 1.70m

19 degrees start angle

177.8 mm x 127 mm change over at 27.65 m

25.95 m of 177.8 mm J-55 BT&C casing, 34.23 kg/m

127 mm J-55 BT&C casing, 10.4 kg/m

177.8 mm x 127 mm

Ten joints of 2.7m TCRL Steel Wool Filter. Inner mandrel: 127.00 mm N-80 casing, 26.8 kg/m, 10% perforated.

Alternated by 10 joints of 127.0 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.

Casing LD = 141.75 m,
Bottom of TCRL Filter approx. 141.75 m. (casing shoe not shown)

TD = 160 m

42.16 mm Schedule 4073 mm J-55 EUE tubing, 9.68 kg/m LD = 139.48 m

2.71 t of Class G cement + 40% Silica to surface

444.5 mm Hole

339.7 mm K-55 casing, 101.2 kg/m LD = 34.72 m

222 mm Hole
Top of TRL Filter at 86.79 m

4.07 t of Class G cement + 40% Silica to surface

444.5 mm Hole

339.7 mm K-55 casing, 101.2 kg/m LD = 34.72 m

222 mm Hole
Top of TRL Filter at 86.79 m

42.16 mm Schedule 4073 mm J-55 EUE tubing, 9.68 kg/m LD = 139.48 m

25.4 mmOD Pipe (Thermocouple String) LD = 137.08 m

TD = 160 m

139.7 mm J-55 BT&C casing, 23.12 kg/m

11.33 m of 177.8 mm J-55 BT&C casing, 34.23 kg/m

139.7 mm J-55 BT&C casing, 23.12 kg/m

177.8 mm x 139.7 mm change over at 12.63 m

Ten joints of 2.7 m TCRL Steel Wool Filter. Inner mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the top of the screen sections.

Casing LD = 141.75 m,
Bottom of TCRL Filter approx. 141.75 m. (casing shoe not shown)
A2 Well Pair

1.89 t of Class G Cement + 40% Silica to surface

444.5 mm Hole

2.06 t of Class G Cement + 40% Silica to surface.

339.7 mm K-55 BT&C casing, 101.2 kg/m LD = 14.33 m

244.5 mm N-80 BT&C casing, 59.53 kg/m LD = 40.45 m

244.5 mm x 177.8 mm Drag Block Assembly LD = 1.65 m

177.8 mm x 127 mm change over @ 36.26 m

34.36 m of 177.8 mm J-55 BT&C Casing, 34.23 kg/m

Ten 2.7 m Joints of 0.010" gap externally wire wrapped screens Inner Mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.

222 mm Hole

Top of TCRL Filter @ 101.91 m

42.16 mm Schedule 40 pipe, LD = 151.97 m

139.7 mm J-55 BT&C casing, 23.12 kg/m

16 degrees start angle

Casing LD = 159.31 m, Bottom of Screens @ 155.87 mm

222 mm Hole

Top of Screens at approx 103.2 m

73 mm J-55 EUE tubing, 9.68 kg/m LD = 154.37 m

33.4 mm Non API tubing, 8RD, 47 joints, LD = 15304 m

Ten joints of 2.7m 0.010” gap externally wire wrapped screen inner mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.

Wellhead Not Shown

244.48 mm N-80 casing, 59.6 kg/m LD = 43.00 m

244.5 mm x 177.8 mm Drag Blok Assembly

177.8 mm x 139.7 mm Crossover LD = 20.7 m

13 degrees start angle

1.89 t of Class G Cement + 40% Silica to surface

1.89 t of Class G Cement + 40% Silica to surface

222 mm Hole

Top of Screens at approx 103.2 m

73 mm J-55 EUE tubing, 9.68 kg/m LD = 154.37 m

33.4 mm Non API tubing, 8RD, 47 joints, LD = 15304 m

Ten joints of 2.7m 0.010” gap externally wire wrapped screen inner mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.

42.16 mm Schedule 40 pipe, LD = 151.97 m

139.7 mm J-55 BT&C casing, 23.12 kg/m

16 degrees start angle

Casing LD = 159.31 m, Bottom of Screens @ 155.87 mm

222 mm Hole

Top of Screens at approx 103.2 m

73 mm J-55 EUE tubing, 9.68 kg/m LD = 154.37 m

33.4 mm Non API tubing, 8RD, 47 joints, LD = 15304 m

Ten joints of 2.7m 0.010” gap externally wire wrapped screen inner mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.
A3 Well Pair

339.7 mm K-55 BT&C casing, 101.2 kg/m. LD = 34.26 m

139.7 mm J-55 BT&C casing, 23.06 kg/m

339.7 mm x 177.8 mm Drag Block and 177.8 x 139.7 mm Crossover Assembly Landed at the Casing Bowl.

17.75 degrees start angle

222 mm Hole

Top of screens @ 89.69 m

27 mm pipe LD = 137.76 m

Ten joints of 2.7 m 0.005” gap externally wire wrapped screen Inner mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.

Casing LD = 140.0 m
Bottom of Screens approx. 140 m

3.87 t of Class G cement + 40% Silica to surface

244.85 mm L-80 casing, 59.53 kg/m LD = 38.85 m

222 mm Hole

Top of Screens @ 81.00 m

73 mm J-55 EUE tubing, 9.68 kg/m LD = 38.85 m

Ten joints of 2.7 m 0.005” gap externally wire wrapped screen Inner mandrel: 139.7 mm N-80 casing, 25.3 kg/m, 10% perforated.

Alternated by 10 joints of 139.7 mm J-55 casing. Centralizers mounted on every joint from TD to the end of the screen sections.

Casing LD @ 142.06 m

73 mm J-55 EUE tubing, 9.68 kg/m LD = 38.85 m

2.28 t of Class G cement plus 40% silica to surface

311 mm Hole

244.5 mm x 177.8 mm Drag Block Assembly
177.8 mm x 139.7 mm Crossover, LD = 20.7 m

16.5 degrees start angle
Chevron HASDrive – Drilling and Completions

- Consisted of two horizontal underground wells (CH and CP) and one surface-drilled vertical injection well (CI)
- HASDrive process used an unperforated horizontal “pipe” (CH) placed in the reservoir to circulate steam to create a heated path between the vertical steam injection well (CI) and the horizontal production well (CP)
- There was no steam injected into the reservoir from horizontal well – only used to conduct heat into the reservoir and maintain heated flow path
HASDrive Well Pair – CH Well

244.48 mm N-80 casing, 59.6 kg/m
L.D. = 43.00 m

2.34 t of Class G cement plus 40% silica to surface

222 mm Hole

177.8 mm J-55 BT&C casing, 29.79 kg/m,
centralizers run over the last 44 m to TD.

Casing L.D. at 161.2 m

Hole TD = 162.85 m

73 mm J-55 EUE tubing, 9.68 kg/m
L.D. = 159.2 m, centralizers run on each collar.

311 mm Hole

1.00 t of Class G cement plus 40% silica flour
between 244.5 mm and 177.8 mm casing.

17.5° start angle
HASDrive Well Pair – CP Well

244.48 mm N-80 casing, 59.6 kg/m
LD = 40.54 m

177.8 mm J-55 BT&C casing, 29.79 kg/m

73 mm J-55 EUE tubing, 9.68 kg/m
LD = 107.17 m
Top of Screens at 86.23 m

Casing LD at 108.70 m
Hole TD = 112 m

Eight 2.8 m joints TCRL Steel Wool Filter.
Inner mandrel: 177.8 mm N-80 casing, approx. 29.79 kg/m, 10% perforated.

2.29 t of Class G Cement plus 40% silica to surface

17.25° start angle
Phase B – Drilling and Completions

• Three horizontal well-pairs (B1, B2, and B3) drilled in 1990 and shut-in in 2004
• Six wells were 600 m long with a 500 m horizontal section completed in the oil sands
• Wells were drilled in pairs with steam injection well 5 m above the production well
• Three pairs spaced 70 m apart
• B1 well-pair achieved recovery of ~ 55% OBIP
• B2 well-pair achieved recovery of ~ 90% OBIP
• B3 well-pair achieved recovery of ~ 51% OBIP
B1 Well Pair

End of Screens 610.06 m from wellhead

15.76 degrees spud angle

47.55 m of 444.5 mm surface hole

40% silica Class G thermal cement with gas check

339.7 mm surface casing, 46.4 m, 101.2 kg/m k-55 with N-80 VAM premium connections

Beginning of Screens 93.3 m from wellhead

88.9 mm tbg, 610.1 m, schedule 40 grade A53

244.5 mm production casing, 613.75 m, 53.57 kg/m J-55 casing with 244.5 mm pins and boxes

Type E Thermocouple MgO Insulation, 316 stainless steel sheath, 3.17 mm to 603.18 m

40% silica Class G thermal cement with gas check

516.76 m

End of Screens 516.76 m

Beginning of Screens 96.3 m from wellhead

339.7 mm surface casing, 50.8 m, 101.2 kg/m k-55 with N-80 VAM premium connections

244.5 mm production casing, 609.63 m, 53.57 kg/m J-55 casing with 244.5 mm pins and boxes

Type E Thermocouple MgO Insulation, 316 stainless steel sheath, 3.17 mm to 603.18 m

15.5 degrees spud angle

51.14 m of 444.5 mm surface hole

40% silica Class G thermal cement with gas check

73.0 mm tbg, 603.48 m, schedule 40 grade A53

244.5 mm production casing, 609.63 m, 53.57 kg/m J-55 casing with 244.5 mm pins and boxes

Used 6 1/4" bit

Used 11" bit

TD of Drilled well 622.25 m

519.0 m

End of Screens 519.0 m

TD of Drilled well 619.72 m

Shoe joints
B2 Well Pair

49.66 m of 444.5mm surface hole

40% silica Class G thermal cement with gas check

339.7 mm surface casing, 48.45 m, 101.2 kg/m k-55 with N-80 VAM premium connections

15 degrees spud angle

57.0 m of 444.5mm surface hole

244.5 mm production casing, 616.63 m, 53.57 kg/m J-55 casing with 244.5 mm pins and boxes

Shoe joints

Type E Thermocouple MgO Insulation, 316 stainless steel sheath, 3.17 mm to 608.1 m

End of Screens 613.58 m from wellhead

TD of Drilled well 629.06 m

88.9 mm tbg, 614.3 m, schedule 40 grade A53

Type E Thermocouple MgO Insulation, 93.3 m from wellhead

Beginning of Screens 93.3 m from wellhead

319.72 m

Screens

244.5 mm production casing, 616.32 m, 53.57 kg/m J-55 casing with 244.5 mm pins and boxes

319.72 m

End of Screens 613.02 m from wellhead

TD of Drilled well 623.06 m

40% silica Class G thermal cement with gas check

Screens

Beginning of Screens 93.3 m from wellhead

319.72 m

End of Screens 613.58 m from wellhead

TD of Drilled well 629.06 m

244.5 mm production casing, 619.72 m

88.9 mm tbg, 614.3 m, schedule 40 grade A53

Type E Thermocouple MgO Insulation, 316 stainless steel sheath, 3.17 mm to 608.1 m

End of Screens 613.58 m from wellhead

TD of Drilled well 629.06 m

339.7 mm surface casing, 55.36 m, 101.2 kg/m k-55 with N-80 VAM premium connections

339.7 mm surface casing, 48.45 m, 101.2 kg/m k-55 with N-80 VAM premium connections

339.7 mm surface casing, 48.45 m, 101.2 kg/m k-55 with N-80 VAM premium connections

339.7 mm surface casing, 55.36 m, 101.2 kg/m k-55 with N-80 VAM premium connections


B3 Well Pair

- 14 degrees spud angle
- 55.67 m of 444.5mm surface hole
- 88.9 mm tbg, 613.29 m, schedule 40 grade A53
- 244.5 mm production casing, 617.75 m, 53.57 kg/m J-55 casing with 244.5 mm pins and boxes
- 339.7 mm surface casing, 59.35 m, 101.2 kg/m k-55 with N-80 VAM premium connections
- 16.09° spud angle
- 59.0 m of 444.5mm Surface hole
- Thermal Cement Class G with 40% Silica and Gas Check
- Screens: 219.1mm 65.5 kg/m N-80 Casing with 0.187mm gap Wire Wrapped Screen Outside flush diameter : 244.5mm
- Injection Tubing String: 613.23m 200 joints (612.0m) 88.8mm Schedule 40 Grade A53
- Blowout Preventer
- 1/4" Bubble Tube stripped outside of the Tubing String to 65.7m
- 49.35m of 339.7mm 101.2 kg/m k-55 surface casing with N-80 VAM Premium Connections
- 1/4" Bubble Tube to Tubing Shoe to 612.79m
- Screens 527.42 m
- Beginning of Screens 37.01 m from wellhead
- End of Screens 614.43 m from wellhead

Figure 4.10
UTF Surface Facilities

Aerial View of Dover UTF Shaft Buildings

#1 Shaft Headframe
Hoist-House
Warehouse
Workshop
Generator Building
#1 Shaft Collar-House
Bath-House
Mine Freshwater Building & Tank
Admin Building

Source: 2010 Approved Dover UTF Mine Abandonment Plan
UTF Surface Facilities
# UTF Wellhead and Shaft Locations

<table>
<thead>
<tr>
<th>UWI</th>
<th>Well Name</th>
<th>Dover Name</th>
<th>Licence</th>
<th>Mine Grid</th>
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Notes:
1. 3TM coordinates are referred to Longitude 111° West of Greenwich.
2. Mine coordinates are obtained by subtracting 6,3200,000 m from the 3TM Northing and adding 60,000 m to the 3TM Easting.
3. Wellhead coordinates for Phase A and HASDrive Wellheads are to an accuracy of about ±1 m.
4. Wellhead coordinates for Phase B are estimated from geotechnical monitoring stations and are to an accuracy of about ±3 m.
5. Phase B Wells are licensed and more accurate wellhead locations are likely to be available.
Observation Wells

• Phase A:
  – 28 observation wells were drilled in 1987
  – 8 temperature, 4 pressure, 5 temperature/pressure, 2 baseline pressure, 3 extensometer (vertical strata movement), and 6 temperature/inclinometer (horizontal strata movement)

• HASDrive:
  – 6 observation wells were drilled in 1987
  – All 6 wells used to measure reservoir temperatures along the underground CH well

• Phase B:
  – 30 observation wells were drilled in 1991
  – 1 extensometer, 7 thermocouple/inclinometer – 7” cased, 12 thermocouple, 5 thermocouple/inclinometer – 4.5” cased, and 5 thermocouple/piezometer
Observation Well Layout – Phase A

Source: UTF Phase A Summary Report (AOSTRA, 1991)
Observation Well Layout – HASDrive

A - Phase "A"
C - Chevron
I - Injection Well
P - Production Well
H - HAS Pipe
T - Temperature Well
GP - Geotechnical Piezometer Well
GE - Geotechnical Extensometer Well
GI - Geotechnical Inclinometer Well
GB - Geotechnical Baseline Piezometer Well
LS - Limestone - oil sand contact for Horizontal Wells
Dover UTF Observation/Monitoring Wells

- 6 observation wells in the direct area of the UTF will be used to monitor the pressure and temperature behavior in the McMurray reservoir.

- At this time Suncor is finalizing the details around post-closure pressure and temperature monitoring in these observation/monitoring wells.
UTF Technical Challenges

• Unique Recovery Process:
  – Prior to the UTF SAGD process, recovery relied on vertical wells for injection and production
  – Previous concept was to develop heated path with steam or combustion between vertical injector and vertical producer
  – Steam or air injection at the injector would drive the heated bitumen to the producer
  – Process was found to be ineffective

• Horizontal Wells:
  – At the time of UTF development, horizontal wells in oil reservoirs were not able to be drilled with assurance
  – SAGD process at the UTF was considered well beyond the accuracy or control of horizontal well technology at the time

• Sand Production:
  – All vertical well projects prior to the UTF were plagued with excessive sand production
  – Three single horizontal wells were drilled prior to the UTF by Texaco, and all three failed do to sand influx and poor production rates
UTF Technical Challenges Continued

• Steam Channeling:
  – Experience with vertical well steam injection prior to the UTF was cause for concern that steam would channel to the producer without spreading into the reservoir to heat oil for production

• No Downhole Pumps:
  – Design of UTF wells with no downhole oil pumps was contrary to all oil sands industry experience up to that point in time

• Steam/Oil Ratio:
  – Steam/oil ratio predicted for the UTF was more favorable (less steam required to produce a barrel of bitumen) than was ever achieved in oil sands operations in Alberta
UTF Technical Challenges Continued

• Production Rates:
  – Technology at the time called for high reservoir and pressure to drive heated bitumen to vertical production wells to achieve production rates
  – Disbelief of the SAGD concept of having heated bitumen flow down to the horizontal producer could provide adequate production rates

• Wells Drilled from Underground Shafts:
  – Used to achieve required accuracy of horizontal well drilling and critical steam trap control on production well
  – This was beyond any experience in the Western Canadian Oil industry at the time
Historical Scheme Performance – Phase A

Source: UTF Phase A Summary Report (AOSTRA, 1991)
Historical Scheme Performance – Phase A

Source: UTF Phase A Summary Report (AOSTRA, 1991)
### Historical Scheme Performance – A1 Well Pair

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- Cumulative Steam Injection: 31,466 m³
- Cumulative Water Production: 17,978 m³
- Cumulative Bitumen Production: 9,548 m³

Source: UTF Phase A Summary Report (AOSTRA, 1991)
### Historical Scheme Performance – A2 Well Pair

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- Cumulative Steam Injection: 12,939 m³
- Cumulative Water Production: 12,401 m³
- Cumulative Bitumen Production: 4,873 m³

Source: UTF Phase A Summary Report (AOSTRA, 1991)
## Historical Scheme Performance – A3 Well Pair

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</table>

- **Cumulative Steam Injection:** 2,476 m³
- **Cumulative Water Production:** 10,830 m³
- **Cumulative Bitumen Production:** 6,830 m³

Source: UTF Phase A Summary Report (AOSTRA, 1991)
Historical Scheme Performance – Phase B
Historical Scheme Performance – B1 Well Pair

- Cumulative Steam Injection: 796,000 m³
- Cumulative Water Production: 447,900 m³
- Cumulative Bitumen Production: 194,300 m³
Historical Scheme Performance – B2 Well Pair

- Cumulative Steam Injection: 360,300 m³
- Cumulative Water Production: 797,400 m³
- Cumulative Bitumen Production: 321,300 m³
Historical Scheme Performance – B3 Well Pair

- Cumulative Steam Injection: 511,800 m³
- Cumulative Water Production: 416,300 m³
- Cumulative Bitumen Production: 181,000 m³
### Historical Scheme Performance Summary

<table>
<thead>
<tr>
<th>Phase</th>
<th>Bitumen Produced (10³ m³)</th>
<th>Water Produced (10³ m³)</th>
<th>Steam Injected (10³ m³)</th>
<th>NCG Injected (10³ m³)</th>
<th>Oil Cut (%)</th>
<th>SOR (m³/m³)</th>
<th>OBIP (10³ m³)</th>
<th>Recovery (%)</th>
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</table>

- Bitumen production from the underground wells at the UTF Mine was discontinued in June 2004
Water Disposal Geology

- The Wabiskaw Sand at the base of the Clearwater Formation was used for water disposal at the UTF
- Core and geophysical logs showed the Wabiskaw sand is thicker and less cemented to the south of the UTF

Source: AOSTRA UTF Project SAGD – Phase B Final Report (AOSTRA, 1999)
Water Disposal Wells
Water Disposal Wells
Water Disposal into Wabiskaw

- EUB Class II Disposal Approval No. 10991
  - 31 water disposal wells (WDWs) associated with the disposal scheme approval
  - No disposal occurred into these wells after 2006
  - All WDWs have been abandoned as of March 2013

Note: The water disposal volume is associated with operations resulting from UTF and Surface SAGD portions of the Dover Facility
UTF Water Source Wells

- 4 Water Source Wells (WSWs) were associated with the Dover UTF:
  - WSW No.1 – drilled in 1984 originally under AENV Approval No. 30414-00-00
    - Suspended in 1996
  - WSW No.2 – drilled in 1984 originally under AENV Approval No. 30414-00-00
  - WSW No.3 – drilled in 1992 originally under AENV Approval No. 30415-00-00
  - WSW No.4 – drilled in 1996 to replace WSW No.1

- In 1984, the Dover UTF was permitted to divert up to 239,120 m³/year of groundwater utilizing WSW No. 1 and No. 2
  - Groundwater withdrawal from the Birch Channel Aquifer

- In 1992, a new permit was issued for WSW No. 3 to divert 438,234 m³/year of groundwater

- WSWs currently under Diversion License No. 251163 for a total diversion of 677,345 m³/year

- License No. 251163 is in the process of being renewed to support Dover and MacKay River future development
UTF Water Source Wells
Note: The fresh water withdrawal rate is associated with operations resulting from UTF and Surface SAGD portions of the Dover Facility.
Note: The fresh water usage rations are associated with operations resulting from UTF and Surface SAGD portions of the Dover Facility.
UTF Cumulative Fresh Water Withdrawal

Note: The fresh water withdrawal volume is associated with operations resulting from UTF and Surface SAGD portions of the Dover Facility.
Dover Net Pay and Resource Areas Impacted by UTF

- Resource net pay thickness isopach at 6% Bulk Mass Fraction of Oil (BMFO) in relation to the facility and wells
- 50 m setbacks from the estimated underground production areas and the tunnels

LEGEND:

- Net Pay - 6% BMFO
- Net Pay Areas
  - Phase A/C (50m Setback)
  - Phase B (50m Setback)
  - Net Tunnel (50m Setback)
- Tunnels
  - Tunnel
  - Tunnel Outline (50m Setback)
UTF Oil-In-Place Volumetric Calculations

- Oil-In-Place (OIP) was based on 6% cut-off from the BMFO measurements from core analysis and wireline logs
- 50 m setback was generated around Phase A, B, and HASDrive (C) wells
- Phase A and HASDrive setbacks combined into one zone (Phase A/C)
- Setback generated around the tunnels, but Phase B and Phase A/C zones subtracted from this area to create a net-tunnel setback
- Volume of sand for the three setback areas was calculated
- Average oil saturation and porosity (SoPHI) from well data was used to calculate oil in place

<table>
<thead>
<tr>
<th>50 m Setback Area</th>
<th>Sand Volume (M m³)</th>
<th>SoPHI</th>
<th>OIP (M m³)</th>
<th>OBIP (M bbl)</th>
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<td>Phase A/C</td>
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<td>net Tunnels</td>
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<td>0.246</td>
<td>1.544</td>
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<td><strong>Cumulative Total:</strong></td>
<td><strong>1.631</strong></td>
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<td><strong>10.257</strong></td>
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</table>
Phase A Operating Experience

• Sand control was a major success – only one well produced more sand than would fill the wellbore

• Any sand produced appeared to readily flow out of the wells when production rates increased

• Sand control and the absence of moving parts in the wellbores obviated the need for underground workovers

• Erosion and jamming of control valves (steam trap valves) was the only common type of equipment failure – caused by flashing of hot produced water across the valve

• Gas breakout in the hot production caused problems with the mass flow meters – a separator was eventually installed upstream of the underground test skid
Phase B Key Learnings

• Long horizontal wells of 500 m horizontal sections could be drilled and completed in unconsolidated oil sands formation

• Results from the Phase A pilot could be scaled up to longer wells

• Production through the tubing was favored early in the well life to keep the entire wellbore hot and accelerate the full wellbore utilization

• When production rates climbed, production from tubing and annulus was favored so that overall pressure drop in the production well was reduced and production maximized
UTF Wellhead Abandonment

• Wellhead abandonment of all 14 wellheads (6 Phase A, 6 Phase B, and 2 HASDrive) was completed in August 2008

• HSE Integrated Ltd. on behalf of Suncor completed all abandonment work

• The scope of work for each of the wellhead abandonments included the following:
  – Closure of all valves found to be in ‘open’ position
  – Hot tapped steam injection and bitumen production lines piped into wellheads. Checked for pressure and bled off as required.
  – Removed insulation piping and cold cut piping to be blind flanged where appropriate.
  – Installed blind flanges onto all flanged wellhead outlets and installed threaded bull plugs into all threaded wellhead outlets.
UTF Mine Abandonment

- Bitumen production from the underground wells was discontinued in June 2004
- In October 2006, the underground facility was placed on a ‘Care and Maintenance’ program undertaken by Petro-Canada
- The ERCB approved the Mine Abandonment Plan in December 2010 and issued Approval No. 9044H
- Alberta Environment approved the decommissioning of surface facilities associated with the UTF in May 2010
- The Dover UTF Mine Abandonment Project was completed December 31, 2013
- Mining Concrete Ltd. completed the UTF Mine Abandonment on behalf of Suncor
- The overall mine abandonment consisted of the following activities:
  - Removal of some limited infrastructure and equipment from underground
  - Closure of shafts with engineered fill, isolation plug and concrete cap
  - Demolition and disposal of some surface buildings
  - Surface grading for drainage control
UTF Surface Facilities Decommissioning

• Mine abandonment was limited to the UTF, including the shafts, tunnels and associated surface buildings and infrastructure directly associated with the shafts

• The surface buildings included the No. 1 Shaft collar house and headframe, and the No. 2 Shaft collar house, fan drift and mine fans

• Surface buildings and infrastructure were removed to a depth of 2 m below ground surface

• Equipment and materials were salvaged for recycling or disposed of in the upper shaft fill or at an approved facility

• Abandonment did not include other surface wells and surface facilities required for steaming and bitumen processing
UTF Surface Facilities Decommissioning

LEGEND:
- Buildings demolished
- Support Buildings left intact

Source: 2010 Approved Dover UTF Mine Abandonment Plan
**UTF Mine Water Treatment Pond**

- Mine water treatment pond originally built to capture produced water and water seepage from the UTF shafts and tunnels.
- Suncor received approval from Alberta Environment in July 2010 to decommission the concrete pond and the associated pump house.
- Soil samples were obtained from the pond area, and as of January 2013 Suncor is waiting on the analytical results before proceeding with backfilling and re-contouring.
UTF Mine Abandonment

- Hybrid shaft-well abandonment method used to provide required groundwater protection over the long term

Source: 2010 Approved Dover UTF Mine Abandonment Plan
Hybrid Shaft-Well Abandonment

• Hybrid shaft-well abandonment method used to isolate the lower saline formation water from the upper freshwater zones
  – Engineered fill used to isolate the McMurray and Clearwater
  – Isolation plugs designed to ensure saline formation water was restricted from connecting with upper freshwater zones
  – Engineered solution with low permeability concrete used in shaft isolation and shaft station plugs
Hybrid Shaft-Well Abandonment

Note: Isolation Membrane at Shaft Isolation Plug and Tunnel Isolation Bulkhead not shown.

Source: 2010 Approved Dover UTF Mine Abandonment Plan
UTF Shaft Closure

• Shaft Bottom Fill:
  – A Very High Volume Supplementary Cementing Material (VHVSCM) with low-permeability, low-shrinking flowable concrete was used
  – Extended from the shaft bottom to 1 m below the shaft station (~27 m in length) for both the No. 1 and No. 2 shafts

• Shaft Station Concrete Plug:
  – Provides low-permeability between the tunnels and the shafts
  – A High Volume Supplementary Cementing Material (HVSCM) with low-permeability, low-shrinking flowable concrete was used
  – Installed from 1 m below the tunnel floor to 1 m above the tunnel roof at the shaft station location

• Shaft Intermediate Fill:
  – Required for a distance of about 36 m above the shaft station plug
  – A VHVSCM with low-permeability, low-shrinking flowable concrete, similar to the shaft bottom fill was used
UTF Shaft Closure

• Shaft Isolation Plug:
  – A HVSCM with low-permeability, low-shrinking flowable concrete was used in this 30 m zone
  – Any infrastructure (e.g. pipes and timber shaft guides) in this zone was removed

• Shaft Upper Fill:
  – A matrix of VHVSCM low-permeability, low-shrink concrete at a ratio of 50% was used in this zone
  – Required for about 110 m above the shaft isolation plug

• Shaft Collar and Cap:
  – A reinforced concert cap 0.5 m thick and 6 m wide was installed on top of the shafts with the top of the cap 2 m below final surface
  – Top 3 m of the shafts below the cap were filled with lean concrete mix
UTF Environmental Summary – Soil and Groundwater

• An ongoing Groundwater Monitoring Program (GMP) and Soil Management Program (SMP) are currently in place at the Suncor Dover Facility, as required under EPEA Approval No. 705-02-00 (as amended)

• The findings from the 2013 GMP include the following:
  – Total dissolved solids concentrations exceeded Tier 1 guidelines in 16 wells, and sodium concentrations exceeded Tier 1 guidelines in 14 wells
  – Concentrations of BTEX and PHC fractions F1 and F2 were less than analytical detection limits at all wells sampled in 2013

• The findings from the 2013 SMP include the following:
  – Hydrocarbon impacted material may remain close to the Hoist/Mine Building
  – Minor hydrocarbon and salinity impacts have not yet been fully delineated in the area of the warehouse and shop building
GMP Monitoring Well Locations

- 35 GW monitoring wells in the current
- Based on the 2013 groundwater quality data, the current groundwater monitoring and sampling program is considered adequate to monitor changes in groundwater

SMP Summary

Source: 2013 Soil Management Program Report – Dover In Situ Oil Sands Plant (WorleyParsons, 2014)
UTF Environmental Summary – Air Emissions

- The only emission source at Dover originates from the BEST Field Pilot under EPEA Approval No. 705-02-00
- Dover has two passive air quality stations and monitors for Sulphur Dioxide (SO₂) and Hydrogen Sulphide (H₂S)
- No H₂S or SO₂ AQAQO exceedances at the Dover site

**Table 1: Approved Air Effluent Stream Overview and Status Update**

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<th>Project</th>
<th>Source</th>
<th>Status</th>
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<tr>
<td>Original Facility</td>
<td>Three 7.3 MW steam generator exhaust stacks</td>
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<td>Original Facility</td>
<td>Two 14.6 MW steam generator exhaust stacks</td>
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<td>Original Facility</td>
<td>Central processing facility flare stack</td>
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<td>BEST Field Pilot</td>
<td>high pressure flare stack</td>
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<tr>
<td>Original Facility</td>
<td>Space heater exhaust vents</td>
<td>Decommissioned</td>
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Closure

- The UTF (Phase A, B and HASDRIVE) was operational from 1987 to 2004
- Resources immediately adjacent to the UTF area are depleted; consequently Suncor decided to proceed with final abandonment
- Wellhead abandonment and underground mine abandonment occurred in 2008 and 2013, respectively
- Suncor is currently considering reutilizing portions of the Plant site and repurposing certain buildings for a camp and/or other future developments
- Suncor will continue to ensure compliance with all regulatory approvals, decisions, regulations and conditions pertaining to the Dover Commercial Project